Eco-friendly Anaerobic Treatment for Coffee Pulping Wastewater

Hariprasad N. V1, Dayananda H. S2, Samanvitha N3, Rakshitha A3
1 Asst. Professor, 2 Professor, 3 Project Associates
Department of Environmental Engineering,
Vidyavardhaka college of Engineering, Mysore, Karnataka, India
DOI: 10.6088/ijaser.030300002

Abstract: An attempt has been made in this research work to treat high strength coffee pulp wastewater using up-flow anaerobic fixed bed reactor with plastic straw sheaf as support media. The reactor was operated at four different hydraulic retention times (HRT). The BOD, COD, Phosphate and Nitrate removal efficiency were found to be 94, 86, 56 and 65% respectively for HRT of 48h. The promising results help in designing an economical treatment facility.

Keywords: Eco-friendly, Coffee Pulping Wastewater (CPWW), Anaerobic Treatment, Up-flow anaerobic reactor, Fixed bed reactor.

1. Background

Coffee belongs to the genus “Coffea” of “Rubiaceae” family. Coffee trading began in the ninth century. It is the second largest traded commodity worldwide after petroleum. Brazil is the largest producer of coffee in the world and India stands in fourth position. Coffee is processed by wet or dry method. The Wet method yields superior quality coffee compared to dry method. Presently in India, around 75–80% of Arabica and 15-20% of Robusta are processed by wet method.

The present practice is to simply discharge the wastewater into nearby stream or river which affects the water quality to neighbors in the downstream. This released wastewater is highly acidic and contains high amounts of biodegradable suspended and dissolved organic solids. If the wastewater from these operations is discharged into the natural water bodies without treatment, it will pollute the receiving water body (Shanmukhappa D. R et al., 1998). Anaerobic reactors have been successfully employed for treating different types of wastewater owing to its excellent capacity of retaining microorganisms in support media (Lima et al., 2005). However, literature review has clearly indicated that not much research work has been carried out for treating coffee pulp wastewater. The support material in the reactor retains biomass in the system interior, in the form of bio-film. The immobilization of micro organisms results from the adherence to a solid or else suspended, being as it is influenced by cell to cell interaction (Von Sperling, 1996). Keeping the above facts in view, an attempt is being made in this research study to utilize Up-flow anaerobic fixed bed reactor to treat high strength coffee pulping wastewater (CPWW) under four different HRTs (8, 16, 24 and 48h) using plastic straw sheaf as a supporting media.

2. Materials and Methods

2.1 Sampling point of CPWW

The CPWW sample for the study was collected from the tail end of the pulping process in a coffee estate near Somwarpet, Madikeri district, Karnataka, India. Due to scarcity of water, the estate owner reuses the
generated wastewater several times before final disposal. As the wastewater sample had high strength characteristics, it was diluted for the study. The collected CPWW sample was stored in a bottle cooler @ 4°C in the laboratory and physico-chemical parameters were analyzed as per the “Standard Methods” (APHA, AWWA 19th Edition, 2003).

2.2 Experimental setup for Bench-scale studies

Figure 1 illustrates the Up-flow anaerobic fixed bed reactor fabricated using a PVC pipe (7.5cm φ and 40 cm height) for treating CPWW. The support media was of depth 22cm. Provisions were appropriately made to collect wastewater sample, sludge removal and release of biogas.

![Figure 1: Schematic of Up-flow anaerobic fixed bed reactor](image)

2.3 Reactor startup

The acclimatization of microorganisms on to the support media was achieved by mixing the plastic straw sheaf with domestic wastewater sludge and retained in a container for a week time. The support media was then seated in the reactor. The wastewater was fed into the reactor and was subjected for different HRT; 8, 16, 24 and 48 h. At the end of each HRT, the wastewater was analyzed for predefined parameters.

3. Results and Discussion

3.1 Characteristics of CPWW

The diluted wastewater sample was analyzed for physico-chemical characteristics and the results obtained are tabulated in Table 1.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameter</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>4.4</td>
</tr>
<tr>
<td>2</td>
<td>COD (mg/L)</td>
<td>3500</td>
</tr>
<tr>
<td>3</td>
<td>BOD (mg/L)</td>
<td>1700</td>
</tr>
<tr>
<td>4</td>
<td>Phosphate (mg/L)</td>
<td>12.8</td>
</tr>
<tr>
<td>5</td>
<td>Nitrate (mg/L)</td>
<td>6.24</td>
</tr>
</tbody>
</table>
The Total solid in wastewater was found to be 2.5mg/L; as such anaerobic method was used to treat CPWW. It can be observed from Table 1 that all the initial characteristics were exceeding threshold values except nitrates. The pH of wastewater was acidic; Hence, NaOH solution was used to adjust the pH to 7.8 before feeding into the reactor. The treated wastewater collected from the reactor outlet was analyzed for routine parameters viz., COD, BOD, Phosphates and Nitrate. The obtained results are indicated in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HRT, hr</th>
<th>Threshold value for disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.49</td>
<td>5.5 – 9.0</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>1600</td>
<td>1200</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>800</td>
<td>400</td>
</tr>
<tr>
<td>Phosphates (mg/L)</td>
<td>11.4</td>
<td>10.87</td>
</tr>
<tr>
<td>Nitrates (mg/L)</td>
<td>3</td>
<td>2.65</td>
</tr>
</tbody>
</table>

It can be observed that with increment in HRT, the pH has shown a declining profile. This is attributed to the growth of acid forming bacteria in excess resulting in overproduction of acid. The BOD removal efficiency increased with increase in contact time between wastewater and the bio-particles. This was achieved due to biological degradation by microorganisms. The COD concentration has reduced significantly in increasing order of HRT. This is the contributed by both biological degradation and fermentation. The initial concentration of nitrate which was 6.24 mg/L has almost reduced by 50% with an HRT of 8 hour. This reduction is attributed to the de-nitrification process that takes place during anaerobic treatment. Reduction in the concentration of phosphate was due to the presence of organic phosphate in CPWW, which will be stored in the cells of microorganisms in the form of polyphosphates, and later into orthophosphate by microbial activity, this phosphorus is used as energy by cell mass.

From the results obtained, it is observed that the concentration of all the concerned parameters are almost brought down to the safe discharge limits. The overall removal efficiency of all the parameters is furnished in Figure 2.

![Figure 2: Percentage removal of chemical parameters](image-url)
From Figure 2, it can be observed that the maximum removal efficiency of organic load was achieved for longer HRT of 48h with COD (86%), BOD (94%), Phosphate (56%) and Nitrate (65%). Hence, this method can be considered as a single feasible treatment facility with plastic straw sheaf as support media for treating high strength CPWW. Further, it could be observed that phosphate removal efficiency is very low compared to the other parameters of concern. For an HRT of 8hr, the removal was only 11% and as the HRT was increased to 16hr, there was an increment in removal efficiency by just 4%. Giving 15% yield. At HRT of 24hr and 48hr, the removal rate was found to be 46% and 56% respectively.

It is known fact that phosphate removal by biological methods is difficult compared to chemical methods. Attempt should be made in this direction for removal of phosphate by combination of biological and chemical methods.

4. Conclusion

This research work has proved that anaerobic treatment is efficient in treating CPWW. The up-flow anaerobic fixed bed reactor was successful in treating high strength wastewater, with BOD reduction from 1700 mg/L to 100 mg/L (94%), COD from 3500 mg/L to 500 mg/L (86%), Phosphate from 12.8 mg/L to 5.6 mg/L (56%) and Nitrate was reduced from 6.24 mg/L to 2.2 mg/L (65%). Plastic straw sheaf can be reused as a packing media for several times before disposal. When this method is implemented in large scale, biogas can be captured, stored and used as energy. This method can be easily implemented and operated economically.

5. References

coffee processing mill in Nicaragua: A service learning design project”, International Journal for service learning in Engineering, 7(1), 69-92


