TREATABILITY STUDIES OF SELECTIVE FIBROUS PACKING MEDIAS FOR SEWAGE TREATMENT

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ABSTRACT

Three reactors filled with fibrous coffee husk blended with wooden chips (packing density 30 kg/m$^3$) and coconut coir fibers (packing density 40 kg/m$^3$ and 70 kg/m$^3$) were taken as fixed film beds and studied under an experimental condition such as detention time of 24 h with 3 h interval of sampling for the removal of COD, NH$_3$-N, TSS and PO$_4^{3-}$ from the sewage.

The results obtained in the Regime phase of experiment revealed that the reactor filled with coffee husk blended with wooden chips showed appreciable amount of COD and ammonia nitrogen removal of 71% at an organic loading rate of 0.78 kg/m$^3$, orthophosphate and TSS removal were found to be 73% and 78% respectively.

Key words: Fibrous Packing, Fixed Bed, Coffee Husk, Wooden Chips, Coconut Coir.

1.0 INTRODUCTION

Wastewater is liquid waste discharged by domestic residences, commercial properties, industry, agriculture, which often contains some contaminants that result from the mixing of wastewater from different sources. Wastewater obtained from various sources need to be treated very effectively in order to create a hygienic environment [1].

Most commonly used traditional physico-chemical treatment methods encompass with various problems like secondary pollution, cost intensiveness etc., Secondary pollution pertains to inevitable by-products and final products generated during and after the treatment which may be more toxic than their precursors. On the contrary, biological treatment processes generate environmentally caring secondary pollutant when compared to that with physico-chemical methods [2].
Attached growth process seems to be more stable than the suspended growth process when the wastewater has considerable fluctuations in flow rate and concentration. Hence, previous research works have proved that innovative packing medias will be efficient in treating of wastewater [3]. As a result, fixed-bed bioreactors have emerged as an alternative to the traditional activated sludge secondary treatment and as a complementary tertiary treatment step after an activated sludge process [3].

Many research works have been carried out in this regard by various scholars throughout the world. To mention, Mohammed Suhail et.al, [4] have carried work on treatment of wastewater using coir geotextile filter bed. In this study with the packing densities of geotextile filter beds varying from 100 kg/m$^3$ to 200 kg/m$^3$ were adopted. The optimum density packing for 10 cm filter bed was found to be 140 kg/m$^3$. The treatment of wastewater was carried out for a constant HRT of 18 h under different packing densities using 10 cm filter depth. The results show that the maximum BOD reduction of 75% in the treatment process.

Most of the researchers have laid emphasis on the applicability of many agricultural by-products. Only a few investigations have been carried out on the suitability of the natural fibrous materials by considering the start up phase and regime phase. In the present study emphasis has been given for cost effective technology of the wastewater treatment by adopting certain organic fibrous materials as fixed film beds, there by different experimental conditions were tried for better performance of the system.

2.0 MATERIALS AND METHODOLOGY

Two different fibrous packing materials were used for the present study, coffee husk blended with wooden chips and coconut coir and are as detailed.

Coir is a hard and tough organic fiber extracted from the husk of coconut the fruit of coconut palm (Cocos nucifera L). It is an inexpensive fiber that is abundant in tropical regions. Coir fiber contains more lignin than all other natural fibers, such as jute, flax, linen, cotton etc. It has a lignin content of 45.84%, which makes it as the strongest of all known natural fibers. As other natural fibers like jute, sisal etc. has much less lignin content, and they are degraded faster than coir.

Coffee (Coffea sp.) is one of the most important agricultural commodities in the world. Industrial processing of coffee cherries is done to isolate coffee powder by removing shell and mucilaginous part from the cherries. There are two methods: dry and wet processing. Depending upon the method of coffee cherries processing, i.e. wet or dry process, the solid residues (sub-products) obtained are termed as pulp or husk, respectively. Coffee husk is a fibrous sub-product obtained during the processing of raw coffee beans.

2.1 Preparation of coffee husk blended with wooden chips

Coffee husk blended with wooden chip aggregates were prepared with the consumption of 1 kg of coffee husk and nearly 0.75 kg of wooden chips. Before starting the procedure to blend, wooden chips were pretreated to reduce the color contribution to the treated effluent. Coffee husk and wooden chips were soaked in a separate container filled with potable water for a contact time of three days until all the color which is brownish is removed from it. Later coffee husk and wooden chips were sun dried completely and placed separately on a bowl and kept inside the hot air oven. Temperature in the hot air oven was set to 60$^0$C and heated for a time span of 45minutes, and then the materials were removed from the hot air oven and cooled to room temperature. These materials were blended together in the ratio of 60:40 to form an aggregate of coffee husk and wooden chips. The aggregates are moulded in to balls of size 40 mm to 50mm diameter by using polyethylene material (plastic covers) which were melted at a temperature between 105 $^0$C to 120 $^0$C using domestic cooking gas flame. Around 275 balls were prepared and placed inside 12 small perforated
plastic bottles i.e., water bottles of half liter capacity in order to avoid buoyancy of balls. These water bottles are Low Density Polyethylene bottles. Each bottle consist nearly 20 to 25 balls. These bottles are placed horizontally inside the reactor volume one above another up to 150 mm.

2.2 Reactors

Three laboratory scale rectangular reactors made of acrylic fiber of size 300×300×350 mm$^3$ were used wherein one filled with Coffee husk blended with wooden chips (RC-1) with a media depth of 150 mm and other two (RC-2 and RC-3) with coconut coir packing densities (40 kg/m$^3$ and 70 kg/m$^3$) with a media depth 120 mm. The reactors were designed for down flow under batch mode of operation. Bottom slope was provided in order to support the media at an angle of 45° for a depth of 100mm. The reactors were continuously aerated using diffused air pumps to maintain aerobic conditions. Fig 1 shows reactor with coffee husk blended wooden chips bed (packing density 30 kg/m$^3$) and Figs 2, 3 shows reactors with coconut coir (packing densities 40kg/m$^3$ and 70 kg/m$^3$).

Fig.1: Cross-section of RC-1 Reactor

Fig.2: Cross-section of RC-2 Reactor
2.3 System start up and operation

The activated sludge from secondary clarifier of sewage treatment plant at Shahi Exports Pvt. Ltd., Gejjalgere, Karnataka, India, was collected as seed sludge for the experiment and kept for aeration. The bioreactors were first inoculated by seed sludge of around 20 Liters to provide the initial microbial mass. The reactors were operated on batch mode to develop attached microbial films. The bioreactors were then aerated with diffused air pumps continuously in order to maintain dissolved oxygen of 2-2.5 mg/L in the reactors. Seeding was done continuously using synthetic wastewater for fifteen days. Subsequently Institutional wastewater was mixed with synthetic wastewater and seeding was continued for five more days in order for the acclimatization and development of biomass. The characters of Institutional wastewater are listed in Table 1. The experiments were performed during Regime phase which will be attained after five weeks of start up phase. In this phase of operation detention time was kept for 24 h and sampling was carried out for an interval of 3 h and the wastewater was applied with an organic loading rate of 0.78 kg of COD/m³.d. MLSS concentration was maintained around 2400-2500mg/L, MLVSS of about 2220 mg/L monitored in all the 3 reactors. The food to microorganism’s ratio was 0.49day⁻¹ and pH was 7.79. The parameters such as COD, BOD₅, Total suspended solids, Ortho-phosphate and NH₃-N were analyzed for these samples.

**Table 1: Initial characteristics of institutional wastewater**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.68</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>28</td>
</tr>
<tr>
<td>COD, mg/L</td>
<td>760</td>
</tr>
<tr>
<td>BOD₅, mg/L</td>
<td>436.5</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>2260</td>
</tr>
<tr>
<td>Ortho-Phosphate, mg/L</td>
<td>6.79</td>
</tr>
<tr>
<td>NH₃-N,mg/L</td>
<td>72.8</td>
</tr>
</tbody>
</table>
3.0 RESULTS AND DISCUSSIONS

The performance of coffee husk blended with wooden chips and coconut coir filter beds were assessed by monitoring the parameters COD, NH$_3$-N, ortho-phosphate and TSS which are discussed in this section.

![Fig 4: Removal efficiency of COD and ammonia nitrogen in reactor packed with coffee husk blended with wooden chips (RC-1)](image1)

![Fig 5: Removal efficiency of Ortho phophate and TSS in reactor packed with coffee husk blended with wooden chips (RC-1)](image2)

As in Fig 4 and Fig 5, it can be observed that COD removal increased from 26.31% at 3h to 70.8% at 24h contact time. NH$_3$-N and ortho-phosphate removal was increased from 30.76% to 71.13% and 32.98% to 73% for a detention time of 24h. Reactor specified excellent removal of TSS i.e., 78.22%. The attained result indicates as biomass was completely acclimatized after 5th week coffee husk blended with wooden chip media exhibited better results of organic matter and nutrient removal.

![Fig 6: Removal efficiency of COD and Ammonia Nitrogen in reactor packed with coir packing density 40 kg/m$^3$ (RC-2)](image3)
In percentage terms, as shown in Fig 6 and Fig 7, it can be inferred that the reactor exhibited better performance efficiency. RC-2 showed 77.6% of COD removal with organic loading rate 0.78 kg COD/m$^3$.d for a detention time of 24h with sampling interval of 3h, 79% of ammonia nitrogen removal, 83% and 87% of ortho-phosphate and TSS removal were achieved for a contact time of 24h. Tiny aperture and pores in the coir fiber could intercept some substances with large molecule structure in the effluent such as soluble starch, peptone and microorganisms also absorbed nutrients when they began to grow and can also attach on them more quickly.
From the figure 8 and 9, it can be observed that COD removal of 68.71%, NH$_3$-N of 75%, Ortho-phosphate of 79% and TSS removal of 83% respectively for a contact time of 24h with a sampling interval of 3h. Major part of COD reduction was observed in the reactor at detention time of 24h. The suspended matter was trapped in the voids between the filter media and also the colloidal particles being adhered to slime layer. As a result TSS reduction was increased from 47.1% at 3h to 83% at 24h. This high TSS removal performance would be due to biofiltration through a submerged medium that serves two purpose, biological conversion of organic matter by the biomass attached to the large support medium surface and physical retention of suspended particles by filtration through the deep filter bed.

4.0 CONCLUSIONS

Based on the results obtained from the present study the following significant conclusions can be drawn:

- Fibrous reactor RC-1 used in the present study took shorter detention time of 24 h to achieve removal efficiency of COD, NH$_3$-N, TSS and PO$_4^{3-}$ greater than 70%, while at the same contact time RC-2 and RC-3 exhibited more than 75% of all selected parameters.
- Reactor filled with coconut coir packing density 40 kg/m$^3$ showed higher removal efficiency of organic matter and nutrients in comparison to reactor of packing density 70 kg/m$^3$.
- Locally available and cost effective medias such as coffee husk blended with wooden chips, coconut coir fiber filter beds can be used as an alternative option for sewage treatment instead of conventional beds.

5.0 REFERENCES