Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 3	pp. 415-418	2012

Original Research Paper

Applicability Studies of Reactor Filled With Coffee Husk Blended with Wooden Chips as a Fixed Bed for Wastewater Treatment

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 2/2/2012
Accepted: 4/3/2012

Key Words:
Fixed film reactor
Wastewater treatment
Coffee husk
Wooden chips

ABSTRACT

Recent interest in environment-friendly materials for the treatment of wastewater leads to the creation of new composites. Organic matter can be effectively removed by packed materials such as plastic honey comb structures, corrugated sheets, stones, etc. in attached growth process. The use of naturally available fibrous materials, which is cost effective and also have characteristics of high specific surface area can be used as a support media in fixed film reactor. Several natural fibrous biomass support mediums are available for use; some of these are coffee husk and wooden chips. The present investigation aims to study the applicability of coffee husk blended with wooden chips as a fixed bed, and also to study the removal efficiency of chemical oxygen demand (COD), phosphate and ammonia nitrogen (NH_3-N) from the municipal wastewater. Two phases of operation were conducted to study the effects of hydraulic retention time (HRT), mixed liquor suspended solids (MLSS) and organic loading rates (OLR). In this study the experiment was conducted for a continuous mode of operation. The bioreactors were continuously aerated and fed with institutional wastewater having an initial average COD of 669 mg/L, ammonia nitrogen of 2.9 mg/L, phosphate of 19.83 mg/L, and TSS of 3600 mg/L. The reactor filled with coffee husk blended with wooden chips showed nominal amount of COD removal of 88-91%, ammonia nitrogen removal of 70-73% and phosphate removal of 91-94% under different reactor conditions.

INTRODUCTION

Fixed-film systems are biological treatment processes that employ a medium such as rock, plastic, wood, or other natural or synthetic solid materials that will support biomass on its surface and within its porous structure for the treatment of wastewater. Attached growth processes exhibited better performance for treating high strength food processing wastewater effectively, compared with conventional suspended methods as given by Abdulgader et al. (2007).

Results of studies carried out by Praveen et al. (2008) showed advantages of using coir geotextile for the removal of organic matter even in crude oil in the small scale units. Jiachang et al. (2009) has reported that integrated fixed-film activated sludge process incorporates fixed-film media in a suspended growth reactor to increase overall biomass inventory for an enhanced treatment without increasing solids loading to subsequent clarifiers.

Recent interest in environment-friendly materials leads to the creation of new composites. This study concentrates in finding an alternative measure from locally available agricultural by-product coffee husk and wooden chips to treat wastewater. The emphasis has been given for viable and cost-effective technology of the wastewater treatment.

The present work is intended to study the application of reactor filled with coffee husk blended with wooden chips as fixed bed for the treatment of wastewater and to know the removal efficiency of COD, phosphate and ammonia nitrogen. Wooden chips act as a supporting material to the coffee husk which are easily and naturally available waste materials with high specific area.

MATERIALS AND METHODS

Experimental set up of the reactors is shown in Fig. 1, and the arrangement of media fills and biomass growth are shown in Figs. 1 and 2. The down flow rectangular reactor is made up of acrylic fibre with 400mm length, 400mm width and 450mm depth with thickness of 5mm. It is arranged for continuous mode of operation. The bed depth is fixed up to a height of 150mm. The bed is made of biomass residues of coffee husk and wooden chips. After the pretreatment, coffee husk and wooden chips were blended together in the ratio of 60:40 as an aggregate. These aggregates were moulded into balls of size 60mm to 70 mm diameter by using polyethylene covers, which were melted at a temperature of 105°C to 120°C and then placed inside small perforated plastic bottles of one litre capacity. These bottles were horizontally placed inside the reactor volume one above another up to 150 mm. The model also consists of a feeding tank, in the form of a plastic bucket with a capacity of 20 litres. The

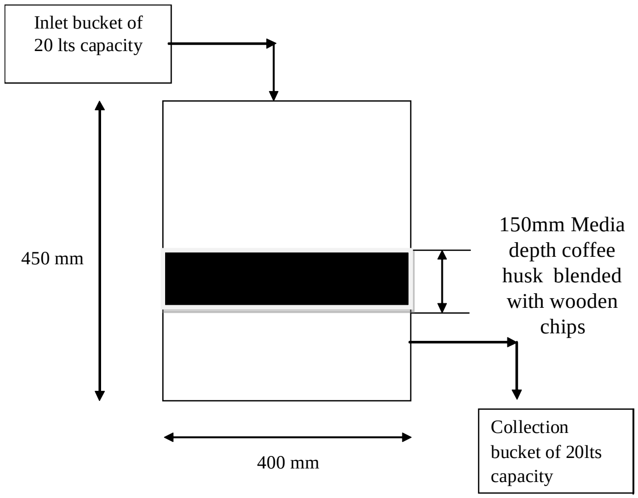

Fig 1: Experimental set up.


Fig. 2: The media fills along with mesh support inside the reactor.


Fig. 3: The biomass growth inside the reactor.

effluent is collected from the bottom of the reactor in the collection tank. A valve of 12 mm diameter is provided at the bottom of the reactor for removing sludge.

Sampling and analytical methods: The samples were of grab type and analysed as per the standard methods (APHA 1998) for the parameters COD, alkalinity, TSS, ammonia-nitrogen and phosphate.

Mode of operation: The sludge of 15-20 kg was applied to the reactor filled with coffee husk and wooden chips aggregates. It was then aerated continuously for three days, and seeding was done simultaneously using hostel wastewater for eighteen days for acclimatization. On 20th day after complete biomass growth on the media, 20 litres of wastewater was run down. The activity of sampling performed was divided into two phases (phase 1 and 2) as given in Tables 1 and 2.

In phase 1, keeping constant organic loading rate of 0.669 kg/m^3 day and MLSS of 2000 mg/L sampling was done for an HRT of 16 hrs at a flow rate of 0.020 m^3/day, for an HRT of 24 hrs at a flow rate 0.013 m^3/day and for an HRT of 48 hrs at flow rate of 0.099 m^3/day.

Table 1: Activity details of sampling carried out for Phase-I of operation.

Date	Activity Flow (m^3/day)	Volume (m^3)	HRT (hrs)	Organic loading COD kg/m^3 day
20-04-2011	0.020	0.02	16	0.669
21-04-2011	0.013	0.02	24	0.669
24-04-2011	0.099	0.02	48	0.669

Table 2: Activity details of sampling carried out for Phase-II of operation with an MLSS concentration of 1500 mg/L.

Date	Flow (m^3/day)	Volume (m^3)	HRT (hrs)	Organic loading COD kg/m^3 day
1-7-2011	0.0138	0.02	24	0.669
4-7-2011	0.0333	0.02	10	0.669
5-7-2011	0.0416	0.02	8	0.669
6-7-2011	0.0555	0.02	6	0.669
7-7-2011	0.0833	0.02	4	0.669
7-7-2011	0.1666	0.02	2	0.669

Table 3: Typical characteristics of hostel wastewater.

Characteristics	Values
pH	7.5
Temperature	28°C
Alkalinity	300 mg/L
COD	669 mg/L
Phosphate	19.83 mg/L
Ammonia nitrogen	2.9 mg/L
Total suspended solids	3600 mg/L

In phase 2, the flow of wastewater was regulated at different HRTs with constant organic loading rate of 0.669 kg/m^3 day and MLSS of 1500 mg/L. Initially, the flow was regulated at 0.0138 m^3/day for an HRT of 24 hrs, 0.033 m^3/day for an HRT of 10 hrs, 0.0416 m^3/day for 8 hrs, 0.0555 m^3/day for 6 hrs, 0.083 m^3/day for 4 hrs, and 0.16 m^3/day for 2 hrs. The different HRTs were tried to check out removal efficiency of COD and phosphates.

RESULTS AND DISCUSSION

The typical characteristics of hostel wastewater are given in Table 3. In this continuous mode of reactor, dissolved oxygen level of 3-3.5 mg/L was maintained throughout the study.

I Phase: The obtained results and percentage removal efficiency of COD, NH_3-N and phosphate are presented in

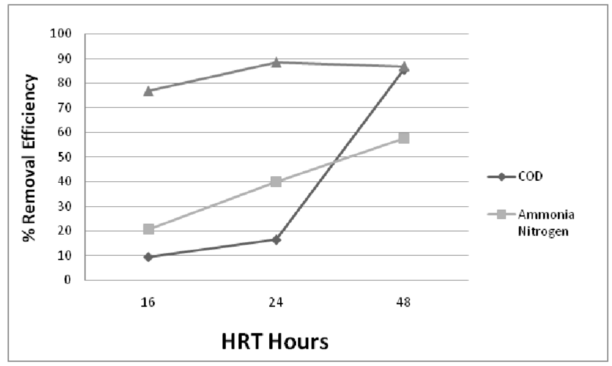

Fig. 4: Percentage removal of COD, ammonia nitrogen and phosphates for Phase-I of operation.

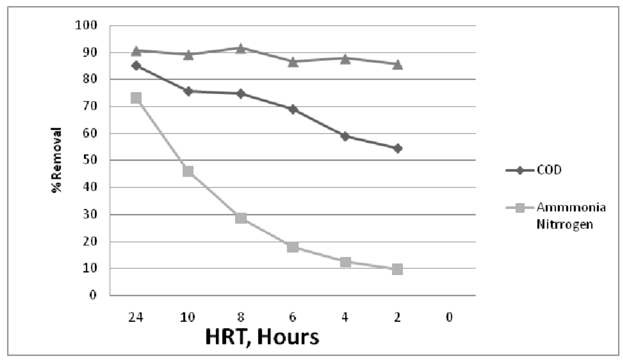

Fig. 5: Percentage removal of COD, ammonia nitrogen and phosphates for MLSS concentration of 1500mg/L for Phase-II operation.

Table 4: Results for Phase-I of operation.

Wastewater source	HRT (hours)	Organic loading COD kg/m^3 day	MLSS mg/L	COD mg/L	Ammonia Nitrogen (mg/L)	Phosphates mg/L
Institutional waste water (sullage)	16	0.669	2000	607	2.03	4.55
	24	0.669	2000	560	1.74	2.27
	48	0.669	2000	96	1.23	2.58

Table 5: Percentage removal efficiency of COD, NH_3-N and phosphate.

HRT (hours)	COD in %	Ammonia Nitrogen in %	Phosphates in %
16	9.26	20.68	77.05
24	16.29	40.00	88.55
48	85.65	57.58	86.98

Table 6: Results for Phase-II of operation with an MLSS concentration of 1500mg/L.

Wastewater source	HRT (hours)	MLSS (mg/L)	COD (mg/L)	Ammonia Nitrogen (mg/L)	Phosphates (mg/L)
Institutional Wastewater (sullage)	24	1500	99.2	0.78	1.86
	10	1500	163.2	1.57	1.68
	8	1500	169.6	2.07	2.161
	6	1500	207.68	2.38	2.67
	4	1500	275.2	2.54	2.45
	2	1500	304.6	2.62	2.86

Table 7: Percentage removal efficiency of COD, ammonia nitrogen, phosphate for Phase-II of operation with an MLSS concentration of 1500 mg/L.

HRT (hours)	COD in %	Ammonia Nitrogen in %	Phosphates in %
24	85.17	73.10	90.62
10	75.60	45.86	89.10
8	74.73	28.62	91.52
6	68.95	17.93	86.54
4	58.86	12.41	87.64
2	54.46	9.65	85.57

Tables 4 and 5. From the Table it is evident that COD and NH_3-N removal is very significant at an HRT of 48 hrs. The graphical representation of percentage removal of COD, NH_3-N and phosphate is shown in Fig. 4.

II phase: The results are presented in Tables 6 and 7, and reveal that at different HRTs, COD removal efficiency decreases gradually with decrease in retention times. For an HRT of 24 hrs, the removal efficiency of COD is 85.17% and for 2 hrs it is 54.56%. Maximum phosphate removal of 91.52% is observed at an HRT of 8 hrs. Fig. 5 shows graphical presentation of percentage removal of COD, NH_3-N and phosphates for an MLSS concentration of 1500 mg/L.

CONCLUSIONS

The present study is intended at application of reactor filled with coffee husk blended with wooden chips for the treatment of wastewater. Based on the results obtained, following significant conclusions can be drawn:

1. The fixed film reactor of coffee husk blended wooden chips aggregate can satisfactorily remove only 85% of COD and 87% of phosphate at a longer HRT of 48 hrs at fixed organic loading rate of 0.669 kg/m^3 day .
2. At an MLSS of 1500mg/L, and HRT of 24 hrs, COD removal is 85%, NH_3-N is 73% and phosphate removal is 91%, but lesser the HRT lower will be the reduction.
3. Even though, system is efficient with longer HRT, optimization of HRT can achieve significant reduction of nutrients and organic matter.

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