Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 1	pp. 163-166	2012

Original Research Paper

Treatment of Wastewater Using Different Fixed Beds Reactors - A Pilot Plant Study

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 20/7/2011
Accepted: 27/8/2011

Key Words:
Wastewater treatment
Fixed bed reactors
Fibrous coconut coir
Corrugated sheets

ABSTRACT

The present investigation was aimed to study removal of COD and NH_3-N in two fixed bed reactors, one filled with fibrous coconut coir and the other with alternate pebble bed with corrugated sheets. The experimental study was conducted for a batch mode of operation. The bio-reactors were continuously aerated and fed with hostel sullage having an initial average COD of 890 mg/L and NH_3-N of 70 mg/L. The reactor with coconut coir showed appreciable amount of COD removal of 79% to 84% and nitrification of 56% to 71% for a detention period of 4-16hrs. The reactor with alternate pebble bed with corrugated sheets showed COD removal of 70% to 75% and NH_3-N of 50% to 65%. The use of various fixed beds having higher surface area is effective in removing COD and nitrogen levels in domestic sullage with high organic impurities. Fibrous materials like coconut coir seem to be a promising option in removal of COD and NH_3-N comparing to conventional attached growth bed such as pebble bed along with corrugated sheets.

INTRODUCTION

Biological fixed film processes continue to be the most practical and economical methods for treating requisite volumes of wastewater from various sources viz., domestic, commercial, industrial and agriculture and its ease of use in small-scale treatment. The attached growth system is almost similar to aquatic treatment system and nutrient film technique (Stowell 1981, Jewell 1983).

Results of the studies done by Fang & Yeong (1993) showed advantages of using fibrous packing materials in a reactor for the effective removal of COD and NH_3-N from municipal wastewater. In addition, attached-growth process seems to be more stable than the suspended growth process when the wastewater has considerable fluctuations in flow rate and concentrations. Shin & Polprasert (1988) has reported the effectiveness of synthetic mesh in removing NH_3-N in attached growth waste stabilization pond. One of the advantages is high biomass per reactor volume which permits higher organic loading rates, shorter liquid detention times and good performance stability.

The present work has intended to study the suitability of coconut coir bed reactor and conventional alternate pebble bed with corrugated sheets as a fixed bed for treating domestic sullage and to know the comparative removal efficiencies of COD and NH_3-N for small volumes and shorter detention periods.

MATERIALS AND METHODS

Experimental setup of the aerobic reactors is shown in Fig. 1. The down flow rectangular reactors were made using PVC fibre sheets, one reactor of 158×10^6 mm^3 and other of 121.5×10^6 mm^3. Each reactor consists of 20mm diameter inlet port for influent, and on the other side two outlet ports of diameter 20 mm connected with rubber tubes to collect the effluent at different depths. Spacing between the outlet ports is 60 mm. Both the reactors consist of hopper bottom for sludge collection and sludge removal port of diameter 60mm is provided at the bottom.

Reactor-1 was filled with coconut coir of 2 kg uniformly and whose average diameter is 2 mm, length 163.2 mm, density 1.2g/cc and void ratio of about 0.8.

Reactor-2 was alternatively filled with pebble of 32 kgs weight and size 10 mm, porosity 70-75% and munters biodek film Media type FB10 which is nowadays increasingly used in many of the industries and municipal treatment plants. Total volume of the media was 60×10^6 mm^3, where corrugated sheets (6 nos.) of volume 9×10^6 mm^3 were placed at centre and remaining portion filled with pebble bed. For both the reactors, diffused aeration was used to maintain dissolved oxygen level in the range of 3-3.5mg/L.

Process start-up and operation: The institutional sullage discharged from washing of utensils, floor washings, decayed fruits and vegetable residues and cooked waste was collected

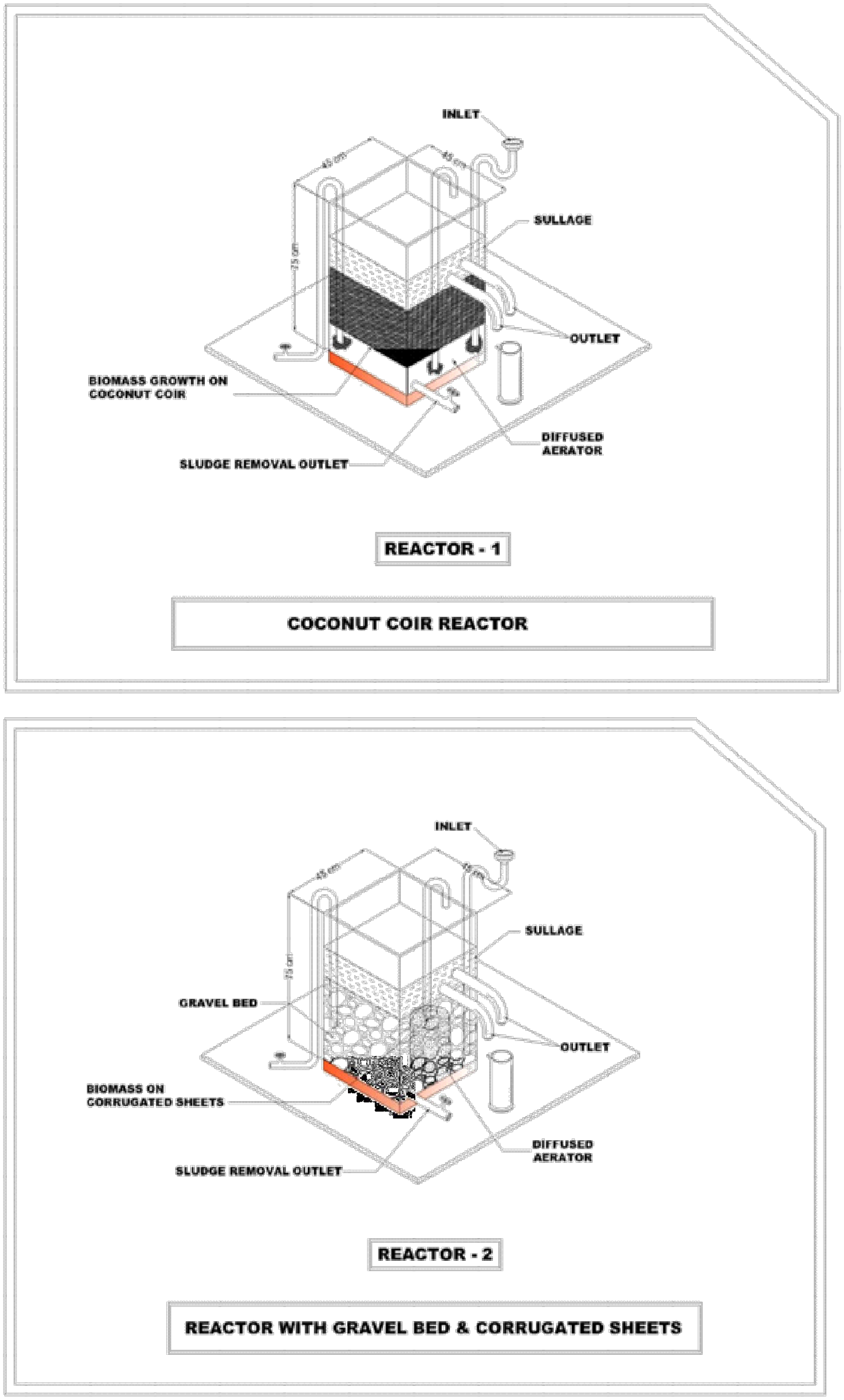

Fig.1: The experimental setup of reactors.

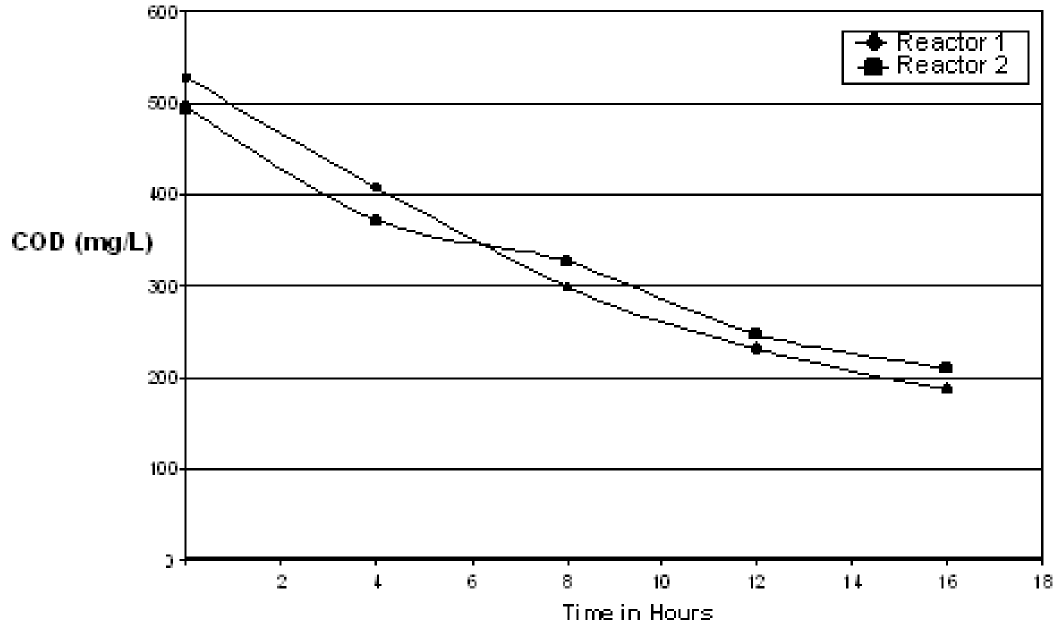

Fig. 2: Arithmetic mean values of COD reduction.

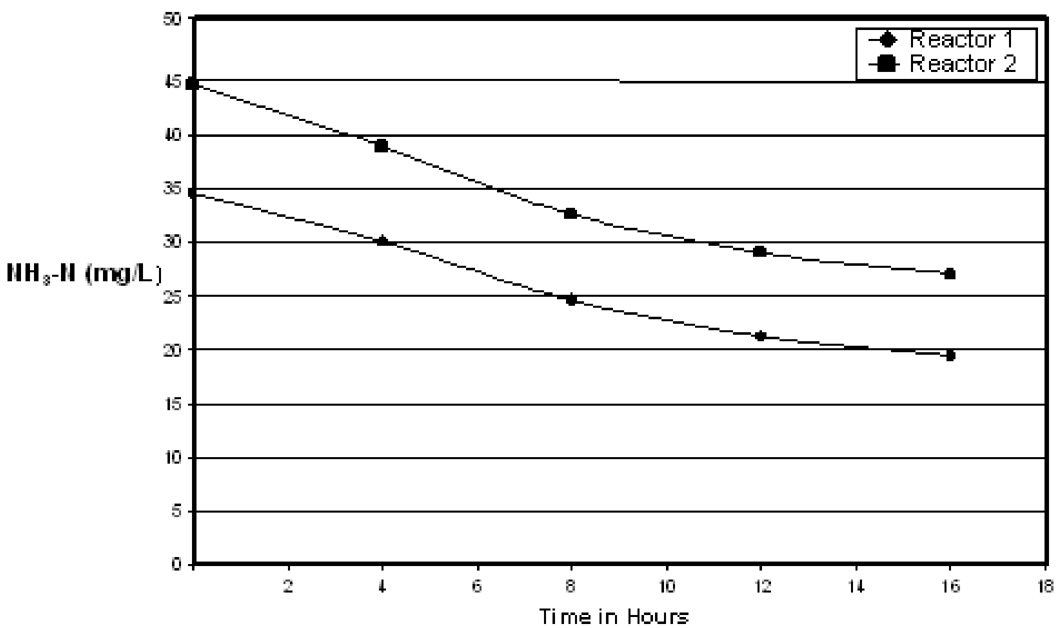

Fig. 3: Arithmetic mean values of NH_3-N reduction.

and taken to the laboratory for analysis. The reactors were seeded with sludge of 20 kg taken from the oxidation pond of a dairy waste treatment plant along with 8-10 litres of wastewater and starting time of 15-18 days was given for acclimatization of aerobic microbes. Daily observations were made to maintain aerobic conditions in the reactor.

After acclimatization and biomass growth, 60 litres of institutional sullage was fed into both the reactors through inlet pipe. The initial characteristics of sullage fed into the reactors are given in Table 1. The first set of sampling was done at an interval of 4 hours over a detention period of 16 hrs and analysed for pH, COD, NH_3-N and nitrate. Meanwhile second and third set of sampling and analysis was done subsequently after a gap of day for each set.

Table 1: Typical characteristics of student hostel wastewater (Institutional sullage).

Characteristics	Values
pH	7.5
Temperature	28°C
Alkalinity	300 mg/L
COD	890 mg/L
BOD	453 mg /L
NH_3-N	60 mg/L

Table 2: Mean values of Reactor-1.

Detention Time, hrs	COD (mg/L)	NH_3-N (mg/L)	Nitrate (mg/L)
0	520	34.5	2.31
4	408	30.09	3.17
8	299	24.6	4.28
12	231	21.23	6.66
16	187	19.4	10.66

Table 3: Mean values of Reactor-2.

Detention Time, hrs	COD (mg/L)	NH_3-N (mg/L)	Nitrate (mg/L)
0	495	44.7	2.26
4	372	38.9	2.2
8	327	32.6	3.52
12	247	29.05	6.40
16	210	27.02	9.77

Analytical methods: The analytical procedures for COD, NH_3-N and alkalinity were performed according to the standard methods (APHA 1985).

RESULTS AND DISCUSSION

In this batch mode of operation, many of the factors like flow, inlet COD and MLSS of 2000-2210mg/L were maintained uniformly in both the bio-reactors. The D.O. level in bulk solution was in the range of 3-3.5mg/L. The arithmetic mean values of COD, NH_3-N and nitrate of both reactors for the sampling days are given in Tables 2 and 3.

Taking the mean for the average initial COD of 890 mg/L, Reactor-1 has reduced to overall 187mg/L, the net removal is 703mg/L with efficiency 79%.

For the same initial COD, Reactor-2 shows reduction up to 210mg/L and net removal 689mg/L with efficiency 76%.

The initial NH_3-N was 70mg/L, while at the end of detention period, Reactor-1 reduces to 19.4mg/L and Reactor-2 reduces to 27.02mg/L.

Based on the results obtained, following conclusions can be drawn.

1. An aerobic fixed film reactor with coconut coir can satisfactorily remove 84% of COD and 71% of NH_3-N, and hence it seems to be the best option for small scale domestic wastewater treatment where COD is high.
2. Rather than conventional single media options, use of dual media or fixed beds like corrugated sheets with gravel bed shows better removal efficiency for COD (70%-75%).
3. It is seen from the results that both coconut coir bed and corrugated sheets with gravel bed start-up being rapid; it is ideally suited for batch process, where wastewater flow is intermittent.

ACKNOWLEDGEMENT

We thank all the faculty members of Environmental Engg. Department, PESCE, Mandya for their valuable suggestions and technical assistance during the completion of this work.

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