International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol.5, No.3, pp 1113-1118, April-June 2013

IPACT-2013[14th – 15th March 2013]

National Conference on Industrial Pollution And Control Technology-2013

Performance Evualuation Studies Of Two Continuous Flow Fixed Bed Filters For Wastewater Treatment

***A.R.Vinod., ** R.M.Mahalingegowda**

***Department of Environmental Engineering,**
****Department of Civil Engineering, P.E.S.College of Engineering,**
Mandya-571401, Karnataka, India.

Corres.author: arbvinod@rediffmail.com, mahalg_pes@yahoo.co.in

Abstract: Small communities, Institutions, or new developments outside the bounds of urban reticulation networks often need to install a robust aerobic wastewater treatment system. Purpose designed aerated fixed film reactor represent an economic treatment option that is robust, simple to operate, and can be retrofitted for nutrients and COD removal.

The present study is intended at performance evaluation of aerated fixed film filters filled with Flocor-R sheets and coffee husk blended with wooden chips as a support media for the treatment of wastewater under fixed organic loading rate (OLR), varied hydraulic retention time (HRT) and predefined MLSS concentration. Organic loading rate was fixed in the range of 0.8 Kg COD/m^3d and HRT from 2-24 hours. Experiments were carried out to study the effect of organic loading rate, HRT on the removal of COD, NH_3-N and phosphate.

In this phase of operation two biological aerated filters(BAF's) filled with Flocor-R sheets and Coffee husk blended with wooden chips were continuously fed with Institutional hostel wastewater having an initial average COD of 800 mg/L, ammonia nitrogen of 4.32 mg/L and phosphate 24.6 mg/L. The biological filters was found to perform satisfactorily when operating under organic loading rate of 0.8 kg COD/(m^3.d), in which the performance of COD removal was 96.4% and 88.4%, NH_3-N removal of 81% and 78.2% for an HRT of 24 hrs was achieved. Phosphate removal was observed to be 98.2% and 90.7% in both the filters. Experimental work has shown that the filters were efficient for the treatment of organic wastewater of 0.8 kg COD/ (m^3.d) without backwash.

Key words: Flocor-R sheets, Coffee husk and wooden chips, Organic loading rate (OLR), Mixed liquor suspended solids (MLSS), Hydraulic Retention time (HRT).

Introduction:

Huge quantity of wastewater generated from human settlement and Industrial sectors accompany the disposal system either as municipal wastewater or Industrial wastewater. This wastewater is enriched with varied pollutants and harmful both to human being and aquatic flora and fauna and its successive accumulation in the soil has adverse effect on soil productivity. The production of organic wastes can be thought of as an integral part of developed society. These organic wastes are generated from Agriculture, food processing industries, domestic wastes, etc.

Biological treatment methods use micro-organisms to degrade organic compounds and materials into inorganic products. Biological wastewater treatment processes can be classified as either attached growth process or suspended growth. In the attached growth processes, micro-organisms are immobilised on a support surface forming bio-film substrates in the wastewater and are absorbed into the film and gradually degraded by micro-organisms. In the suspended growth process, micro-organisms in the suspension have more intimate contact with the substrate. Attached growth process seems to be more stable than the suspended growth process when the wastewater has considerable fluctuations in flow rate and concentration[1]. An Investigation with food processing wastewater had established that attached growth process exhibited better performance for treating high strength food processing wastewater effectively, compared with conventional suspended methods[2]. An aerated submerged fixed film (ASFF) bio-reactor was developed to treat an artificial wastewater based on Crude Oil. Bee-cell 2000 was used as support media; ASFF process showed that it was feasible to treat high oily wastewater in order to meet the discharge standards[3].

Coir geo-textiles were presently used as viable and cost-effective technology for the removal of organic matter from wastewater[4]. Experiment with biological aerated filters was conducted to treat the oil-field produced water using porous ceramic particles as support media[5]. A detailed study using Sequential Batch reactor for treating Milk Industry wastewater was carried out and proposed that ammonia removal is also successfully accomplished through biological nitrification in which ammonia is converted into nitrite and then to nitrate by nitrifying bacterias[6].

Attached growth bio-reactors also offer better performance for cases with higher wastewater strengths. The high specific surface area and low sludge production of flexible fibre bio-film reactors are further advantages when compared with other attached growth bio-film system.

Recent interest in environment friendly materials leads to creation of new composites. This study concentrates in finding an alternative measure from locally available agricultural by-products coffee husk and wooden chips and an inert material such as Flocor-R sheets as packing medias in biological aerated filters in treating wastewater under varied experimental condition, and to know the removal efficiency of COD, Ammonia nitrogen and phosphates at constant organic loading rate with varying HRT and fixed MLSS concentration.

Materials And Methodology[1-9]

Flocor – R Sheets: For the present study two different bed materials such as Flocor-R sheets and coffee husk blended with wooden chips were used as a fixed media.

Packing materials such as Flocor-R sheets (corrugated sheets) made of PVC plastic were washed using distilled water and dried, and then the sheets were cut and made into a module of six pieces and arranged randomly in the reactor. About 600 grams of Flocor-R sheets was uniformly filled into the reactor. The depth of the Flocor-R sheets in the reactor was maintained 150mm and the volume acquired by them is $0.0345m^3$. Plate 1 represents the Flocor-R sheets to be inserted inside the reactor. Some of the critical tests for assessing properties of Flocor-R sheets are presented in Table 1.1.

Plate. 1 Flocor-R sheets

Plate 2: Coffee husks blended with wooden chips placed inside perforated plastic bottles.

Table 1.1 Properties of Flocor-R Sheets used as Supporting media in aerated Fixed bed filter (Harrison, 2000)

Sl. No	Properties	Value
1.	Modulus Of Elasticity	350,000 - 550,000
2.	Heat Distortion	155 to 160^{o}F @ 18.202*10^{5} N/m^{2}
3.	Service Temperature	Maximum 3 - hour water temperature
4.	Specific Gravity	1.4 - 1.6
5.	Composition	PVC
6.	Specific area	90 – 135 m^{2}/m^{3}
7.	Voidage	95%

Table 1.2 Physical properties of coffee husk and wooden chips

Properties	Coffee husk	Wooden chips
Length	0.3mm	25 mm
Diameter	20µm	10-20 µm
Designation	Short, fine	Short, fine

Table 1.3 Chemical properties of coffee husk and wooden chips

Properties	Coffee husk	Wooden chips
Cellulose	24.5%	57 %
Hemi cellulose	29.7%	23 %
Lignin (total)	23.7%	25 %
Ash	0.6%	1%

Coffee Husk blended with wooden chips.

In the present study coffee husks were blended with wooden chips. The aggregates are moulded in to balls of size 60 mm to 70mm diameter by using polyethylene covers (plastic covers) which were melted at a temperature between105 ^{o}C to 120 ^{o}C using domestic cooking gas flame. Around 600 balls were prepared and placed inside 12 small perforated plastic bottles i.e., empty water bottles of 1 litre capacity and were randomly arranged inside the reactor and were as shown in Plate 2. The properties of these materials used for the present study are presented in Table 1.2 and 1.3.

Setup of Filters:

Filter filled with Focor-R sheets (R-1) : The filters were made of acrylic fibre, one with dimension of 480*480mm, height 780mm and of thickness 5mm and effective volume of 0.175m^{3}, which was filled by Flocor-R sheets

Filter filled with coffee husk blended with wooden chips (R-2): Another filter was fabricated with dimensions 400mm*400mm, height 450mm and of thickness 5mm and effective volume of 0.072m^{3} , which was filled with coffee husk blended with wooden chips for a depth of 150mm. Bottom slope was provided in order to support the media at an angle of 45^{0} for a depth of 150mm.

The filters were designed for down flow mode of operation and arrangements were made for the collection of treated wastewater. These were fed through a plastic bucket of 20 litres capacity made out of PVC with inlet tap size 12 mm diameter from the top, and were continuously aerated using diffused air pumps to maintain aerobic condition through out. Fine bubble diffusers producing bubbles of approximately 2.0mm to 2.5mm in diameter were used. Accessories such as Mesh, Inlet and Outlet pipes and taps are used.

Methodology:

The wastewater was collected from the Institution hostel and the initial characteristics were presented in the Table 1.4. The factors considered for the study include, Organic loading rate, HRT and MLSS.

The wastewater samples were analysed as per the Standard Methods for Examination of water and wastewater, 20^{th} Edition for the parameters COD, alkalinity, total suspended solids, ammonia nitrogen and phosphates.

Process Start Up and Operation:

Here the sampling methodology used was of grab variety. Initially the filters were fed with 40litres of domestic sewage sludge collected from an Activated sludge process unit of a nearby resort. The filters were then aerated with diffused air pumps continuously for three days to achieve stabilization. Seeding was carried out daily for eighteen days in order for the acclimatization and development of biomass.

After the complete growth of biomass on the plastic media and coffee husk binded wooden chips, 20 litres of wastewater was run down in the filters. The flow of wastewater was regulated proceeding from an HRT of 2,4,6,8,10 and 24 hours with a constant organic loading rate of 0.8 Kg/m^3 day for an MLSS concentration of 3000 mg/L, and the pH maintained was around 7.64. Activity details of the process were shown in Table 1.5.

Table 1.4 Initial characteristics of Institutional hostel wastewater

Sl. NO	Characteristics	Value
1.	pH	7.68
2.	Temperature	28^o C
3.	COD	800 mg/L
4.	Ammonia Nitrogen	4.32mg/L
5.	Phosphates	24.6 mg/L
6.	Alkalinity	384 mg/L

Table 1.5 Activity details of the sampling carried out for operation

MLSS (mg/L)	HRT (hours)	Volume (m^3)	Flow (m^3/d)	OLR kg/m^3 d
3000	2	0.02	0.24	0.8
	4	0.02	0.12	0.8
	6	0.02	0.08	0.8
	8	0.02	0.06	0.8
	10	0.02	0.048	0.8
	24	0.02	0.0198	0.8

Table 1.6 Performance of R-1 with MLSS of 3000mg/L

Run	HRT (Hours)	pH	COD(mg/L)	NH_3-N (mg/L)	Phosphates(mg/L)
1	2	7.68	259.2	3.6	1.41
2	4	8.00	182.4	2.99	1.09
3	6	7.90	166.4	2.4	1.28
4	8	7.81	121.6	2.12	1.16
5	10	7.42	118.4	1.83	1.04
6	24	8.24	80	0.82	1.31

Table 1.7 Performance for R-2 with MLSS of 3000mg/L

Run	HRT (Hours)	pH	COD(mg/L)	NH_3-N (mg/L)	Phosphates(mg/L)
1	2	7.76	284.2	3.76	1.32
2	4	7.67	212	3.19	1.34
3	6	7.56	184.32	2.86	1.22
4	8	7.62	148.8	2.52	1.23
5	10	7.60	134.4	1.93	1.18
6	24	8.27	57.6	0.94	1.07

Table 1.8 Percentage removal of COD, ammonia nitrogen and phosphates in R-1

HRT (hours)	COD (%)	Ammonia nitrogen (%)	Phosphates (%)
2	67.6	16.6	94.2
4	77.2	30.7	95.5
6	79.2	44.4	94.7
8	84.8	50.9	95.2
10	85.2	57.6	95.7
24	90	81.0	94.6

Table 1.9 Percentage removal of COD, ammonia nitrogen and phosphates in R-2

HRT (hours)	COD (%)	Ammonia nitrogen (%)	Phosphates (%)
2	64.4	12.9	94.6
4	73.5	26.1	94.5
6	76.9	33.7	95
8	81.4	41.6	95
10	83.4	55.3	95.2
24	92.8	78.2	95.6

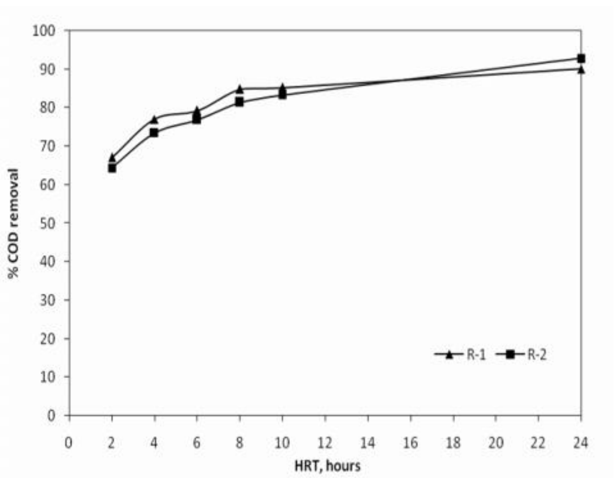

Fig 1. Percentage removal of COD in R-1 and R-2 for MLSS of 3000 mg/L

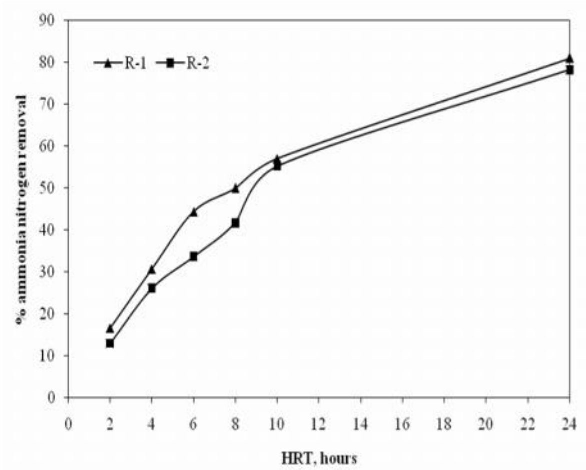

Fig 2. Percentage removal of ammonia nitrogen in R-1 and R-2 for MLSS of 3000 mg/L

Results And Discussions:

The performance evaluation of R-1 and R-2 was done at constant organic loading rate of 0.8 kg/m3 day, with an MLSS concentration of 3000 mg/L. The obtained results were presented in Table 1.6 and 1.7. Meanwhile Tables 1.8 and 1.9 present the results in percentage.

The result shows that majority of the COD removal occurred in R-1 compared to R-2 in the first 10 hrs HRT, but at an HRT of 24 hrs, R-2 shows 92.8% COD removal as shown in Fig.1, indicating higher stabilization due to domination of aerobic bacterias at the bio-film increasing the bio-degradation rate.

Ammonia nitrogen removal was studied simultaneously with COD removal in both the filters. From the Tables 1.8 and 1.9 it is evident that R-1 shows satisfactory removal of 81% than R2 which is 78% at 24 hrs HRT. This might be due to organic material media getting clogged in R-2 thereby enhancing anoxic condition on the biomass at a longer run. Also in both reactors NH_3-N removals at lower HRT's of 2, 4, 6, 8 hrs is not significant as shown in Fig.2, since time wastewater retained in the reactors was short and nitrobacteria did not have sufficient time to nitrify NH_3-N. Moreover, more organic loading could be favourable to heterotrophs against autotrophic bacteria. As a result nitrification was inhibited and NH_3-N removal decreased. But HRT of 24 hrs was sufficiently long to allow biomass to degrade NH_3-N in both filters.

In terms of removing total phosphorous, both the filters showed better removal efficiency of 95.7% and 95.2% for an HRT of 10 hrs and same trend was maintained even at an HRT of 24 hrs. The phosphorous was removed mainly as the nutrition for micro-organisms. The wastewater in this study did not contain so much high phosphate concentrations and hence at a system pH of 7.4 improvement in PO^{3-}. Removal is excellent.

Conclusions:

During the study , the raw Institutional wastewater was fed into two down flow filters and performance of these Biological aerated filters packed with Flocor-R sheets (R1) and Coffee husk blended wooden chips (R2) was observed at an organic loading rate of 0.8 kg/m^3 day with an MLSS of 3000 mg/L . Since Flocor-R sheets were made of plastic and are a common and superior filter medium for biological filters, the efficiencies of these two were compared for simultaneous removal of organic pollutants, NH_3-N and TP from the wastewater.

1) Both the biological filters had excellent removal of COD, NH_3-N removal for a longer HRT of 24 hrs for an MLSS 3000 mg/L.

2) Total phosphorous removal was found to be high (94.2% to 95.7%) in both Biological filters at all HRT's.

3) Coffee husk blended wooden chips is a good medium of Biological filter to treat wastewater especially with higher concentration of COD.

References

1 Fang. H.H.P and C.L.Y.Yeong. Biological wastewater treatment in reactor with fibrous packing,. Journal of Environ.Eng.,1993,119(5),946-957.

2 Abdulgader M.E, Yu Q. J, Williams.P and Zinatizadeh A. A. L. A review of the performance of aerobic bioreactors for treatment of food processing wastewater. Proceedings of the International conference on Environmental Management, Engineering, planning and Economics. Skiathos, June24-28, 2007,1131-1136.

3 Izanloo.H, Mesdaghinia.A, Nabizadeh. Effect of organic loading on the performance of aerated submerged fixed-film reactor for crude oil-containing wastewater treatment. Iran. J. Environ. Health. Sci, Eng., 2006,Vol3(2), 85-90.

4 Praveen, P. B. Sreelakshmy and M. Gopan. Coir Geo-textiles packed conduits for the removal of bio-degradable matter from wastewater. Current science, 2008,95(5),655-658.

5 SU Delin, WANG Jianlong, LIU Kaiwen and ZHOU Ding. Kinetic Performance of Oil-field Produced Water Treatment by Biological Aerated Filter. Chin. J. Chem. Eng., 2007,15(4), 591-594.

6 Suntud Sirianuntapiboon, Narumon Jeeyachok, Rarintorn Larplai. Sequencing batch reactor biofilm system for treatment of milk industry wastewater. Journal of Env.management,2005, 76,177-183.

7 Ewert. J. A, Brice. R. J and Farhaaz. F., (2003) "Submerged Aerated Filters – A Treatment Solution For Small Communities", AWT New Zealand Limited K Sears Taupo District Council.

8 Ramin Nabizadeh, Kazem Naddafi, Alireza Mesdaghinia, Amir Hosien Nafez. Feasibility study of organic matter and Ammonium removal using loofa sponge as a supporting medium in an aerated submerged fixed-film reactor (ASFFR), Electronic Journal of Biotechnology, 2008.11(4),1-9.

9 Standard Methods for the examination of water and wastewater. APHA, AWWA.HPCR, 20^{th} Edition,1998.

*****