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A Feasibility Study On Fibrous Material As Fixed Media For Wastewater Treatment

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Abstract

Biological methods are invariably employed for the treatment of biodegradable wastewaters. Biological aerated filters are an attractive process option, particularly when low land usage is required. The treatment process consists of high void space media that is submerged in wastewater and typically aerated from beneath. In this present study emphasis has been given to evaluate removal prospects of organics and the nutrients by natural fibrous media, coconut coir as fixed bed. The media was operated under batch mode for 24 hour to treat the domestic wastewater and sampling was grab type. In this research work, coconut coir of two different packing densities of 40 kg/m^3 and 70 kg/m^3 with media depth of 120mm and 150mm respectively was used. Removal efficiency of coconut coir of packing density 40 kg/m^3 and 70 kg/m^3 were 92.24% and 91.3% of COD, 93.1% and 91.74% 0f NH_3-N, 93.66% and 92.17% Ortho-Phosphate, 95.5% and 92.17% of TSS respectively. The results depict that coconut coir fibre with packing density 40kg/m^3 and media depth of 120mm showed appreciable organic removal efficiencies.

KeyWords: *Submerged aerated fixed film, Coconut Coir, Media Depth, Packing Density.*

1.INTRODUCTION

Civilization equates to pollution, this is an extreme statement and one which is partially true. Nevertheless, as civilization developed so as industrialization and urbanization which resulted in increased water usage and the use of chemicals of increasing complexity. Nowadays biological wastewater treatment seems to be a most promising tool in treatment of wastewater which is having economic advantage, both in terms of capital investment and operating cost. A recent development in high-rate biological fixed film process treatment is the Biological Aerated Filters. These are flexible reactors which provide a small footprint process option at various stages of wastewater treatment. True BAFs; contain a granular medium that provides a large surface area per unit volume for biofilm development. The medium also allows the reactors to act as deep, submerged filters and incorporate suspended solids removal. As a fixed-film process, optimal conditions for the relevant micro-organisms can be maintained independently of hydraulic retention times [1].

SAFF utilizes the concept of attached growth process with plastic media used as a medium for growth of bacteria. Bacteria cling to the surface of media and utilizes the organic matter (BOD) in wastewater in presence of diffused air (from diffusers) thus converting it to biomass. Biomass can be removed thereby in subsequent reactors. It does not require close operator attention and was normally unattended except for sampling and data gathering. A good biofilter will have the best properties such as high COD removal, resistance to clogging and shock loading, and toxicity tolerance to mitigate pollution load with high efficiency and reduced costs [2].

Many research works have been carried out with inorganic materials (polystyrene, polyethylene), conventional beds (coke, ceramic) and very few fibrous materials including coir geotextile, but emphasis has not been given for cost effective, locally available agricultural byproducts as fixed beds for the removal of organic matter and nutrients. In this present study exclusively fibrous material such as coconut coir fibre were used to check out their suitability for long term operation of wastewater treatment.

2. MATERIALS AND METHODOLOGY

Coir is a hard and tough organic fibre extracted from the husk of coconut (Cocos nucifera L). It is an inexpensive fibre that is abundant in tropical regions. Coir fibre contains more lignin than all other natural fibres, 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 fibres. As other natural fibres like jute, sisal etc.., has much less lignin content, they are degraded faster than coir. Studies conducted under similar environments, jute geotextile is degraded within one year whereas a coir geotextile degraded after 8-10 years for slope protection works .The feasibility of using of coir geotextiles, made out of natural material, as the medium in filters for treatment of wastewater has not been studied extensively yet. Filters employing coir geotextile media exhibit high organic and nutrient removal rates, compared to filters using plastic or sand as the medium. Fig 1 depicts the extraction of coir fibre from coconut.

Coir fibre consists lignin of 45.84%, cellulose of 43.44%, Hemicellulose of 0.25%

Fig 1: Extraction of coir fibre

2.1 EXPERIMENTAL SET UP & DESIGN

Two reactors were fabricated with dimensions 300mm X 300mm, height 350mm and of thickness 5mm and effective volume of 0.091m3. Fig 2&3 illustrates the setup of reactors filled with coconut coir media of two different packing densities. Bottom slope was provided in order to support the media at an angle of 45o for a depth of 100mm. The reactors were designed for down flow under batch mode of operation and arrangements were made for the collection of effluent at the bottom located 50mm above the base through a tap of 12mm dia. The reactors were entitled as RC-1 and RC-2, in which the Coconut coir with packing densities of 40 kg/m3 with 120mm media depth and 70kg/m3 with 150mm media depth were packed respectively.

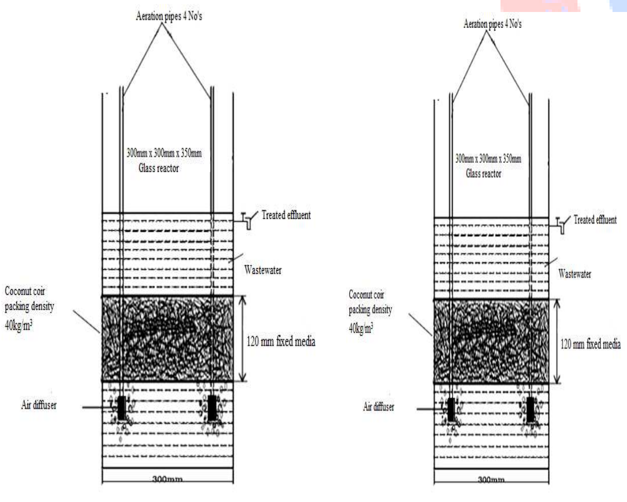

Fig 2 & 3. Reactors filled with coconut coir packing density 40kg/m^3 (RC 1) & 70kg/m^3 (RC 2)

2.2 CHARACTERISTICS OF INSTITUTIONAL WASTEWATER

The institutional wastewater was collected and examined. Table 1 exemplifies the characteristics of wastewater.

Characteristics	Value
pH	7.13
Temperature	28^0 C
Chemical Oxygen Demand (COD)	760 mg/L
Ammonia Nitrogen (NH_3-N)	72.8 mg/L
Ortho- Phosphate	6.79 mg/L
Total Suspended Solids (TSS)	2460 mg/L

2.3 SYSTEM SET UP

The biological process was implemented to accelerate the biodegradation and oxidation of organic compounds in the wastewater. The experiments were performed with a pilot plant composed of a submerged biological aerated filter, a rectangular settling tank made of glass. The activated sludge from secondary clarifier of sewage treatment plant in Shahi Exports Pvt. Ltd., Gejjalgere was selected as seed sludge in the experimentation and kept for aeration. The bioreactor was first inoculated by seed sludge of around 20Liter to provide the initial microbial mass. The reactor was operated on batch mode with clean supporting media to develop attached microbial films. Further seeding was done continuously using institutional wastewater for the acclimatization and development of biomass.

2.3.1 START UP AND LOADING STRATEGY

Here the sampling procedure used was batch and of grab sampling. On 20th day after the complete growth of biomass. Institutional wastewater of about 8 liter was run down in the reactor. The experimental operation was carried out with detention time of 12 hour. The flow of wastewater was regulated with organic loading rate of 0.76 Kg of COD/m^3.d The MLSS concentration of around 2200 and 2500 mg/L was maintained in both the reactors RC-1 and RC-2. MLVSS was originated around 2200 mg/L with food to microorganism ratio of 0.19. The pH was around 8.13. The sampling was started after attaining a DO concentration in the range of 3-3.5 in the predefined reactors. The parameters such as COD, Total Suspended Solids; Ortho-phosphate and NH_3-N were analyzed for these samples.

3.0 RESULTS AND DISCUSSIONS

3.1 Performance evaluation of the reactor RC-1

The present work depicts as detention time increases removal efficiency also increases. RC-1 showed COD removal of 75% at 12h and 92.24 % at 96h. Similarly ammonia nitrogen removal was increased from 74.01% at 12h to 93.1% at 96h. ortho-phosphate removal was started from 76.82% at 12h to 93.51% at 96h has tabulated in table 2. Removal efficiencies increased progressively, which implied that a balance of competition between heterotrophic bacteria and nitrifying bacteria were observed. By observing the trend of removal efficiency from figure 4 & 5, natural coir fibre showed higher removal efficiency than conventional beds.

Table 2-Results of reactor packed with coir packing density 40kg/m^3 (RC-1)

Contact time Hour	COD		Ammonia Nitrogen		Ortho-Phosphate		TSS	
	C mg/L	R %	C mg/L	R %	C mg/L	R %	C mg/L	R %
0	760	-	72.8	-	6.79	-	2460	-
12	190	75	18.79	74.01	1.52	77.6	587	76.13
24	83.6	89	7.88	89.1	1.21	82.17	250	89.83
36	60.8	92	5.35	92.6	0.5	92.63	150	93.9
48	59.7	92.14	5.21	92.79	0.51	92.48	120	95.1
60	58.5	92.3	5.19	92.82	0.49	92.78	118	95.2
72	59.1	92.22	5.13	92.9	0.47	93.07	115	95.3
84	59.05	92.23	5.06	93	0.44	93.51	110	95.5
96	58.97	92.24	4.98	93.1	0.43	93.66	110	95.5

C- Concentration R- Removal Efficiency

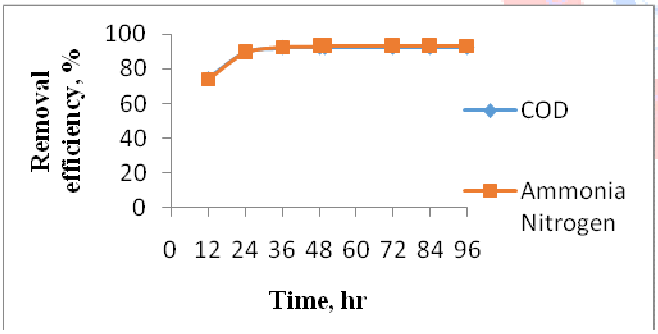

Fig 4-Removal efficiency of COD, NH_3-N in reactor packed with coir packing density 40kg/m^3 (RC-1)

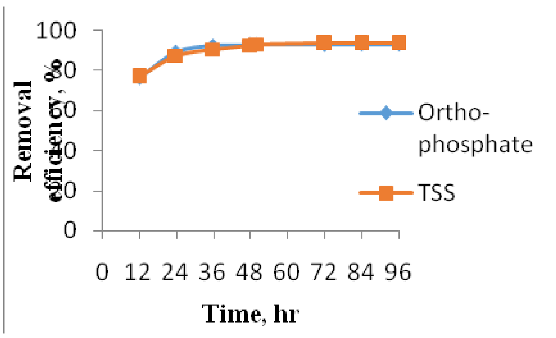

Fig 5- Removal efficiency of ortho-phosphate and TSS in reactor packed with coir packing density 40kg/m^3 (RC-1)

3.2 Performance evaluation of the reactor RC-2

In this study the reactors were monitored with continuous aeration, clogging didn't occurred. RC-1 showed COD removal of 72% at 12h and 91.33% at 96h and ammonia nitrogen removal of 91.74% at 96h. When these results are compared with RC-2, directs lowering the packing density of filter media exemplifies higher removal efficiencies because higher packing density causes overlapping of fibre's, in turn reduces the size of pores responsible for the biomass growth. Figure 6 & 7 shows the graphical representation of efficiency of coir reactor with packing density 70kg/m^3

Table 3-Results of reactor packed with coir packing density 70kg/m^3 (RC-2)

Contact Time Hour	COD		Ammonia nitrogen		Ortho-phosphate		TSS	
	C mg/L	R %	C mg/L	R %	C mg/L	R %	C mg/L	R %
0	760	-	72.8	-	6.79	-	2460	-
12	212.8	72	19.52	73	1.65	74.09	640	73.98
24	106.4	86	9.76	86.5	1.3	79.59	370	86.17
36	68.4	91	6.14	91.5	0.53	91.67	220	91.05
48	67.1	91.17	6.1	91.56	0.52	91.83	210	91.46
60	66.3	91.27	6	91.7	0.51	91.99	200	91..86
72	66	91.31	5.98	91.72	0.5	92.15	197	92.27
84	65.96	91.3	5.97	91.73	0.49	92.16	180	92.16
96	65.96	91.3	5.94	91.74	0.49	92.17	170	92.17

C- Concentration R- Removal Efficiency

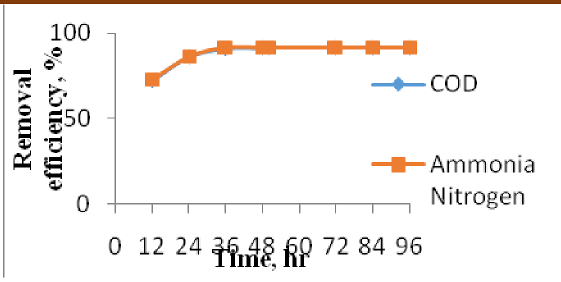

Fig 6. Removal efficiency of COD, ammonia nitrogen in reactor packed with coir packing density 70kg/m^3 (RC-2)

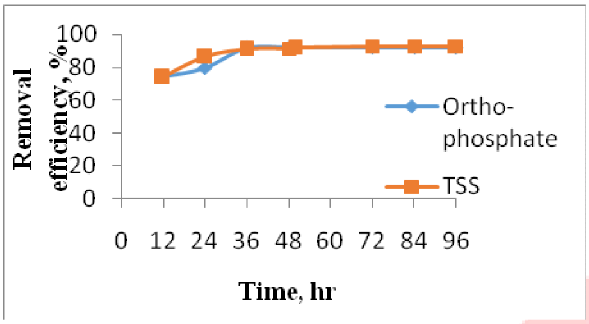

Fig 7. Removal efficiency of ortho-phosphate and TSS in reactor packed with coir packing density 70kg/m3 (RC-2)

Both the reactors were in stable condition monitored with continuous aeration. Reactors RC-1, RC-2 showed remarkable removal efficiency more than 70% of organics and nutrient removal at 12^{th} hour itself. Since the reactors were not provided with the recirculation, the beds in both the reactors reached saturation state and attained endogenous condition at this phase as the media used in the experiment were fibrous in nature. Both reactors showed similar trend of removal efficiency till 36h. After this contact time, removal of organics and nutrient neither increased nor decreased and which implied the reactors optimized at 36h contact time.

As a final engineering observations the proposed system were regarded as an effective process as it showed simultaneous high removal of organics and nutrients from the wastewater.

4. CONCLUSIONS

- Reactor filled with coconut coir packing density 40kg/m^3 (RC-1) results indicated higher removal efficiency of organic matter and nutrients when compared to reactor packed with coconut coir packing density 70kg/m^3 (RC-2) indicates as packing density decreases removal efficiency of organic matter and nutrient increases and there by reduces the clogging of filter. Finally results depicts that both the reactors filled with coconut coir fibre of two different packing density has reached a saturation value at 36h.
- Phosphate removal from domestic wastewater by adopting submerged aerated filter was found to be high at all operating conditions in all the three reactors.
- Locally available and cost effective media coconut coir fibre filter beds seems to be better for domestic wastewater treatment rather than conventional beds.
- Submerged aerated filter is the best biological treatment method to treat domestic wastewater as they are more amenable to biological small scale wastewater treatment.

5. RECOMMENDATIONS

- Since the coconut coir media is locally available, their use in offsite municipal wastewater treatment can be tried for local areas.
- Kinetic coefficients can also be evaluated for fixed film beds

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