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Research Paper

ECO-ENGINEERED TREATMENT OF COFFEE PROCESSING WASTEWATER

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In this study, an attempt is being made to treat acidic coffee processing wastewater containing high amount of suspended and dissolved organic matters using up-flow anaerobic fixed bed reactor, with two different supporting media and varying Hydraulic Retention Times (HRT) of 8, 16, 24 and 48 h. The effluent from the reactor was aerated for 24 h for the purpose of odor removal. The reactor performed better at higher HRT. For 48 h HRT, aerated for 24 h, the COD, BOD, phosphate and nitrate removal efficiency with jute and broken Mangalore tile as support media were 73, 59, 56, 69%, and 71, 47, 54, 70%, respectively. This method of treatment proves to be economical and can be easily operated for effective treatment of coffee processing wastewater.

Keywords: Eco-friendly, Coffee processing wastewater, Anaerobic, Up-flow, Anaerobic reactor, Aeration

INTRODUCTION

India is one of the largest producers of coffee in the world, and is one of the few countries that produce both Arabica and Robusta varieties of coffee. Arabica is more expensive due to its richer flavor and lower caffeine content. Coffee is manufactured by dry and wet processing. Wet processing includes pulping of fruits, followed by drying. The water requirement for production of one ton of clean coffee is 80,000 L for Arabica and 93,000 L for Robusta using conventional pulper and washer. The traditional practice is to simply discharge the wastewater into nearby stream or river which affects water quality to the neighbors in the downstream. The resultant wastewater is acidic, containing high amounts of suspended and dissolved organic solids which are biodegradable. If the wastewater from these operations is discharged into the natural water bodies without treatment, it will pollute the receiving water body (Shanmukhappa *et al.*, 1998). Anaerobic reactors have been successfully employed for the treatment of different types of wastewater owing to the excellent capacity of retaining microorganisms in support media (Lima *et al.*, 2005). These reactors have a support

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material whose purpose is to retain biomass in the system interior, glued to the material surface in the form of bio-film. The immobilization of microorganisms results from the adherence to a solid or else suspended, being as it is influenced by cell to cell interaction or by environmental composition (Von Sperling, 1996).

In this study, Coffee Processing Wastewater (CPWW) is being treated using up-flow anaerobic fixed bed reactor, followed by aeration, under different HRT. Readily available, in-expensive materials like jute coir and broken Mangalore tile were used as supporting media.

MATERIALS AND METHODS

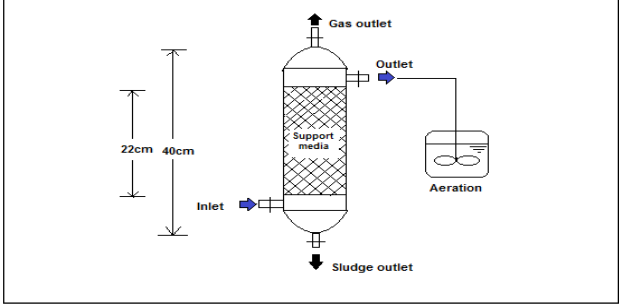
Sample Collection

The wastewater sample was collected from a private estate in Somwarpet, Madikeri district, Karnataka, India. Due to scarcity of freshwater the planter was reusing the CPWW for several times in pulping process before disposing. The collected CPWW sample was stored in bottle cooler at 4 °C. Further, the analysis of diluted sample was conducted in the laboratory for various physico-chemical parameters. All the analysis was made as per "Standard Methods" (APHA, AWWA 19th Edition, 2003).

Up-flow Anaerobic Fixed Bed Reactor

Figure 1 illustrates the Experimental setup. PVC Pipe of diameter 7.5 cm and height 40 cm was used as a reactor. Provision was made for sample collection and for release of biogas at the top.

Figure 1: Experimental Setup of CPWW Treatment Facility



Reactor Startup

To acclimatize the microorganisms on to the supporting media, domestic wastewater sludge was mixed with support media in a container, and allowed for one week. Each supporting media was then transferred into both the reactors. CPWW of known characteristics was fed into the reactors with HRT of 8, 16, 24, 48 h. At the end of each HRT, the sample was drawn and analyzed for predefined parameters, viz., pH, COD, BOD, Phosphates and Nitrate.

RESULTS AND DISCUSSION

Characteristics of CPWW

The results of the physico-chemical analysis are furnished in Table 1. As the CPWW had less Total solids (2.5 mg/L), up-flow anaerobic fixed bed reactor was the right choice to treat CPWW. As observed in Table 1, the CPWW was acidic. Hence, NaOH was added to bring the pH to 7.8 before feeding it to the reactor. The other three parameters except Nitrate are exceeding the permissible limits for disposal on land.

The wastewater from the reactor had offensive odor, this is attributed to acidification and fermentation process in anaerobic digestion and further due to CH_4 and H_2S. Hence, the samples were subjected to aeration for 24 h. Finally, the aerated samples were analyzed for predefined parameters. The results obtained after 24 h aeration are tabulated in Tables 2 and 3, respectively

It can be observed from Table 2 and 3 that, for each HRT considered BOD removal has

Table 1: Physico-Chemical Characteristics of CPWW			
S. No	**Parameter**	**Concentration**	**Threshold values for disposal**
1.	pH	4.4	5.5 – 9.0
2.	COD (mg/L)	3500	-
3.	BOD (mg/L)	1700	100
4.	Phosphate (mg/L)	12.8	5.0
5.	Nitrate (mg/L)	6.24	20

Table 2: Characteristics of Aerated Effluent - Jute coir				
Parameters	**HRT in h**			
	8	**16**	**24**	**48**
pH	7.9	8.08	8.3	8.5
COD, mg/L	1900	1730	1230	930
BOD, mg/L	1300	1000	900	700
Phosphates, mg/L	10.13	8.4	6.75	5.6
Nitrates, mg/L	3.14	2.5	2.04	1.9

Table 3: Characteristics of Aerated Dffluent - Mangalore Tiles				
Parameters	**HRT in h**			
	8	**16**	**24**	**48**
pH	7.95	8.09	8.20	8.23
COD, mg/L	2400	2100	1500	1000
BOD, mg/L	1300	1100	1000	900
Phosphates, mg/L	11	10.38	9.38	5.88
Nitrates, mg/L	3.2	2.47	2.33	1.87

increased with increase in contact time between wastewater and the bio-particles, which is due to biological degradation by microorganisms. Concentration of COD has reduced significantly in increasing order, due to biological degradation and fermentation. Due to nitrification and de-nitrification process during the treatment, Nitrate concentration has reduced. Reduction in the Phosphate concentration was due to the presence of organic phosphate in CPWW, which will be stored in the cells of microorganisms in the form of polyphosphates, and later it will be converted into orthophosphate by microbial activity. This phosphorus is used as energy by cell mass. From the result, it can be observed that pH, Phosphate and Nitrate are well within the limits, so there is no risk of pollution or eutrophication, when discharged. But, the

concentration of COD and BOD are high. Hence, this method can be considered as only a pretreatment followed by other treatment facility or the two reactors can be connected in series, and performance has to be ascertained with different support media.

For the sample with 48 h HRT aerated for 24 h, the removal efficiency of COD, BOD, Phosphate and Nitrate for jute and broken Mangalore tile as support media were 73, 59, 56, 69%, and 71, 47, 54, 70%, respectively. The overall removal efficiency of all the parameters for both support media are shown in Figures 2 to 3, respectively.

Figure 2: Percentage Removal of Chemical Parameters of Concern - Jute Coir

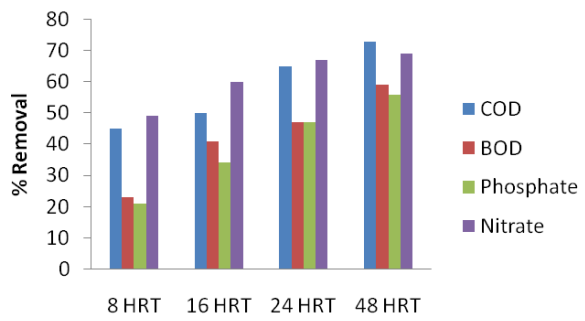
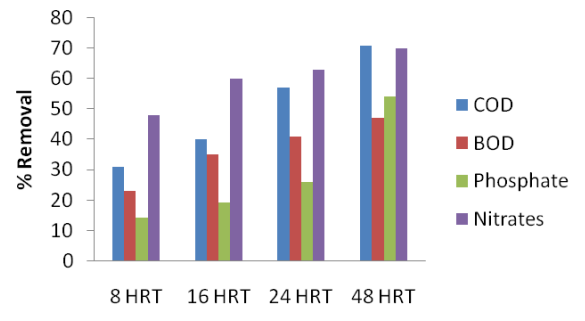


Figure 3: Percentage Removal of Chemical Parameters of Concern - Mangalore Tiles



From the above results, it can be observed that jute performed better in reducing the pollution load with a maximum removal efficiency of 73% COD, 59% BOD, 56% Phosphate. However, broken Mangalore tile performed slightly better in the removal of Nitrate with 70% efficiency.

CONCLUSION

There is an urgent need for developing technically feasible and economically viable wastewater treatment method which reduces the pollution load and meets Central and State Pollution Control Board Norms. This research study has proved that anaerobic treatment followed by aeration is efficient in treating CPWW. As this method does not require any chemicals and much energy, it can be easily implemented and operated at low cost.

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