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Appropriate Fermentation Process for Tapioca's Wastewater in Indonesia

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Abstract: Tapioca's wastewater containing BOD of about 3000 mg L^{-1} was treated by means of yeast fermentation in anarobic batch scale reactors. Various dosages of the yeast ranging from 10 to 30% of effective reactor volume and wastewater concentrations in the range of 50 to 100% were investigated for different fermentation periods ranging from 3 days to 21 days. Without nutrients amendment to the diluted wastewater of 50% concentration, the yeast suspension dosage of 10% was resulted in the maximum absolute BOD removal of 40% during 14 days period. At the same conditions, increasing the yeast dosage of 30% was shown to increase the maximum absolute BOD removal up to 70% for non-diluted wastewater.

Key words: Yeast dosage, BOD removal, detention time

INTRODUCTION

Tapioca is one of primary sources of food industries as well as bio-energy. There was intensive and widespread investigation for the purpose (Balagopalan and Rajalakshmy, 1998; Balagopalan, 2002; Novem, 2003). The extraction of starch from cassava tubers requires large quantities of water, resulting in the release of significant quantity of wastewater. Moreover the tapioca production plants discharge wastewater of high biodegradable organic matter content. Balagopalan (2002) found the average content of BOD in the range of 13000 to 14000 mg L^{-1} and at least 3000 mg BOD L^{-1} was typical organic matter content of tapioca's wastewater in Indonesia (Anonymous, 1996) which might be due to dilution practices. Hence, wastewater treatment should be provided to remove substantial BOD concentration for discharging the wastewater according to pre-determined standard.

The removal of the high BOD would be appropriate using fermentation process by which increasing gas production and/or decreasing biomass formation (Anonymous, 1997) prior to subsequent treatment. This was also compared favorably with biotreatment of solid waste using aerobic and anaerobic processes (Borglin *et al*., 2004). Many anaerobic microbes are capable of fermentation process. *Aspergillus niger* and *Saccharomyces cerevisae* were mostly used in fermentation of biodegradable organic matter, however they require mineral nutrients supplementation (Abui *et al*., 2005). Another one of the yeast, *Candida utilis* was chosen due to fast growing ability in less nutrient content and acid conditions (Biwi, 2001) in addition to cheap and easy for seed. However, a specific performance of the yeast in fermentation of tapioca's wastewater was not well known.

In response to the need of tapioca's wastewater treatment and exploring the performance of the yeast, the current research was to investigate a specific relationship between BOD removal and the yeast dosage. This was aiming to figure out how much the yeast dosage in conjunction with BOD removal of tapioca's wastewater. Hence, the study is supporting the assessment of appropriate wastewater treatment technology for tapioca industries, particularly in Indonesia.

MATERIALS AND METHODS

A laboratory research was conducted in the Laboratory of Environmental Technology and Process Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia. This experiment was replicated three times subsequently and run for four months, commencing in January 2004.

Wastewater was collected from tapioca production plant in Desa Sidomulyo, Kediri, located about 150 km south-west of Surabaya. Preservation of wastewater as well as BOD measurement were conducted prior to experimental run.

Three arrangements of three series batch scale anaerobic reactors were provided with an effective capacity of 300 mL. These were filled with 50, 75 and 100% of wastewater respectively. Dilution of raw wastewater was carried out using tap water.

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A suspension of the yeast *Candida utilis* (pro-analysis) with an amount of 10% of wastewater volume were poured in a series of the three batch reactors. The yeast suspension of 20 and 30% of wastewater volume were poured in the other two series of batch reactors respectively. For evaluation purposes, counting number of Colony Forming Unit (CFU) was carried out to each dosage of the yeast.

BOD measurements and counting number of CFU for each reactor were carried out following fermentation process during 3, 7, 14 and 21 days. BOD measurements were determined using the dilution method in accordance with Standard Methods (1995). In addition, measurement of temperature, pH and Total Suspended Solids (TSS) were carried out daily for process monitoring purposes.

Moreover, the up side of reactor was equipped with a pipe to allow gas flows to up turned cylinder glass containing water. Gas was produced as a result of the fermentation process. This monitoring equipment was useful to be as early warning system for possible inhibition of fermentation process due to the presence of toxicant such as cyanogen (Balagopalan and Rajalakshmy, 1998).

RESULTS AND DISCUSSION

Gas produced during the fermentation was significantly small, i.e., up to 7 mL gas over the high BOD concentration of about 3000 mg L^{-1}. This suggests biodegradable organic matter-containing wastewater was acidified to produce alcohol such as ethanol and represented by daily measurement of pH, ranging from 3.2 to 3.9. In addition, daily observation on temperature and TSS were 27 -30°C and 0.9-1.2 mg L^{-1} respectively. The range finding value of the physical parameters were suitable for the yeast *Candida utilis*, suggesting that fermentation process was in well performed conditions. These fermentation conditions were compared favorably with Ogiehor *et al.* (2004) in their study with post fermentation quality changes in bobozi produced from cassava.

The yeast dosage was represented as a percentage of suspension over the effective volume of reactor; this was evaluated by means of counting number of CFU following the fermentation periods. Table 1 showed that the numbers were increased substantially as increasing of wastewater concentration. This explains the biodegradable organic matter of tapioca's wastewater was a suitable carbon source for the yeast growth even the wastewater has no nutrient addition. In comparison with the yeast growth in tofu's wastewater with nutrient addition (Biwi, 2001) at the same level of BOD removal, the tapioca's wastewater was more appropriate to be fermented using the yeast *Candida utilis* than the tofu's wastewater.

Wastewater concentration was represented as a percentage of raw wastewater; this was evaluated by means of measuring BOD removal following fermentation periods. The initial BOD concentrations were in the range of 3000-3300 mg L^{-1} and the removal figures were

Table 1: Periodical number of the yeast

Concentration variables		Counting number of the yeast (10^7 CFU mL^{-1}) Days			
The yeast (%)	Wastewater (%)	0-3	0-7	0-14	0-21
10	50	10	10	40	20
	75	20	20	60	25
	100	50	50	100	50
20	50	20	20	60	20
	75	60	60	120	50
	100	75	75	140	100
30	50	60	60	120	100
	75	100	100	130	120
	100	150	150	200	150

Table 2: Periodical BOD removal of the tapioca's wastewater

Concentration variables		BOD removal of the waste water (%) Days			
The yeast (%)	Wastewater (%)	0-3	0-7	0-14	0-21
10	50	5	9	21	30
	75	10	13	31	34
	100	17	21	40	26
20	50	8	6	21	10
	75	14	24	41	35
	100	21	31	43	36
30	50	7	21	32	30
	75	24	34	40	42
	100	31	46	68	45

presented in Table 2. The results were shown that BOD removal was increased as tapioca's wastewater had no dilution. However, it should be noted that increasing the yeast dosage for increasing BOD removal may not be appropriate and impractical. Hence, further study will be interesting for addition of nutrient in tapioca's wastewater to enhance BOD removal in comparison with Abui *et al.* (2005) in their work with *Aspergillus niger* and *Sacharomyces cerevisae*.

Assessment on fermentation period was clearly shown that the maximum growth of the yeast and BOD removal of the wastewater were 14 days. During the period, the relative growth of the yeast was achieved ranging from 30 to 400% of the shortest period and the relative BOD removals were twice to four times than the shortest period. At the maximum conditions, the wastewater concentration was 50% that resulted in absolute BOD removal of about 30%. However, the wastewater concentration of 100% brought about absolute BOD removal of 70%. Therefore, it will be valuable for scientific development to undertake in depth study of tapioca's wastewater on the kinetics of BOD removal, both relative and absoule figures, in conjunction with the growth kinetics of the yeast.

For application of appropriate technology purposes, the minimum and maximum limits of absolute BOD removal would be evaluated in relation to the yeast dosage for non-diluted wastewater and the maximum detention time conditions. Based on the results presented in Table 1 and 2, it follows that increasing the yeast dosage up to 300% would result in increasing absolute BOD removal of 150% regardless the dilution pre-treatment of wastewater. This suggest, firstly, that increasing of the yeast dosage more than 30% as an effort to increase BOD removal was not necessary. Secondly, the fact that wastewater concentration of 100% would brings about maximum BOD removal, hence, dilution of wastewater would not be required.

CONCLUSIONS

Tapioca's wastewater containing BOD of about 3000 mg L^{-1} was not necessary to be diluted for fermentation process using the yeast in achieving maximum absolute BOD removal. No nutrients addition were required for the wastewater, suggesting the yeast *Candida utilis* fermentation was appropriate. Fourteen days detention time was the period to achieve maximum growth of the yeast and BOD removal.

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