CHARACTERIZATION OF KENAF FIBRE-RETTING WASTEWATER

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Introduction

Kenaf, or known as *Hibiscus cannabinus L.* plants in scientific name is categorized under *Malvaceae* family that is close to the cotton and hollystock plants. Kenaf (Figure 1) is known to live in tropical and subtropical atmosphere and it can grow rapidly which in turn contribute to the high production yields. This plant is acknowledged for its potential as a source to produce plant-based raw material and also capable to absorb carbon dioxide (CO_2) higher than other plant.

Figure 1: Kenaf Plants

Kenaf possesses a lot of potential for specific use including its utilization as a green composite for textile. The whole stalk of kenaf (bast and core fibres) has been identified as a promising fibre source for paper pulp. The bast and core can be pulped together or individually depending on the pulping process and the type of paper pulp to be produced (Kaldor, *et al.,* 1990). Bast-fibres contained in kenaf plant play an important role as a raw material for plant-based or bio-composite products. Production from bio-based feedstock is estimated to increase from 5% to 12% in 2010 and continues to rise up to 18% in 2020 and reach 25% in 2030 (Alexander *et al* , 2005). This number shows a good progress in reducing human dependability to petroleum based materials. Nevertheless, for certain applications, bast-fibres cannot be used directly as a raw material because it needs to be separated into individual fibre. This individual fibre can be obtained through retting process. Retting process can be defined as a slow degradation process that can take up a few days to complete. There are various types of retting, for example using chemical, dew- or water-retting. Commonly water-retting procedure is selected because it is simple and often produced as a good quality fibre. Typically water used in the process will be released to the watercourse without any treatments. According to Zhang *et al.* (2005) and as reported by Yu & Yu (2007), retting is defined as treatment degrading the pectin-rich middle lamella connecting adjacent fibre cells to release bast fibres. Retting method play an important role in producing a good quality of fibres. Effective retting involves degradation of pectin and other cementing materials, which act as binding agents between the individual bast fibres as well as between fibre bundles and the epidermal and core tissues (Morrison III *et al.*, 1999). If the fibres are under-retted, it will produce coarse fibres and a lot of non-fibres fractions still adhere, whilst over-retted fibres will produce low strength fibre due to an excessive thinning of bundles or microbial attack on cellulose (Alexander *et al.*, 2005)

Large amount of water in fibre separation (retting) process is required to obtain the fibres. At present, industrial sector are producing fibres in large quantity through water-retting process, hence, the process generating enormous amount of wastewater from the separation process. According to Mondal & Kaviraj (2008) as reported by Huda *et al*. (2012), 10,000kg of jute requiredapproximately 432m^3 of water in water-retting process. Since kenaf and jute are from same family known as Malvaceae, the retting process might be similar. In the future, amount of wastewater will be increased tremendously when the amount of fibre production will be greater than before as kenaf become one of the commodities in Malaysia. The condition of wastewater that turbid and produces odour makes it unacceptable by public. This problem can be resolved with an appropriate treatment process. Hence, an effective wastewater treatment process is necessitated to protect the environment, to fulfil the standard required by authority and also to help to recover water resource.

Characteristics of kenaf retting wastewater

Kenaf retting wastewater samples were analyzed according to procedure provided by APHA (2005). The results of wastewater characterization were listed in Table 1. The values of parameter were varied depend on different conditions of kenaf in terms of moisture content. The wastewater characteristics were compared with the allowable limit that regulated by Department of Environment (DOE), Malaysia. It is important to identify either the wastewater is allow to be released into water stream or required further treatment. Table 1 also shows the allowable limit of pollutants that can be released into watercourse. Standards A and B are referred as area point of effluent release before water intake and after water intake point, respectively.

Table 1: Analyses results from the wastewater characterization (Zawani, 2015)

Parameter	Value	Unit	Allowable Limit			
			A	B	Unit	Remarks
pH	3.5 - 5.5	-	6.0-9.0	5.5-9.0	NA	
Total Solids (TS)	2200 – 2400	mg/L	[1]NA	NA		
Total Suspended Solids (TSS)	200.0 – 500.0	mg/L	50	100	mg/L	
Volatile Suspended Solids (VSS)	150.0 - 300.0	mg/L	NA	NA		
Chemical Oxygen Demand (COD)	2000 – 2500	mg/L	80 80	300 200	mg/L mg/L	
Biological Oxygen Demand (BOD_5)	70.0 – 230.0	mg/L	20	50	mg/L	
Colour	1000 - 1200	PtCo	100	200	ADMI	
Turbidity	180.0-280.0	NTU	NA	NA		
Sulphate	200.0 – 250.0	mg/L SO_4^{2-}	NA	NA		for pulp mill effluent
Sulphide	290.0 – 400.0	µg/L SO^{2-}	0.5	0.5	mg/L	for other industry effluent
Phosphorus	30.0 – 40.0	mg /L	NA	NA		
Ammoniacal Nitrogen	4.0 – 20.0	mg/L NH_3-N	10	20	mg/L	
Nitrite	0.15 – 0.35	mg/L NO_2-N	NA	NA		
Nitrate	4.5 – 7.0	mg/L NO_3-N	NA	NA		

[1] NA – Not Available
[2] American Dye Manufacturer Institute

Inorganic Compound

Presences of heavy metals in wastewater were determined using ICP-OES. Table 2 lists several types of inorganic compounds existed in the sample. The presence of these elements possibly comes from the soil at plantation or from the fertilizer used. All inorganic compounds detected in the samples were lower than permissible limit set by DOE regulations.

Table 2: List of inorganic compound identified in the sample (Zawani, 2015)

Element	Concentration, mg/L	Standard deviation	Allowable Limit (mg/L)	
			A	B
Calcium	20.36	0.134	NA	NA
Magnesium	34.37	0.217	NA	NA
Manganese	0.313	0.0053	0.20	1.0
Zinc	0.108	0.0007	2.0	2.0
Kalium	237.9	0.60	NA	NA
Arsenic	0.0077	0.0074	0.005	0.05
Ferum	1.096	0.0088	1.0	5.0

Organic Compound

Organic compounds were analyzed by GC-MS. In total there were 30 types of organic compounds detected in the sample and the results are tabulated in Table 3. Most of the compounds detected were fatty acids that exist abundantly in the plant and also important for the growth of the plant. These fatty acids possibly influence the pH value of wastewater samples.

Table 3: List of specific organic compound detected in the sample(Zawani, 2015)

No.	Name of compound	No.	Name of compound
1	Tetradecanoic acid	16	9,12-octadecanoic acid
2	Dodecanoic acid	17	Methyl ester
3	Undecanoic acid	18	Stearolic acid
4	Pentadecanoic acid	19	9-octadecynoic acid
5	Pentacyclic acid	20	Acetic acid
6	N-hexadecanoic acid	21	Ethanoic acid
7	Hexadecanoic acid	22	Glacial acetic acid
8	Z-9-tetradecanoic acid	23	Butanoic acid
9	Eicosanoic acid	24	Butyric acid
10	Arachid acid	25	N-butyric acid
11	Octadecanoic acid	26	2-propanone
12	2-(2-hydroxethoxy)ethyl ester	27	Undecanoic acid
13	Z-8-methyl-9-tetradecanoic acid	28	n-decanoic acid
14	Oleic acid	29	Dodecanoic acid
15	9-octadecanoic acid	30	Ethylacetic acid

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