THE FIRST ATTEMPT OF CHICKEN WASTEWATER TREATMENT USING SAND FILTRATION

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ABSTRACT

Chicken processing industries was done in large and small scale in Malaysia currently. The small scale was referred to the activities done in wet market and chicken processing stall. Chicken processing stall mostly situated near the drainage system, where this untreated wastewater goes in directly to drainage system. Furthermore it contained oil, grease, fat, blood and feathers. This study was conducted to assess the feasibility of chicken processing wastewater as onsite treatment. The fine and coarse sand sized of 2.00 mm and 3.36 mm respectively were used as a media. Two layer and three layer sand filtration were used in this study. The sand filtration was initially inoculated with a mixture of 50% raw chicken processing wastewater and 50% BOD_5 dilution water. The batch operation for 10 days was done first to establish biofilms and pre-treatment was applied in order to remove fat and feathers. Experiments involved the measurement of wastewater characteristics i.e. BOD_5, COD and SS for five days continuous analysis. The both sand filtration had removed 66.8 % SS. Two layer sand filtration had removed effectively 45.8% BOD_5 and 43.8% COD whereas 32.1% BOD_5 and 41.9 % COD for three layer sand filtration. This study had revealed that sand filtration has a potential in treating chicken processing wastewater.

Key words: chicken processing wastewater, sand filtration and BOD, COD, SS

1. Introduction

Today, there are many domesticated varieties of poultry including chicken, turkey, duck, goose and etc. However, chicken is one of importance human food source which is easy to access at low price (Hutchins, 2003). Chicken had eaten by people in Malaysia for years. Currently, chicken processing industries exist in large and small scale. The small scale was done in wet market, and chicken processing stall, unfortunately the chicken processing centre (small production) situated nearby to drainage system and do not apply any treatment on their discharges. This untreated chicken processing wastewater goes directly into drainage system and contained high chemical oxygen demand (COD), oil, grease, fat, blood and feathers that could lead to environmental pollution. Fat, oil, and grease (FOG) of chicken processing wastewater can create environmental problems. Animal fats and oils with high 5-day biochemical oxygen demand (BOD_5) can reduce the dissolved oxygen status of receiving waters and impact aquatic biota. In addition, if a film of oil and grease forms on the surface in receiving waters, it is unsightly and reduces the natural re-aeration process. Soluble and emulsified FOG can inhibit oxygen and other gas transport processes that are necessary for plants and animals and ultimately result in aquatic ecosystem disruption.

Therefore, this study was conducted to investigate the feasibility of chicken processing wastewater to eliminate the organic materials and suspended solid using sand filtration columns as onsite treatment. The samples had been collected from the chicken processing centre (small production) nearb y Kolej Universiti Teknologi Tun Hussein Onn with daily production approximately 60 – 80 birds.

The pollutant concentration in chicken processing wastewater might be differ from one source to another source depends on the chicken food source, chicken litter and water usage (clearing and rinsing). Generally, the pollutant concentrations in poultry processing wastewaters are summarized in Table 1. By referring to BOD, COD and SS concentrations, chicken processing wastewater can be categorized as medium concentration (untreated domestic wastewater) (Metcalf & Eddy, 1991).

Table 1: Data of The Comparison on Poultry Processing Wastewater

Types of Wastewater	BOD_5 mg/L	COD mg/L	FOG mg/L	TSS mg/L	SS mg/L
Poultry Processing Wastewater[1]	600-6400	-	55-3570	40-3700	-
Poultry Processing wastewater[1]	1116	1177	169	-	-
Turkey Processing wastewater[1]	706	1552	253	281	-
Turkey Processing wastewater[1]	704	270	93	-	-
Turkey Processing wastewater[1]	2192	981	-	981	-
Poultry Processing Wastewater[2]	706	1552	-	281	-
Turkey Processing wastewater[3]	1000 - 9000	1800 -16000	-	-	600-10900
Chicken Processing Wastewater[3]	3300 – 25000	5900 -45000	-	-	100 – 22000
Chicken Processing Wastewater[4]	222	624	<2.0	-	132
Turkey Processing Wastewater[5]	8000	-	-	800	-

Source [1] : (Young, 2004)
Source [2] : (Sheldon and Merka, 1988)
Source [3] : (Verheijen, 1996)
Source [4] : (PPNJ Poultry & Meat Sdn. Bhd., 2005)
Source [5] : (Heintz, 2003)

Sand filtration is one of the oldest wastewater treatment technologies. Thus, it will produce a very high quality effluent if properly designed, constructed, operated and maintained. Sand filtration also a biofilm technology that been used in wastewater treatment because of its low cost and maintenance and relatively high treatment efficiency. The performance of sand filtration is influenced by many engineering design factors such as media depth, grain size distribution, mineral composition of media, pre treatment, hydraulic and organic loading rates, temperature and dosing techniques. It is however, difficult and complex, and sometimes even unpredictable, to correlate multiple parameters for improving performance of sand filters (Young, 2004). It has been used for poultry and meat processing wastewater as additional or tertiary stage treatment in Japan (Young, 2004), (Tadashi Tanimoto, 1990) and other developed countries as advanced technology. However, studies on the suitability of sand filtration for chicken wastewater treatment have been reported are very limited under tropical climate.

The study of sand filtration performance for turkey processing wastewater (containing high concentration of oil and grease) treatment was conducted by Young (2004). The result shows an excellent performance, where BOD_5 removal remained more than 97% at the end of sand filter operation (81 days) in low rate sand filters. But with the high and medium loading rate, the BOD_5 removal efficiencies declined and fluctuated after appearance of black layers on the top of sand filtration. The research also found that treatment efficiencies of two layer sand filter averaged 95% of TOC and 97% of BOD_5 removal for 35 days while, three layer sand filter averaged 97% of TOC and 99% of BOD_5 removal for 49 days in turkey wastewater using pea gravel for pre-treatment. This study initiated that multiple layer sand filters had better performances of BOD_5 and COD removal than single layer filter where three layer sand filters had highest COD removal capacity due to longer filter runs.

2. Material and Method

2.1 Experimental setup

A unit of bench-scale model of each two-layer and three-layer sand filtration had been designed and constructed. The schematic diagrams with details for both filtration models are shown in the Figure 1(a) and 1(b) respectively.

The sands with effective size of 2.00 mm (uniformity coefficient of 1.50) and 3.35mm (uniformity coefficient of 1.35) were used in this study. A batch operation for 10 days had been conducted concurrently to establish biofilms and clogging test. For the batch operation, six liter of mixed sample was applied into the model. The influent effluent ration must 1:1 (clogging index ≈1) to ensure no clogging in the filter.

The mixed sample was inoculated with a mixture of 50% chicken processing wastewater and 50% of BOD dilution water. This mixture could help the accumulation of the biofilms.

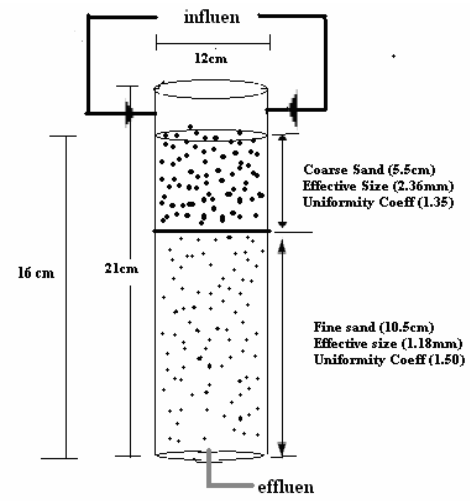

Figure 1 (a)

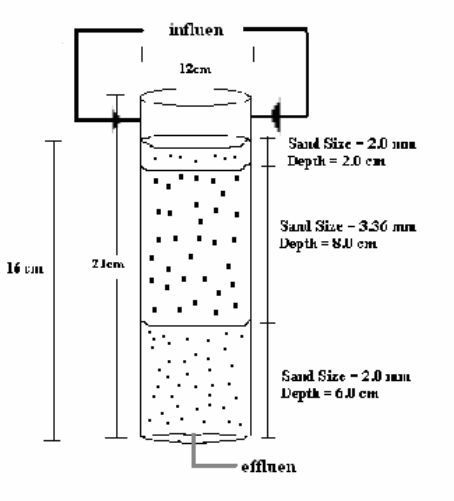

Figure 1 (b)

2.2 Monitoring

Pretreatment is very important to sand filtration performance. The solids and particles in chicken processing wastewater had been removed during the screening process (pre-treatment).

The wastewater samples were collected daily throughout the study period especially during the peak hour. Samples were analyses for BOD_5, COD and SS. All analyses were conducted in accordance with the 19th Edition of the Standard Methods of the Examination of Water and Wastewater. In situ measurements for temperature, pH and Do were also recorded daily at sampling point. Table 1 shows the analyses conducted in this study.

Table 1 : Analyses Conducted

Parameter	Method of analysis	Time
pH	pH meter	In-situ test
DO	DO meter	
BOD_5	BOD apparatus : APHA 5520B (Position Gravitimetric Method)	Five data per parameter per day
COD	COD apparatus : Low range method (DR 2010)	
SS	SS apparatus (DR 2010)	

3. Results and Discussion

Wastewater influent and effluent from the two-layer and three-layer sand filtration were monitored and recorded daily. The formations of biofilms were found on the one-fourth of the filter's depth part and also on the surface of the filter's side wall. The wastewater had filtered effectively through the sand with clogging index ≈ 1. The sample used is a mixed sample consisted of 50% chicken processing wastewater and 50% BOD dilution water.

Performance of two-layer and three-layer sand filtration was assessed on the basis of mean and standard deviation of removal percentage of BOD, COD and SS. The analysis of the three parameters is divided into two measurement which are in-situ and laboratory measurement.

3.1 In-situ measurement

All samples were taken from the same location at the same time everyday. Results obtained from the observation are shown in Table 2. By referring to mean of pH and temperature, this effluent is considered as standard B effluent which can be discharged directly to the receiving water bodies (Environmental Quality Act, 1974).

Table 2 : pH, DO and temperature measurement.

Sampling	pH	DO mg/L	Temperature (^{o}C)
#1	7.3	8.3	27.3
#2	7.1	8.5	26.9
#3	7.1	8.6	27.7
#4	7.5	8.2	26.3
Mean	7.3	8.4	27.1
Std. Dev.	0	0	1

3.2 Laboratory measurement

In the laboratory, three parameters had been measured from the effluent taken from each sand filtration. The parameters are BOD_5, COD and SS. The ranges of BOD_5, COD and SS removal from the units detected during this study are presented in Table 3 and Table 4 respectively. The results obtained from experiment shows that sand filtration performed better especially in SS removal. This might because of the pre-treatment that had been applied before.

The consistent in BOD_5 removal can be seen through this study for two-layer and three-layer sand filtrations with the mean removal are 50% and 32% respectively. This result revealed that two-layer sand filtration performed better. However, the effluent still could not be discharged directly to the receiving water bodies because the BOD_5, COD and SS concentration are much higher than standard effluent concentration (Environmental Quality Act, 1974).

Table 3 : BOD_5, COD and SS Measurements for Two-Layer Sand Filtration.

Sampling	BOD_5, mg/L		BOD_5 Removal,	COD, mg/L		COD Removal,	SS, mg/L		SS Removal,
	Inf	Eff	%	Inf	Eff	%	Inf	Eff	%
#1	846	360	57	2660	972	63	1001	366	63
#2	816	376	54	1772	1172	34	576	206	64
#3	848	504	41	1592	1076	32	547	187	66
# 4	826	414	50	2252	1264	44	782	216	72
Mean	834	414	50	2069	1121	43	727	244	66
Std. Dev.	16	64	7	483	126	14	211	82	4

Table 4 : BOD_5, COD and SS Measurement for Three-Layer Sand Filtration.

Sampling	BOD_5, mg/L		BOD_5 Removal,	COD, mg/L		COD Removal,	SS, mg/L		SS Removal,
	Inf	Eff	%	Inf	Eff	%	Inf	Eff	%
#1	866	614	29	2268	1148	49	999	360	64
#2	800	516	36	1770	1076	39	519	208	60
#3	834	522	37	1622	1082	33	545	207	62
#4	820	592	28	2132	1328	38	767	220	71
Mean	830	561	32	1948	1159	40	708	249	64
Std. Dev.	28	49	5	302	118	7	224	75	5

4. Conclusion and Recommendation

The treatment of chicken processing wastewater is essential in this country due to the high concentration of the wastewater and it is supposed not to be discharged into receiving water bodies. This finding could be a stepping stone to enhance the understanding of sand filtration for chicken wastewater treatment even though the excellent performances could not be seen in this study. The better results will be achieved if the duration of experiment be extended. This sand filtration could be one of an alternative treatment for chicken processing wastewater with further studies concerning on the sand filtration design.

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