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Treatment of Slaughterhouse Wastewater Utilizing Cogon Grass (*Imperata cylindrica*) in a Subsurface Flow System Constructed Wetland in Zamboanga City, Philippines

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Abstract
Natural treatment systems are gaining preference as a wastewater treatment option since it is a form of ecosystem-based adaptation to climate change. The study investigated the performance of a laboratory scale horizontal, subsurface flow constructed wetland (SSFCW) planted with cogon grass (*Imperata cylindrica*) in reducing the pollutant concentration of slaughterhouse wastewater in Zamboanga City, Philippines. Results showed that the mean efficiency of BOD_5 removal at seven (7) and 14 days detention time were 94.49 percent and 89.31 percent, respectively; while the average TSS removal efficiency were 97.8 percent and 99.9 percent, respectively. Statistical analysis of the BOD_5 removal efficiencies revealed significant difference; which means that higher BOD_5 removal is achieved at seven (7) days detention time. Analysis of the TSS removal efficiencies likewise revealed a significant difference, proving that longer detention time results in higher suspended solids removal. Therefore horizontal, SSFCW planted with cogon grass can be used to treat slaughterhouse wastewater at seven (7) days detention time. A pilot study is recommended to validate laboratory-scale finding. Future reseach should also investigate the performance of horizontal, SSFCW using other wastewater sources, different parameters, other endemic hydrophytic grasses, and to consider meteorological and climatological factors.

Keywords: Constructed wetlands; Slaughterhouse Wastewater; Environmental Engineering; Ecosystem-based Adaptation; Natural Wastewater Treatment

1. Introduction

Ecosystems have natural self-purification capacities which have been modelled in order to make possible the creation of artificial (man-made) systems that optimize the natural phycial and biochemical processes to treat wastewater. Constructed wetlands fit into this category; which are shallow basins filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions. A constructed wetland comprises of the following five major components: (1) basin, (2) substrate, (3) vegetation, (4) liner, and (5) inlet/outlet arrangement system. Subsurface flow constructed wetlands are designed to allow wastewater to flow through the substrate, and is discharged out of the basin via a structure which controls the depth of the wastewater in the wetland (UNHSP, 2008). Meat establishments are major contributors to pollution in the bodies of water in the Philippines (NMIS, 2016). The application of constructed wetlands as a technology for wastewater treatment has significantly expanded to treatment of industrial waastewaters, including abbatoirs (Skrzypiec and Gajewska, 2017). This research evaluated the efficiency of a horizontal, SSFCW is reducing the five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) concentration of pretreated slaughterhouse wastewater planted with cogon grass (*Imperata cylindrica*), a water-tolerant grass with various uses that is commonly found in natural wetlands in Zamboanga City, Philippines, at seven (7) days and 14 days detention time.

2. Methods

Laboratory-scale experimental set-up was constructed for a locally sourced slaughterhouse wastewater, pretreated though screening and settling. The influent had an average raw BOD_5 concentration of 2000 ppm. The theoretical design parameters adopted were as follows: detentiont time of one (1) week and two (2) weeks; organic loading rate of 100 kilograms per hectare per day, hydraulic loading rate of 750 cubic meters per hectare per day, and basin slope of 2 percent (Tchobanoglous, 1991). Selected cogon grass (*Imperata cylindrica*) plantlets of 50 to 60 centimeters height were planted into the sandy soil subrate with gravel base at intial plant depth of 40 centimeters and spacing of 22 centimeters by 22 centimetrs, and allowed to grow for a week with constant feeding of tap water prior to introduction of wastewater. The actual wastewater application rate was 317 liters weekly. The experimentation period was 6 weeks. Influent samples were taken prior to allowing it to enter the experimental set-up. Effluent samples were collected every seven (7) days and 14 days prior to draining the experimental set-up to receive the next batch of wastewater. The actual configuration of the experimental cell is illustrated in Figures 1 and 2, respectively.

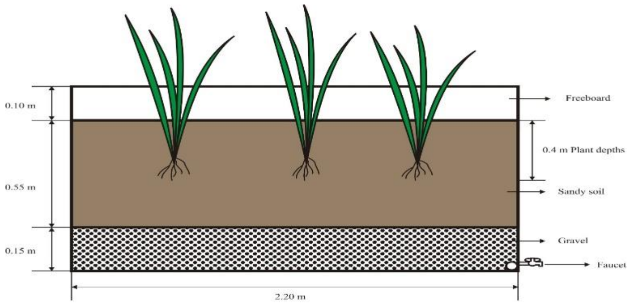

Figure 1. Longitudinal view of the experimental set-up.

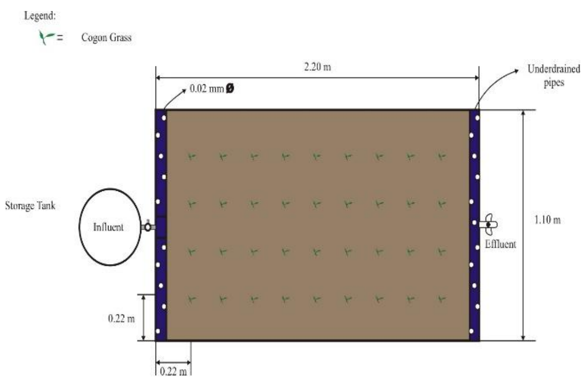

Figure 2. Top view of the experimental set-up

3. Results and Discussions

3.1 Efficiency of BOD_5 Removal

Table 1 summarizes the performance of the horizontal, SSFCW planted with cogon grass (*Imperata cylindrica*) in terms of BOD_5 removal.

Table 1. Influent and effluents BOD_5 results

Test Number	Influent (ppm)	Effluent Seven days detention time (ppm)	Effluent Fourteen days detention time (ppm)
1	1098	98	232
2	2680	87	106
3	2552	111	178
Total	6330	296	516
Mean	2110	98.67	172

Results showed that the mean efficiency of BOD_5 removal at seven (7) and 14 days detention time were 94.49 percent and 89.31 percent, respectively. Statistical analysis of the BOD_5 removal efficiency revealed significant difference; which means that higher BOD_5 removal is achieved at seven (7) days detention time as compared to 14 days detention time. This can be attributed to the anaerobic conditions that develop in the substrate and to the worms in the substrate that flow out with the effluent. The presence of worms can be attributed to the slime layer in the wetland substrate which are significantly consumed or decomposed when the set-up is drained prior to the next feeding. Likewise, it will be noted that organic loading affects the performance of the wetland; i.e., lower efficiency is achieved at higher BOD_5 loading.

3.2 Efficiency of TSS Removal

The TSS removal in the horizontal, SSFCW planted with cogon grass (*Imperata cylindrica*) is reflected in Table 2.

Table 2. Influent and effluents TSS results

Test Number	Influent (ppm)	Effluents Seven days detention time (ppm)	Effluents Fourteen days detention time (ppm)
1	365	18	1.0
2	395	2.5	0
3	192	2	0
Total	1712	22.5	1
Mean	856	11.25	0.5

Results revealed that the average TSS removal efficiency of the horizontal, SSFCW was 97.8 percent and 99.9 percent, respectively at seven (7) days and 14 days deterntion time. Analysis of the TSS removal efficiencies likewise revealed a significant difference, proving that longer detention time results in higher suspended solids removal.

4. Conclusions and Recommendations

Horizontal, SSFCW planted with cogon grass (*Imperata cylindrica*) can be used to treat slaughterhouse wastewater at seven (7) days detention time. Its performance exceeds the average efficiency of cosntructed wetlands reported by Ulsido (2014). Pilot study should be conducted. Future studies should also evaluate its performance using other wastewater sources, different parameters, other endemic hydrophytic grasses, and to consider meteorological and climatological factors in the design.

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