

# **Optimization of biogas production with water hyacinth**

**MASTER OF SCIENCE**



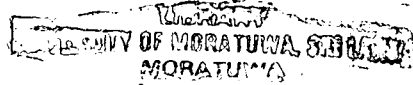
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**UNIVERSITY OF MORATUWA**

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# Optimization of biogas production with water hyacinth

J.A.T. DILHANI



THIS THESIS WAS SUBMITTED TO THE DEPARTMENT OF CIVIL  
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## DECLARATION

I certify that this dissertation does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any University and to the best of my knowledge and belief it does not contain any material previously published or written or orally communicated by another person except, where due references are made in the text.

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## Abstract

The water hyacinth (*Eichhornia crassipes* [Mart.] Solms) due to its high growth rate and vegetative reproduction has been classified as an obnoxious freshwater weed especially in the tropics and subtropics. It has been reported that the presence of water hyacinths in waterways results in the displacement of native freshwater plants due to intense competition for light, space and essential resources such as nutrients, restricts navigation, fishing activities, cultural and social usage by affecting water quality, harbors disease causing vectors, etc. However the use of water hyacinth in the production of biogas has been an appealing solution to control the ever expanding infestation of this nuisance plant. This study therefore aimed at optimizing the biogas production from water hyacinth by enhancing the hydrolysis process. This study also attempted to investigate the optimum nutritional state (i.e. C/N and C/P ratios) required for effective biomethanation and to evaluate the kinetics of anaerobic digestion.

This study was conducted using six numbers of batch bed barreled digesters each having a capacity of 45 l. For this study aerial parts (stems and leaves) of water hyacinth were used as the substrate with fresh cow dung mixed in the ratio of 2:3 by wet weight (w/w). Several parameters such as TS and VS were measured once a week while TOC, TN and TP were measured every 2 weeks. Biogas production rate, pH and temperature were measured on a daily basis. The study was conducted at ambient mesophilic temperature for a period of 4 months.

Both C/N and C/P ratios decreased after mixing with cow dung having a very low C/N and C/P ratio of 8 and 165, respectively. The C/N ratios did not approach to the optimum range of 20-30. Nevertheless the C/P ratios exceeded the optimum ratio of 167 required to enhance biogas production. However gas production commenced from all digesters within 3 days of the study (i.e. a production rate of 0.73-1.35 l/kg/day was recorded).

This study showed that substrates having TS and VS contents in the range of 63-77 g/l and 45-50 g/l, respectively produced biogas more efficiently. Higher gas production rates were obtained from the substrates in the f-1 digester (i.e. digester containing the hyacinths grown in a nutrient solution containing 28 TN mg/l and 7.7 TP mg/l) particularly during the period of 14<sup>th</sup>-27<sup>th</sup> day. f-1 digester had the highest C/N ratio of 16, with an optimum initial pH of 7.28 and temperature of 30.3°C to account for optimum biogas production.

This study concluded that cow dung and water hyacinth mixtures produced biogas even though the C/N ratios were not within the optimum range of 20-30. Nevertheless higher biogas productions were reported from substrates having higher C/N ratios of 16. Chen and Hashimoto model fitted well with the experimental data except for a few initial values since the correction for the temperature, pH and mass transfer were not accounted. Kinetic constants  $\mu_m$  and  $K$  for the substrates were in the range of 0.0074-0.0332 day<sup>-1</sup> and 0.0360-0.0386 day<sup>-1</sup>, respectively.

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## LIST OF TABLES

Table	Page
Table 1.1: District cumulative summary data from 1996, survey on the biogas systems in Sri Lanka	7
Table 1.2: Cumulative summary of biogas systems	7
Table 1.3: Basic guide values for biogas consumption for house hold use	9
Table 2.1: Some typical temperature ranges for various bacteria	15
Table 2.2: Some overall reaction schmes of important conversion in anaerobic digestion	29
Table 2.3: Comparison of Completely Mixed Digester with Plug Flow Digester	36
Table 2.4: Toxic levels of various inhibitors	38
Table 4.1: Nutrient composition of water hyacinth systems	47
Table 4.2: Initial and final nutrient composition of water hyacinth systems after seeding with cow dung	47
Table 4.3: Kinetic parameters	70



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## LIST OF FIGURES

Figure	Page
Figure 1.1: Areas affected by water hyacinth in Colombo municipal area	2
Figure 1.2: Problem of hyacinth infestation with	3
Figure 1.3: Schematic diagram showing the potential utilization of water hyacinth for the phytoremediation & biogas production	4
Figure 1.4: Biogas Projects in Sri Lanka	8
Figure 2.1: Typical cell structures	12
Figure 2.2: Common bacterial shapes	14
Figure 2.3: The role of syntrophs and methanogens in anaerobic digestion	17
Figure 2.4: Structure of adenosinephosphate	20
Figure 2.5: Mode of action of catalysts	20
Figure 2.6: Substrate link to the enzyme	21
Figure 2.7: Inhibition effect for the substrate uptake	22
Figure 2.8: Overall process anaerobic digestion	23
Figure 2.9: Protein chain with amino acid linked by amide group	25
Figure 2.10: Hydrolysis of cellulose fibers	26
Figure 2.11: The metabolic pathways and the products, from the anaerobic decomposition of carbohydrates by acid forming bacteria	28
Figure 2.12: Batch digesters	33
Figure 2.13: Fixed dome digesters	35
Figure 2.14: Plug flow digester	35
Figure 3.1: Digester design stages	43
Figure 3.2: Cross section of the reactor combination	44
Figure 3.3: Water hyacinth plants which were subjected to phytoremediation	45
Figure 3.4: Substrate prior to feeding to the digesters	46
Figure 4.1: Variation of TOC of the hyacinth substrate with time	49
Figure 4.2: Variation of TN of the hyacinth substrate with time	51
Figure 4.3: Variation of TP of the hyacinth substrate with time	52
Figure 4.4: Variation of TS of the hyacinth substrate with time	54



Figure 4.5: Variation of VS of the hyacinth substrate with time	54
Figure 4.6: Variation of biogas production of the hyacinth substrate with time	57
Figure 4.7: Cumulative biogas production of hyacinth systems	60
Figure 4.8: Variation of pH of the hyacinth substrate with time	62
Figure 4.9: Temperature Variation of the hyacinth substrate with time	63
Figure 4.10: The volume of methane produced per gram of substrate VS added to	66
Figure 4.11: Graph of $\ln(G_o/(G_o-G_t))$ vs day for different folds	68
Figure 4.12: Graph $(S_o-S)/S$ VS time	70
Figure 4.13: Experimental and theoretical methane production for f-1/8	72
Figure 4.14: Experimental and theoretical methane production for f-1/4	72
Figure 4.15: Experimental and theoretical methane production for f-1/2	73
Figure 4.16: Experimental and theoretical methane production for f-1	73
Figure 4.17: Experimental and theoretical methane production for f-2	74
Figure 4.18: Experimental and theoretical methane production for f-out	74



## ABBREVIATIONS

ADP	-	Adenosinediphosphate
ATP	-	Adenosinetriphosphate
$B$	-	Volume of methane produced at time $t$ , per gram of substrate (VS) added
$B_0$	-	Volume of methane produced per gram of substrate added at infinite retention time or for complete utilization of substrate
$C$	-	Carbon content (mg/l)
$C$	-	Concentration of substrate at time $t$ (g/l)
$C_0$	-	Initial substrate Concentration (g/l)
COD	-	Chemical Oxygen Demand (mg/l)
$G_0$	-	Biogas produced under complete digestion of influent (l)
$G_t$	-	Cumulative biogas at any time $t$ (l)
$K$	-	Kinetic parameter ( $\text{day}^{-1}$ )
$K_s$	-	Half velocity constant ( $\text{day}^{-1}$ )
$K_t$	-	Reaction rate at temperature $T$ ( $\text{day}^{-1}$ )
$K_{20}$	-	Reaction rate at temperature $20^\circ\text{C}$ ( $\text{day}^{-1}$ )
$N$	-	Nitrogen (mg/l)
$P$	-	Phosphorus (mg/l)
$P_v$	-	Volumetric methane production (l/(l/day))
$R^2$	-	Linear Regression coefficient
$r_g$	-	Rate of bacterial growth (mg/(l/day))
$S$	-	Volatile solids content at any time $t$ (g/l)
$S_0$	-	Initial volatile solids content (g/l)
SRB	-	Sulphate reducing bacteria
SRT	-	Solids retention time (day)
$T$	-	Temperature ( $^\circ\text{C}$ )
TN	-	Total nitrogen (mg/l)
TOC	-	Total organic carbon (mg/l)
TP	-	Total phosphorus (mg/l)
TS	-	Total solids (g/l)
TVS	-	Total volatile solids (g/l)
UOM	-	University of Moratuwa
VFAs	-	Volatile Fatty acids
VS	-	Volatile Solids
$X$	-	Concentration of microorganisms (mass/ unit volume)
$\mu$	-	Specific growth rate ( $\text{day}^{-1}$ )
$\mu_m$	-	Maximum Specific growth rate ( $\text{day}^{-1}$ )
$\theta$	-	Hydraulic Retention Time (day)
$\nabla G$	-	Activation energy
$\alpha$	-	Temperature activity coefficient
$\theta_{min}$	-	Minimum hydraulic retention time