Biomethanation of invasive water hyacinth from eutrophic waters as a post weed management practice in the Dominican Republic

Yessica A. Castro and Foster A. Agblevor

UtahStateUniversity · BIOLOGICAL ENGINEERING · PERI LOYOLA · MESCYT

Abstract

Water hyacinth (*Eichhornia crassipes*) is an invasive aquatic plant with phytoremediation properties targeting heavy metals, and organic and inorganic compounds. The use of water hyacinth as a biogas feedstock combines remediation of contaminated waters with sustainable production of bioenergy. However, studies correlating the eutrophication profile of the water source with the characteristics of this species and its biomethane potential are scarce. In the present study, we compare the characteristics of water hyacinth from anthropogenic hypereutrophic, and biogenic eutrophic waters within Ozama River and its potential as a biogas feedstock.

Introduction

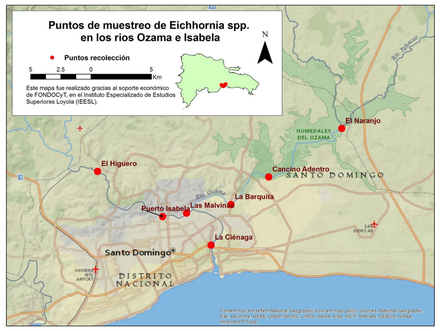
Water hyacinth has been identified as the main plant associated with the high nutrient contamination of Ozama-Isabela river due to plant debris sedimentation [1].

Water hyacinth

Water hyacinth grows very efficiently in eutrophic and contaminated waters [2, 3, 4]. Cultivating this species for bioenergy production is a sustainable approach.

Ozama River (DR) covered by water hyacinth .

	La Ciénaga	El Naranjo
pH	7.11	7.13
Temperature (°C)	28.1	26.4
Salinity (ppT)	1.23	0.09
DO (mg/L)	1.37	2.50
NO3- (mg/L)	12.5±2.8	3.6±1.4
TDS (mg/L)	122 - 640	1550 - 3028



La Ciénaga (hypereutrophic brackish waters) and El Naranjo (eutrophic freshwaters) are the sampling sites under study.

Anaerobic digestion is a suitable conversion process for aquatic plants like water hyacinth [5]. But the biomethane potential is affected by the characteristics and growth condition of the species [6, 7].

Conclusions

The differences in the characteristics of the water hyacinth from eutrophic freshwaters and hypereutrophic brackish waters of Ozama River were linked to the condition of the water source and posed some dissimilarities in the biodigestibility of the biomass. The water hyacinth collected from La Ciénaga (brackish water) had higher methane yield and production rate than that from El Naranjo (freshwater). Harvesting water hyacinth from Ozama River to mitigate the effect of the macrophyte debris on the water bodies can be anaerobically digested for biomethane production.

Further work to assess possible inhibition due to presence of heavy metals. should be conducted.

Methods

Thermogravimetric analysis TGA-Q500

$$\%VS = ((W_{T=190°C} - W_{T=550°}) * 100\%)/W_{T=190°C}$$

$$\%FC = ((W_{T=600°C} - W_{T=700°}) * 100\%)/W_{T=190°C}$$

The summative analysis (moisture, ash, carbohydrates, protein, extractives, and lignin content) were determined following NREL methods. The elemental analysis (CHNSO) was conducted using FLASH 2000 Organic Elemental Analyzer (Thermo Fisher Scientific.For the total inorganic elemental composition, the ash of the samples was acid digested according to EPA 3050 and analyzed using ICP-AES.

For the **biomethanation** of water hyacinth the inoculum was anaerobic sludge from North Davis Sewer District, Syracuse, UT). The produced gas was measured using an Agilent 490 Micro Gas Chromatograph.

For methane potential and production rate estimation the modified Gompertz model was used where, W [N.L CH4/kg VS added] is the accumulated methane produced as a function of time, A [N. L CH4/kg VS added] is the maximum methane produced, and Kz [N. L CH4/Kg VS added * day] is the methane production rate

$$W(t) = A * EXP\left(-EXP\left((e * k_z/A) * (T_{lag} - t) + 1\right)\right)$$

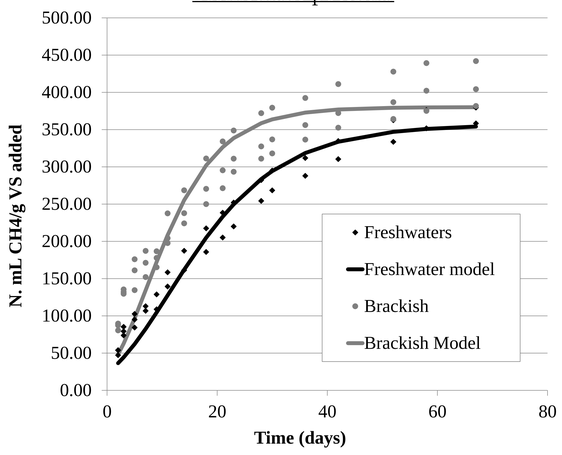
Results

	Proximate % (w/w)		Composition (% w/w)						Ultimate Analysis (% w/w)			
	Volatile Solids	Fixed Carbon	Cellulose	Hemicellulose	Lignin	Ash	Protein	Extractives	C	H	N	C/N
El Naranjo	59.9±0.7	19.9±0.2	**24.5±1.2**	**16.8±1.5**	4.0±0.05	20.22±0.3	9.8±0.7	17.32±0.2	38.5±1.0	3.9±0.2	1.8±0.2	**21.4**
La Ciénaga	58.4±0.5	19.9±0.6	19.5±0.5	12.6±1.2	3.6±0.1	20.47±0.2	**18.8±1.9**	**26.45±0.1**	39.4±0.4	4.0±0.2	**3.7±0.1**	10.5

	Macronutrients (% w/w)					Micronutrients (%w/w)					Heavy metals (mg/Kg)								
	Ca	K	Mg	P	S	Fe	Mn	Al	Na	Si	Cu	Ni	Se	Mo	Co	Zn	As	Cd	Cr
El Naranjo	10.9	19.3	1.38	0.95	0.40	**1.22**	0.26	**1.77**	0.74	1.49	50.6	51.3	<1.25	4.16	**7.64**	109	**1.91**	0.34	**26.2**
La Ciénaga	7.15	21.1	2.89	**2.91**	1.00	0.18	0.16	0.19	**2.21**	0.76	39.2	32.9	<1.25	5.19	2.13	127	<0.05	<0.05	7.57

* Values in bold are significantly higher than the rest within same column.

Biomethane potential



- The **highest non-structural components**; protein and extractives were found in the biomass **from La Ciénaga** (45.2±2.0%), whereas the highest amount of holocellulose was in El Naranjo (41.2±2.8%) .
- **The biomethane potential for water hyacinth from La Ciénaga (380.2 ± 5.2 NmL CH4/g VS) was higher** (p = 0.012) than that from El Naranjo (356.6 ±3.7 NmL CH4/g VS).
- The estimated methane production rate for the biomethanation of brackish water hyacinth at La Ciénaga (19.2 N. mL CH4/g VS · day) , was higher than that of freshwater hyacinth at El Naranjo (11.6 N. mL CH4/g VS · day).

Acknowledgments

This research was supported by the National Research Fund for Science, Technology, and Innovation [FONDOCYT 2015-2A3-123] of the Dominican Republic Ministry of Higher Education, Science and Technology (MESCYT).

Publication

This work is based on the pre-print version of the published article:

Castro YA, Agblevor FA (2020) Biomethanation of invasive water hyacinth from eutrophic waters as a post weed management practice in the Dominican Republic, a developing country. Environ Sci Pollut Res. doi: 10.1007/s11356-020-07927-w

Cited Works

[1] Salas, H., Martino, P., 1988. Evaluación y control de la contaminación de las aguas superficiales en la vecindad de Santo Domingo.
[2] M. Delgado, M. Bigeriego, E. Glardiola, Biomass and Bioenergy. 3 (1992) 57–61.
[3] J.E. Hronich, L. Martin, J. Plawsky, H.R. Bungay, J. Ind. Microbiol. Biotechnol. 35 (2008) 393–402.
[4] W.H.T. Ting, I.A.W. Tan, S.F. Salleh, N.A. Wahab, J. Water Process Eng. 22 (2018) 239–249.
[5]A. Wellinger, J. Murphy, D. Baxter, The Biogas Handbook: Science, Production and Applications, 1st ed., Woodhead Publishing, 2013
[6] Angelidaki, I., Sanders, W., 2004. Assessment of the anaerobic biodegradability of macropollutants 117–129.
[7] Agblevor, F., Pereira, J., 2013. Progress in the summative analysis of biomass feedstocks for biofuel production, in: Wyman, C. (Ed.), Aqueous Pretreatment of Plant Biomass for Biological and Chemical Conversion to Fuels and Chemicals. pp. 335–354.
[8] Holliger, C., Alves, M., Andrade, D., Angelidaki, I., Astals, S., Baier, U., Bougrier, C., Buffière, P., et al , 2016. Towards a standardization of biomethane potential tests. Water Sci. Technol. 74, 2515–2522. https://doi.org/10.2166/wst.2016.336

yessica.castro@aggiemail.usu.edu · foster.agblevor@usu.edu