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

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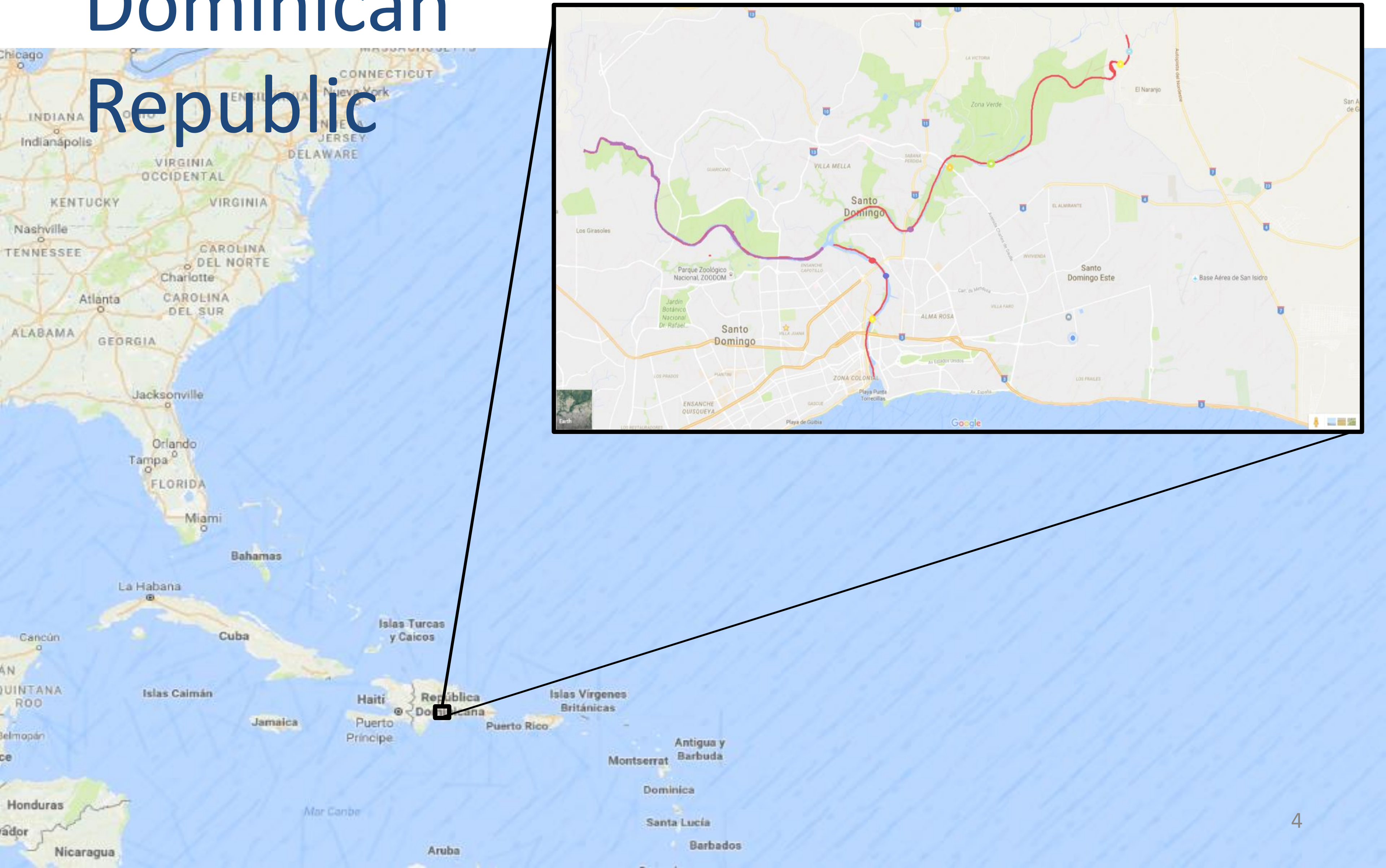
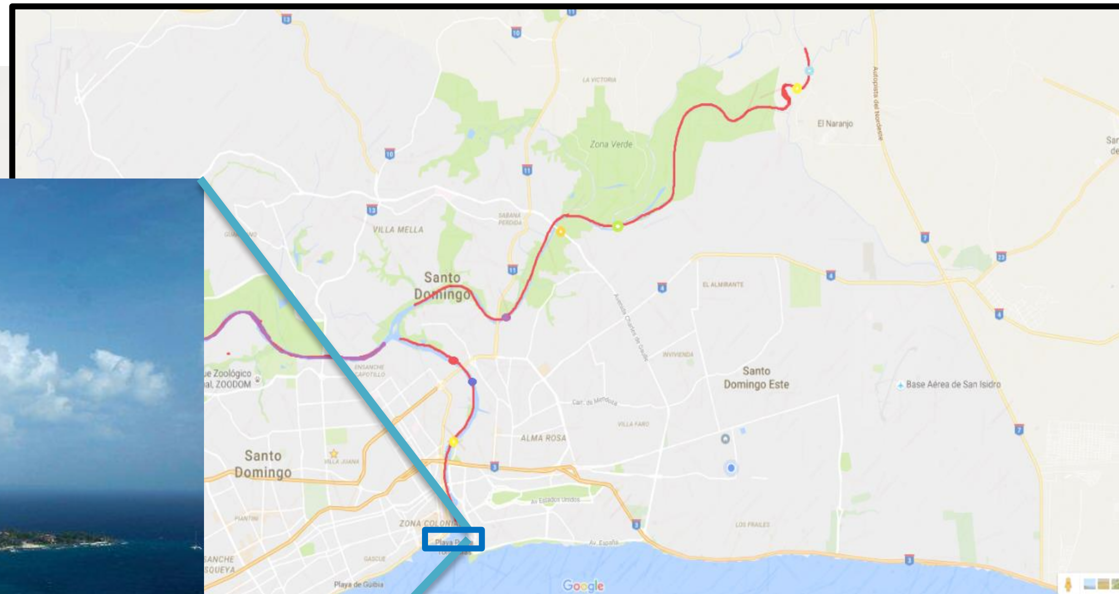
I. BACKGROUND

Dominican Republic



Santo Domingo



Ozama river

148 km long

Caribbean sea (mouth)

Ozama River Eutrophication

Salinity: 3-10 PSU

Turbidity : up to 30 NTU

Phosphorus: > 0.1 mg/L

Chlorophyll-a: ~30 µg/L, up to 75 µg/L

Dissolved oxygen: ~6 mg/L, down to 0.29 mg/L

Results from 2011, https://conference.ifas.ufl.edu/EMECS9/Presentations/Wednesday/Salon%209-10/am/0835%20E%20Mino.pdf

Ozama River Eutrophication

- Industrial waste
- Ships dismantling
- Riverbank settlements

September 2015, Vigilante informativo

Water hyacinth !!

Sustainable Weed Management

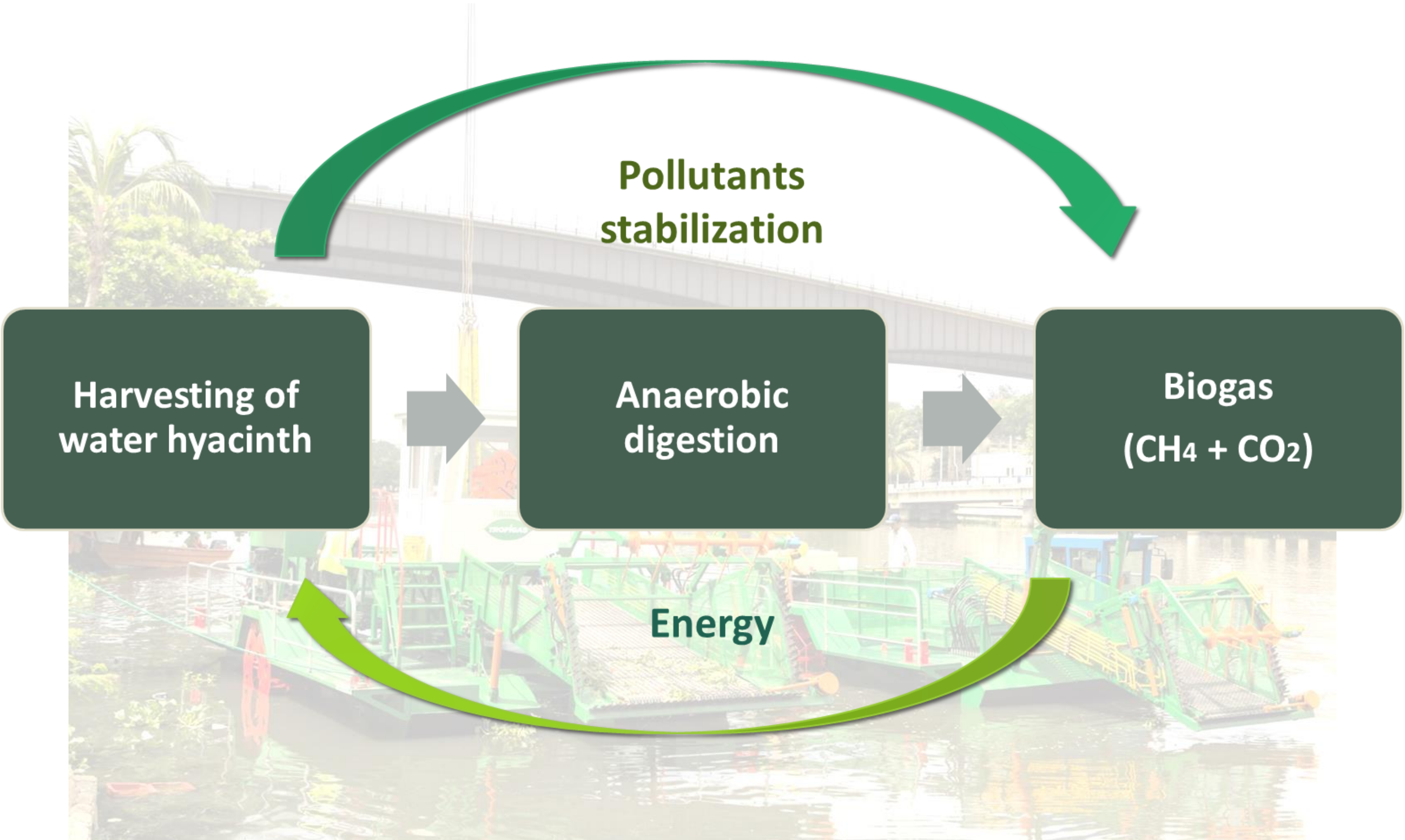
Sustainable Weed Management

USES OF WATER HYACINTH

- **Water pollution**
- **Phytoremediation properties (e.g. heavy metals)**

November 2016, El Dinero

Sustainable Weed Management



ANAEROBIC DIGESTION

HYDROLYSIS

e.g. *Clostridia, Bacteroidetes,*

ACIDOGENESIS

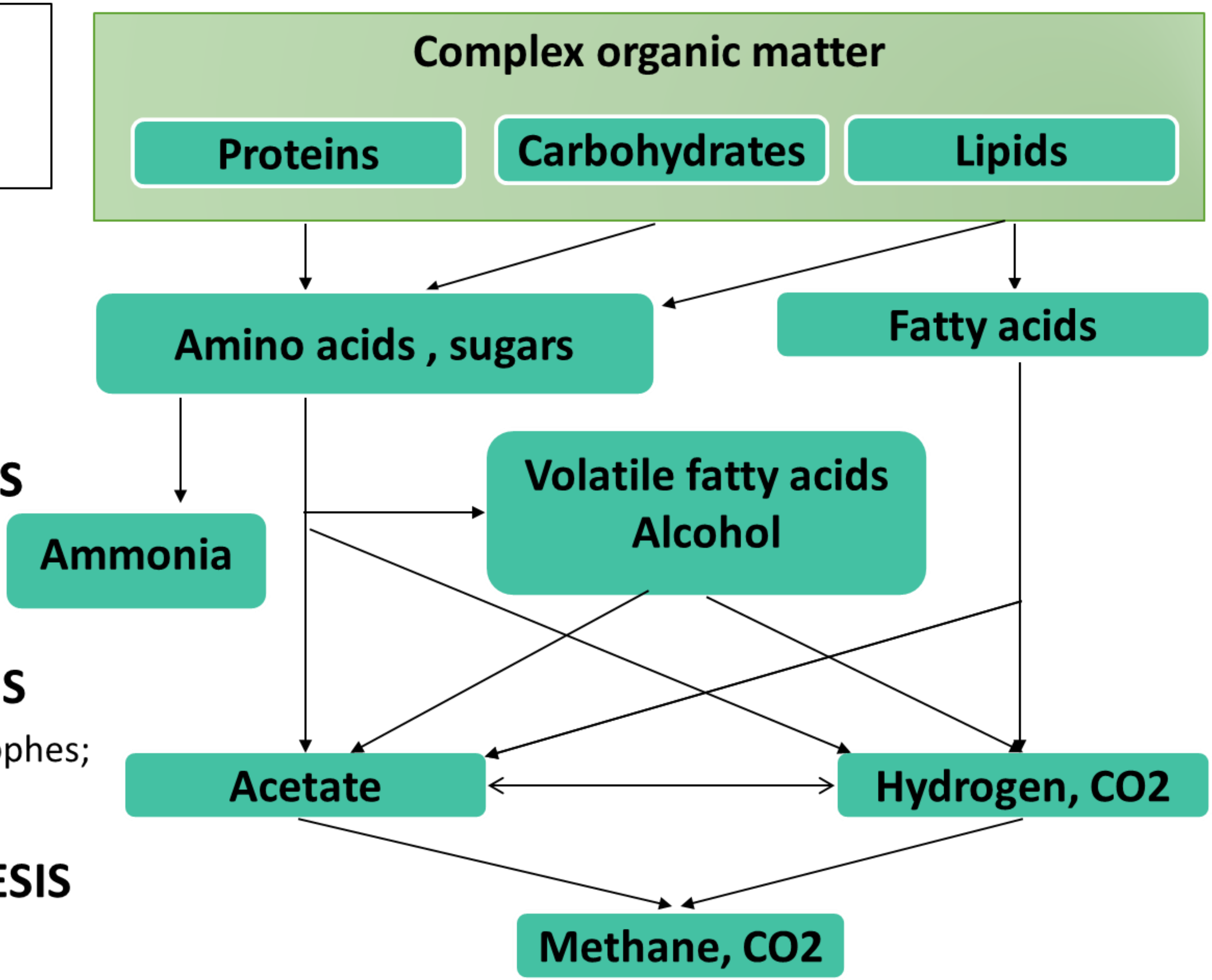
e.g. *Clostridia, Thermoanaerobia,*

ACETOGENESIS

Homoacetogens; Syntrophes; and Sulphoreductors.

METHANOGENESIS

Archaea



Modified from Giraldo-Gómez, 1991. and Vigeli et al, 2014

Project Grant

Use of Standardized Mix Inoculum in the Anaerobic Digestion of the Invasive Water Hyacinth from Ozama river for Biogas and Fertilizer Production.

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II. Biomethanation of Water Hyacinth from Fresh and Brackish Waters as a Post Weed Management Practice

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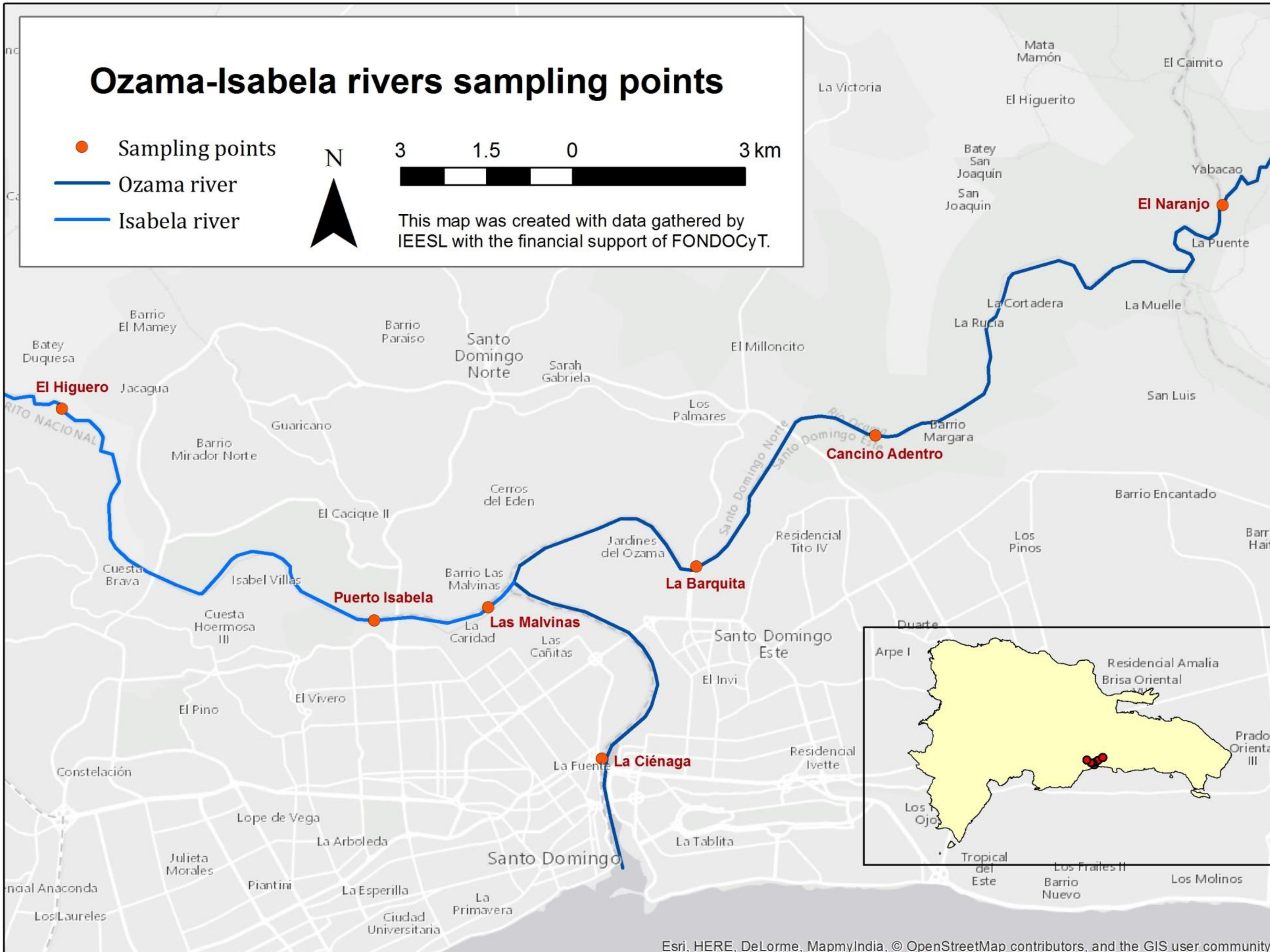
Castro, Y.A., Agblevor, F.A. Biomethanation of invasive water hyacinth from eutrophic waters as a post weed management practice in the Dominican Republic: a developing country. ***Environ Sci Pollut Res*** **(2020)**. https://doi.org/10.1007/s11356-020-07927-w


Ozama-Isabela rivers sampling points
Sampling points
Ozama river
Isabela river
N
3 1.5 0 3 km
This map was created with data gathered by IEESL with the financial support of FONDOCyT.
El Higuero
Puerto Isabela
Las Malvinas
La Barquita
Cancino Adentro
El Naranjo
La Ciénaga
Santo Domingo Norte
Santo Domingo Este
Santo Domingo
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Sampling points

La Ciénaga (brackish water)

- 1.5 km North of Caribbean Sea
- TDS ~ 1000 – 35,000 ppm
- High populated area
- Settlements on the riverbank
- Anthropogenic contamination (i.e. solid waste, raw sewage, industrial discharges, ..)

El Naranjo (freshwater)

- 23.14 km North of Caribbean sea
- Salinity barrier between Caribbean sea and the site
- TDS below 1000 ppm
- Low populated rural area

Objectives

- To determine the characteristics and biomethanation kinetics of water hyacinth from brackish and fresh waters within Ozama river.
- To compare the energy required for harvesting with the energy produced during anaerobic digestion of this weed.

Water quality

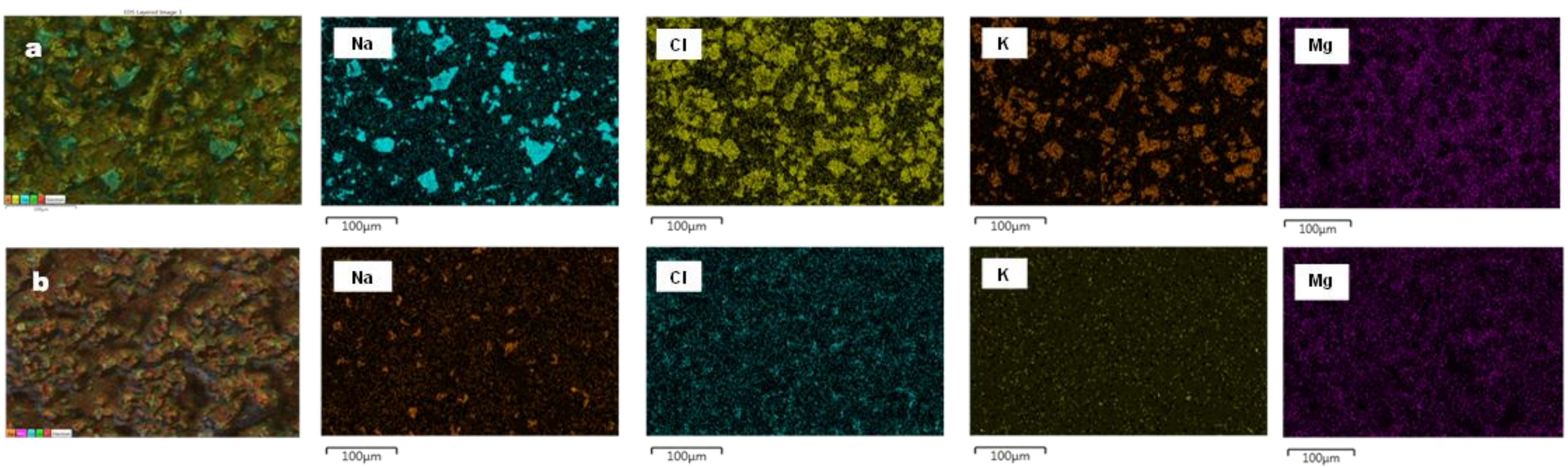
<u>Method</u>: Water quality indicators were measured in situ during harvesting using a YSI DSSPro (YSI Incorporated).

	La Ciénaga (brackish water)	**El Naranjo (freshwater)**
Salinity [ppT]	1.23	0.09
Dissolved oxygen [mg/L]	1.37	2.50
Nitrate [mg/L]	11.76	2.6
Total dissolved solids [mg/L]	1550	122

Salt Accumulation

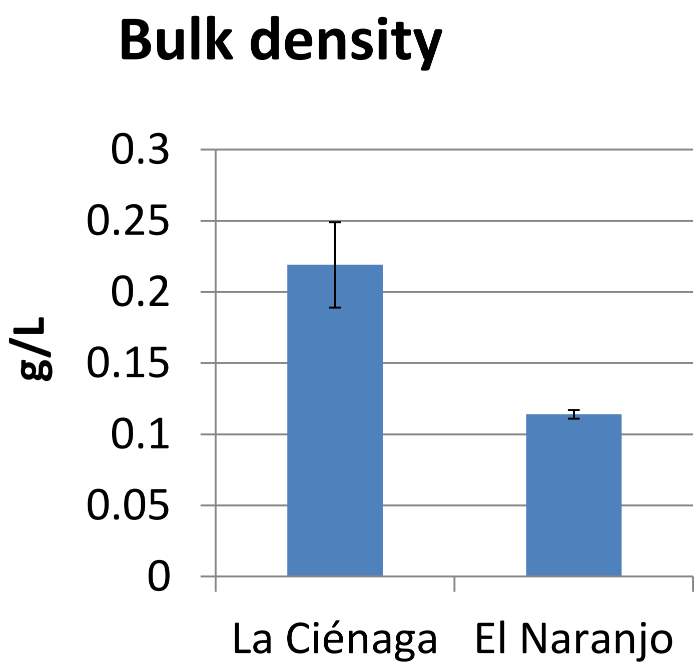
Method: Ethanol extractives of water hyacinth from **a) La Ciénaga** and **b) El Naranjo** were analyzed with SEM-EDX (FEI Quanta FEG 650).

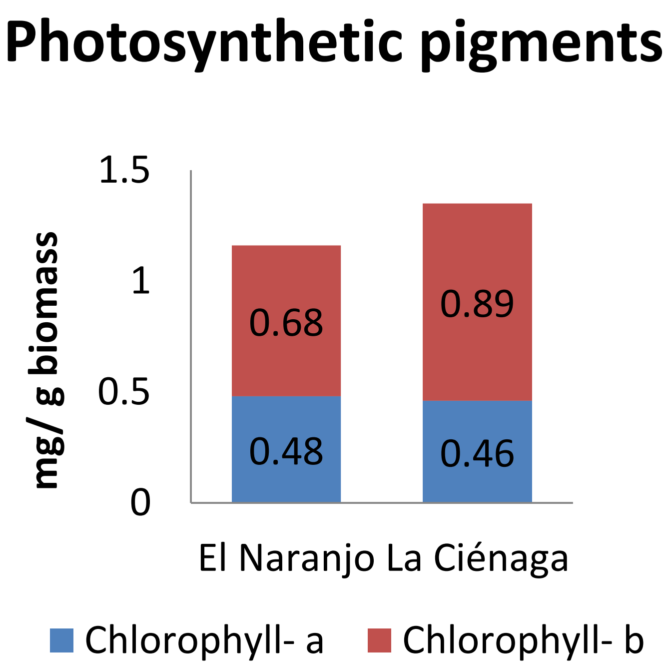
	Map Sum Spectrum (%wt)			
	Cl	K	Na	Mg
La Ciénaga	18.6	9.7	4.1	1.4
El Naranjo	6.6	1.7	1.1	0.7



Stress factors and productivity

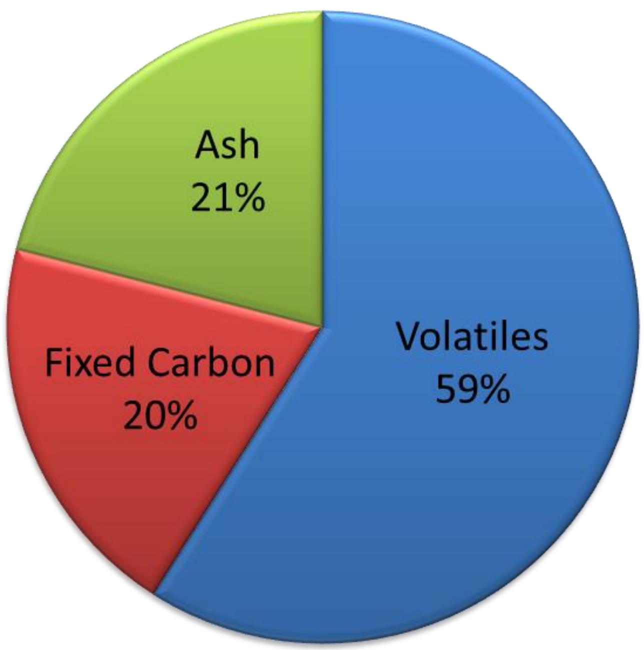
Total dissolved solids (TDS) are organic solutes and salt ions that could act as stress agents for water hyacinth and be detrimental for anaerobic digestion when they accumulate in the plant biomass [1-6].

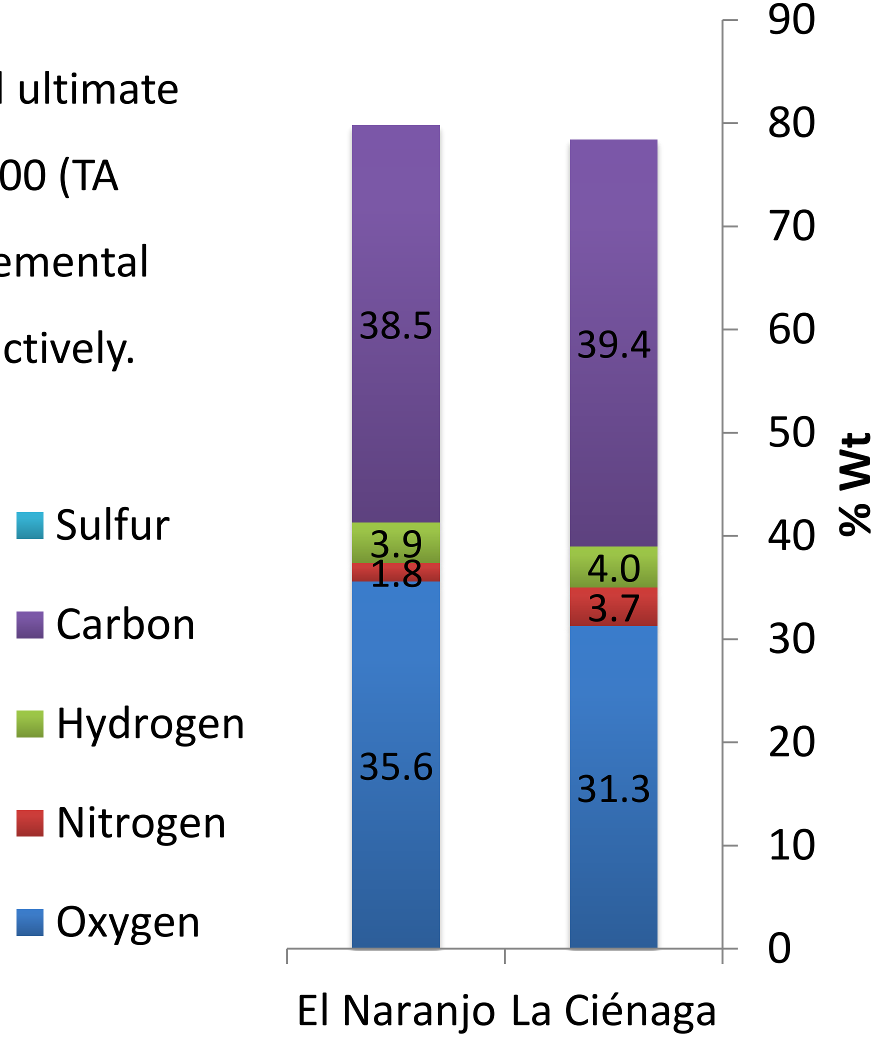




Proximate and Ultimate Analyses

<u>Method</u>: Water hyacinth's proximate and ultimate analyses were conducted using a TGA-Q500 (TA Instruments,) and FLASH 2000 Organic Elemental Analyzer (Thermo Fisher Scientific), respectively.

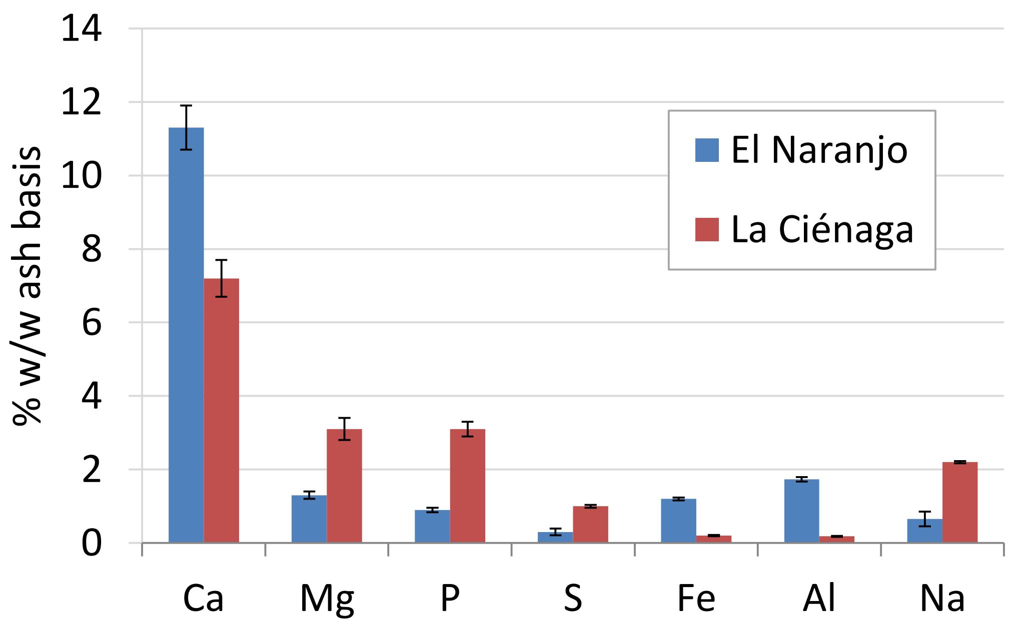


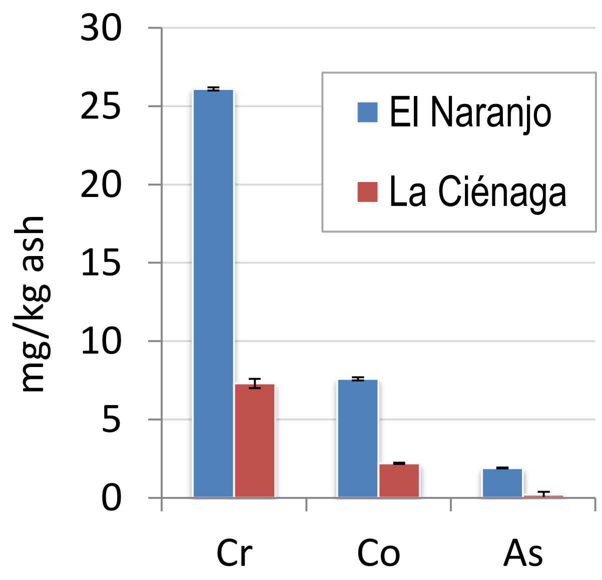


Inorganic Elemental Analysis

Method: The ash of water hyacinth was digested according to EPA 3050 and analyzed using ICP-AES by Utah State University Analytical lab (USUAL)

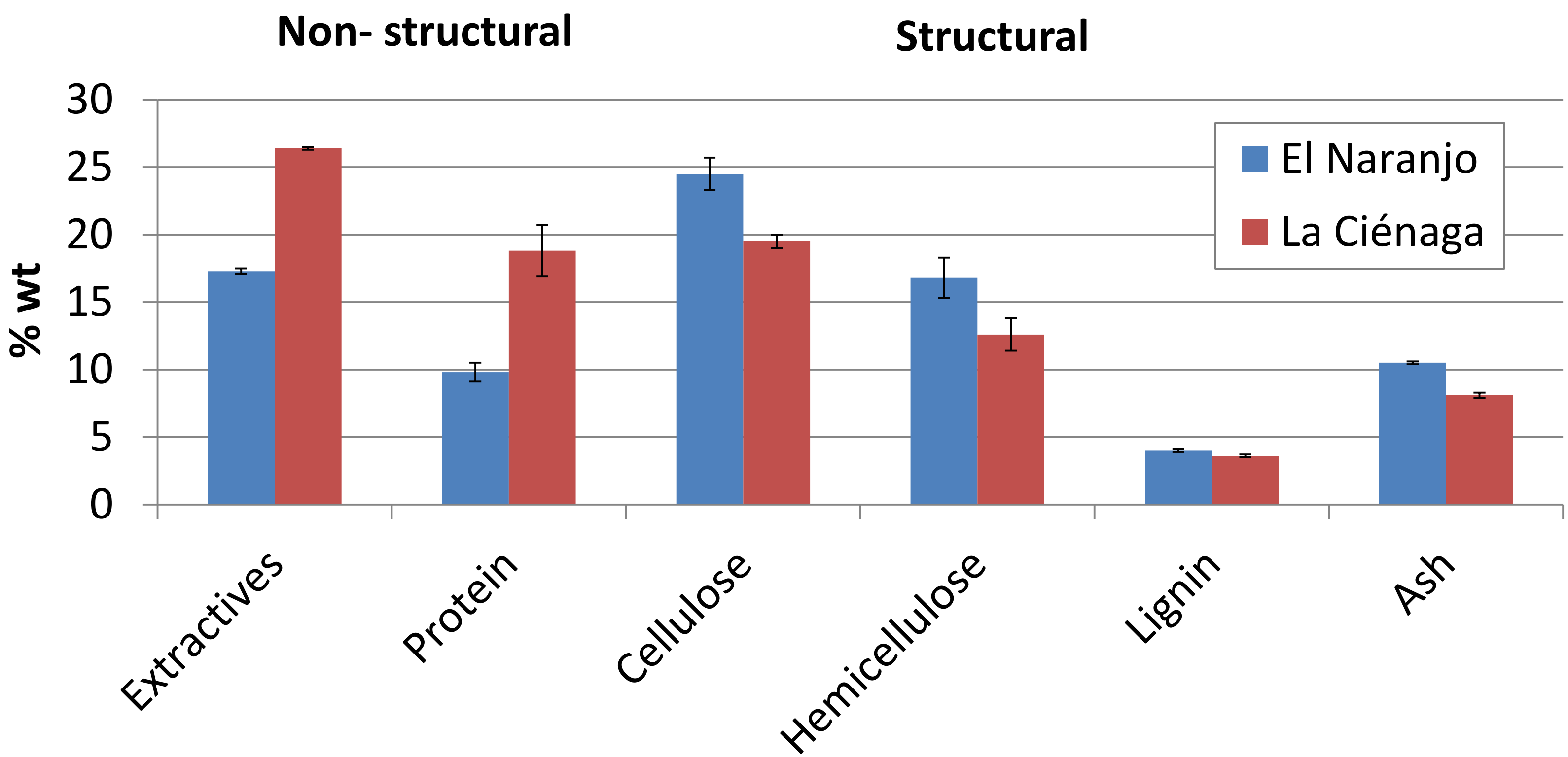
Nutrients (% w/w)			Heavy metals (mg/kg)				
K	Mn	Si	Cu	Ni	Mo	Zn	Cd
19.9 ± 2.6	0.25 ± 0.06	1.04 ± 0.3	47.6 ± 8.4	30.9 ± 15.5	4.2 ± 2.4	128.4 ± 21.1	0.22 ± 0.6





Summative Analysis

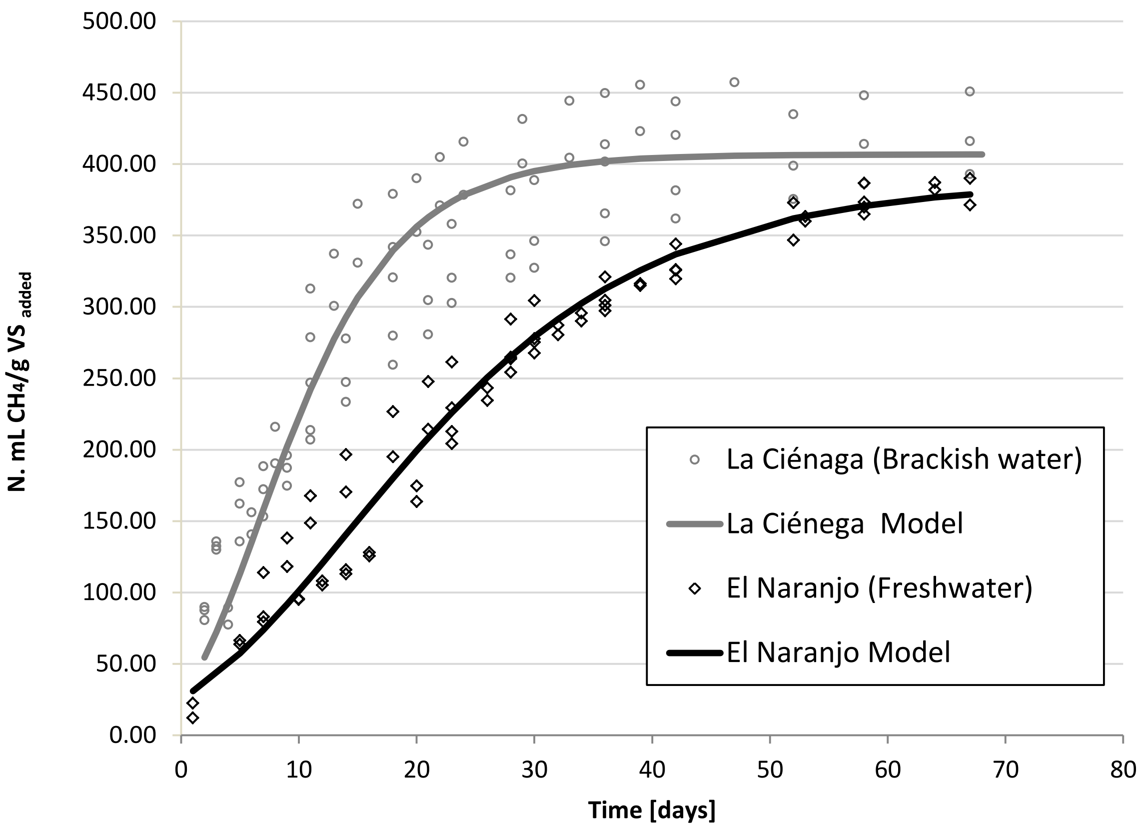
Water hyacinth's composition was determined following ASTM guidelines (E1756-08, E1690-08 , E1755-01, E1758-01 and E1721).



Biomethanation Kinetics

Modified Gompertz Model

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



A [N. L CH_4/Kg VS]
Kz [N. L CH_4/Kg VS $_{added}$ · day]
T_{lag} [day]
T_d [day]
RMSE [N. L CH_4/Kg VS $_{added}$]

	Ciénega (Brackish)	Naranjo (Fresh)
A	408.5	389.8
K_z	**22.5**	10.0
T_{lag}	0	0.0
T_d	**9.1**	19.5
RMSE	4.6	4.03
R^2	0.886	0.901

Energy Assessment

Energy consumed

$$E_c = (FC/HR) * HHV_{fuel}$$

Energy Produced

$$E_p = BMP * (1000kg/t) * (VS/100) * (TS/100) * HHV_{CH_4}$$

	Parameters	Value	Energy (MJ/t biomass)
Consumption	FC [L/h]	15	E_c = 57.9
	HR [$t_{biomass}$/h]	10	
	HHV $_{Diesel}$ [MJ/L]	38.6	
Production	BMP $_{Mean}$ [L CH_4/kg VS]	399.2	E_p = 846.5
	HHV $_{Methane}$ [MJ/L]	0.0398	
	VS $_{Mean}$ [%]	59.2	

Conclusions

- The **brackish water** (La Ciénaga) had 3 times higher nitrates and phosphorus than freshwater (El Naranjo).
- The higher salt content in the biomass from La Ciénaga did **not affect the plant productivity** (photosynthetic activity , and density).
- The non-structural compounds (extractives and protein) are higher in the biomass from **La Ciénaga**.
- The **methane yield and production rate are higher**, and the doubling time shorter in the biomethanation of the biomass from La Ciénaga.
- The **energy** from the biodigestion of the Ozama river water hyacinth is more than 10 times that required for harvesting.

Cited Works

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