Faecal Sludge Treatment and Utilization by Hydrothermal Carbonization Process

BILL & MELINDA GATES foundation

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INTRODUCTION

FS Storage & Collection

FS Transportation

Reuse

Treatment

INTRODUCTION

Hydrothermal Carbonization (HTC) **Can be Defined as Carbonization of Biomass in Water to Raise Its Carbon Content, HTC Product is Called "Hydrochar"**

Process Condition

- Operation Limited in Subcritical Condition of Water (180-250 °C at About 20-60 bar)
- Reaction Time Varied Between 1 to 12 h.
- Feedstock is Surrounded by Water During the Reactions
- Requiring Closed System Under Saturation Pressures.

INTRODUCTION

➢ Advantages of HTC for Faecal Sludge Treatment:

- ❑ Not Require Feedstock Drying
- ❑ Convert High Load of Organic Matter into Hydrochar
- ❑ Temperature Employed Result in the Destruction of Pathogen
- ❑ Hydrochar is a Valuable Product

INTRODUCTION

Applications of Hydrochar

- **Solid Fuel**
- **Soil Amendment**
- **Absorbent for Water Purification** : *Heavy Metal and Micropullutant Removals*
- **Energy Storage** : Li-ion Battery, Carbon Fuel Cells
- **Catalyst** : *Supported Catalyst for Selective Hydrogenation*
- **CO_2 Sequestration**

OBJECTIVES

To Identify HTC Products Characteristics

To Investigate Potentials of HTC products Utilization

METHODOLOGY

HTC Experiments

Feedstock:

- Faecal Sludge (FS) of 20% Solid Content

HTC Process Conditions:

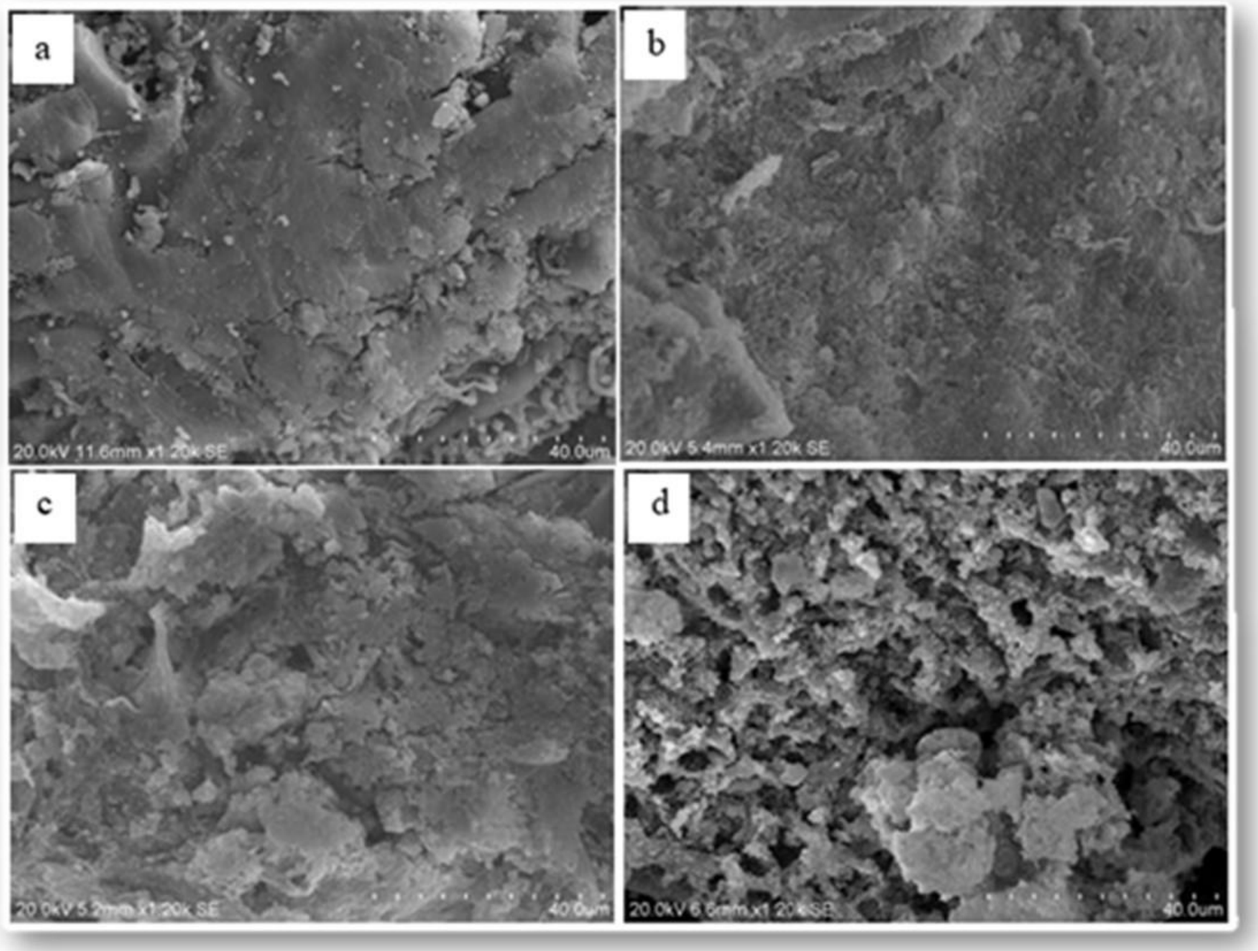
- Temperature of 180-250 °C
- Reaction Time of 5 h
- Heating Rate of 6 °C/min
- Cooling Rate of 45 °C/min

HTC Products:

- Hydrochar
- Liquid, Filtrate, Process Water
- Gases

RESULTS & DISCUSSION

Hydrochar Characteristics



SEM Images

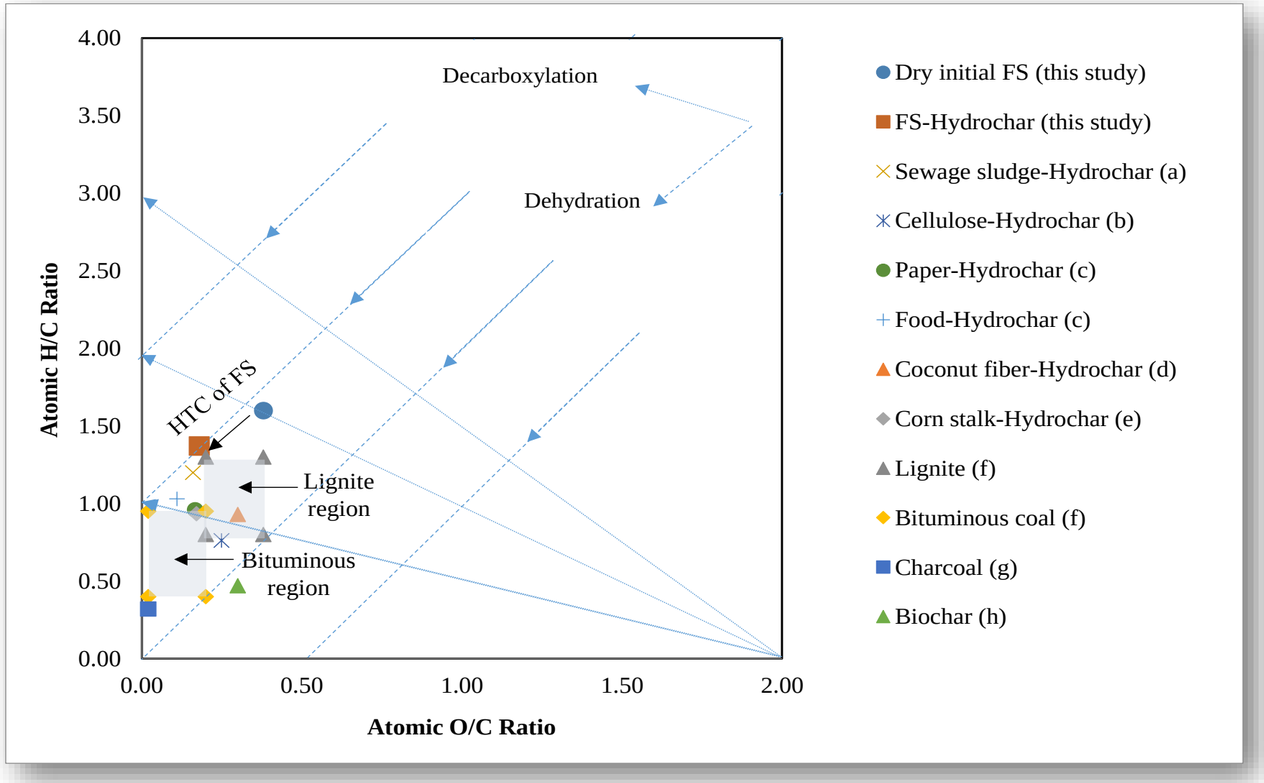
(a) Dried FS
(b) Produced Hydrochar at 180 °C
(c) Produced Hydrochar at 220 °C
(d) Produced Hydrochar at 250 °C

RESULTS & DISCUSSION

Hydrochar Characteristics and Applications

Parameters	Unit	Dried FS	Hydrochar
Energy Content	MJ/kg	13.5-14.1	19.3-19.9
Hydrochar Yield	%	-	70-73
Atomic Ratio			
H:C		1.60-1.70	1.28-1.37
O:C		0.38-0.40	~ 0.18

- Energy Content and Atomic Ratios of H/C and O/C of the Hydrochar Were Comparable to Natural Coals
- Hydrochar Could be Use as a ***Solid Fuel*** in a Typical Combustion Process



Van Krevelen Diagram

RESULTS & DISCUSSION

Hydrochar Characteristics and Applications

Parameters	Unit	Dried FS	Hydrochar
Ultimate Analysis			
Carbon	%wt	37.8-38.1	38.8-39.7
Hydrogen	%wt	5.0-5.5	4.1-4.5
Nitrogen	%wt	3.0-3.5	1.9-2.0
Sulfur	%wt	1.4-1.6	1.2-1.3
Oxygen	%wt	19.40-19.52	9.13-9.56

- Further Processes to Make It Suitable for Use as an Anode

Anode in Li-ion Battery

RESULTS & DISCUSSION

Hydrochar Characteristics and Applications

Parameters	Unit	Dried FS	Hydrochar
Bulk Density	g/cm^3	~ 0.33	~ 0.37
BET Surface Area	m^2/g	~ 1.07	4.4-5.6
Total Pore Volume	cm^3/g	~ 0.010	0.035-0.049
Mean Pore Diameter	nm	38.6-38.7	1.72-1.84

- The Mean Pore Diameter Was Found in the Range of the Mesopores
- Hydrochar can be used as an ***adsorbent*** for Adsorption of Sugar, Heavy Metals and Micro-pollutants

RESULTS & DISCUSSION

HTC Liquid Characteristics

Parameters	Unit	FS [a]	HTC Liquid Product
TOC	g/L	16-40	12-16
COD	g/L	43-50	25-31
BOD_5	g/L	3-4	11-14
TN	g/L	5-8	7-8
TP	mg/L	10-15	5-10
pH		6.8-7.2	5.8-6.2
Phenol	mg/L	Not detected	260
VFA	g/L	1.0-1.1	5.2-5.4

[a] FS at solid content of 20%wt

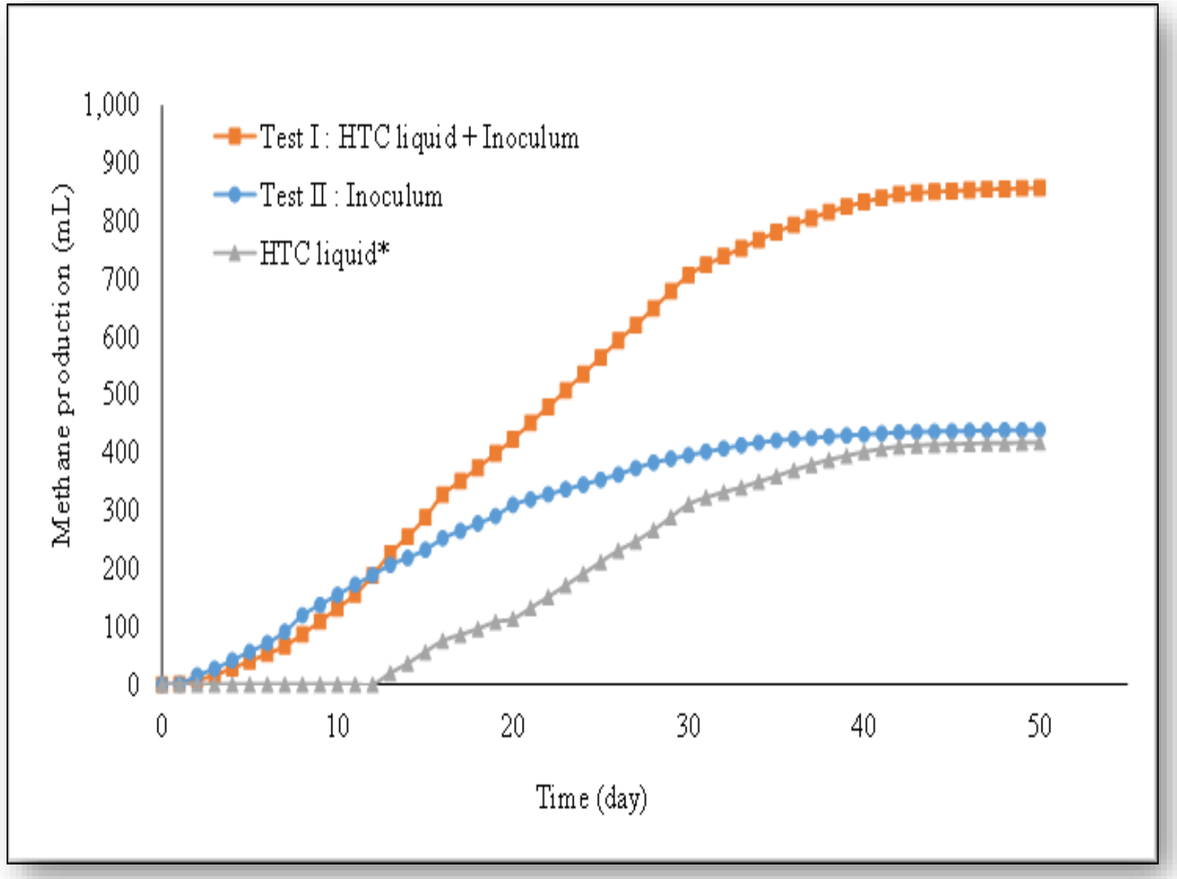
- Liquid Products Still Contained High Concentrations of TOC, COD, BOD_5, TN and TP.
- pH Was Decreased Due to the VFA Generation From Decomposition of the Hydrolyzed Products During HTC Process

RESULTS & DISCUSSION

HTC Liquid Applications and Treatment Options

- **Anaerobic Digestion and Biogas Production**

- Bio-Methane Potential (BMP) Test
- Methane Production Was About 2.8 L-CH_4 per kg-HTC Liquid or 2.0 L-CH_4 per kg FS
- The produced biogas could be used as a ***fuel gas***



RESULTS & DISCUSSION

HTC Liquid Applications and Treatment Options

- **Recirculation in HTC Process**

- Increasing Hydrochar Yield
- Increasing Energy Content of the hydrochar
- Reducing Wastewater Treatment Costs

- **Liquid Fertilizer**

- NH_4-N of 2000 mg/L
- P_2O_5 of 10 mg/L
- K_2O of 100 mg/L
- HTC Liquid Products Could be Further Processed to Make It Suitable to Use as a Liquid Fertilizer in Farmlands.

RESULTS & DISCUSSION

HTC Gas Composition and Treatment Options

- Gases produced from the HTC process were about 10 L-gas/kg-FS

Gas Composition

CO_2	61.9 %V
CH_4	0.7 %V
O_2	1.7 %V
N_2	21.5 %V
H_2S	2.0 %V
CO	1.6 %V
VOCs	3.1 %V
Other	7.5 %V

Treatment Options

- Activated Carbon Adsorption
- Absorption With a Wet Scrubber

CONCLUSIONS

- Energy Contents of the Hydrochar Were Found to be About 19-20 MJ/kg, Comparable to Natural Coals
- The HTC Liquid Products Obtained from the HTC Process Contained High Concentrations of Organic Matter, with the BMP Test Suggested the Potential of Methane Production
- The Results Indicated the Technical Feasibility of the HTC Process for Treating Wastes Producing Hydrochar for Using as Solid Fuels and Other Value-added Products, Which Minimizing Environmental Problems and Public Health Risk

NATS

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Thank you