Utilization of the Aqueous Phase from Hydrothermal Liquefaction

Catherine Brewer, Hengameh Bayat, Srimali Munasinghe-Arachchige, Isuru Abeysiriwardana-Arachchige, Nagamany Nirmalakhandan

Chemical & Materials Engineering | Civil Engineering

tcbiomass

NM STATE UNIVERSITY

APRIL 21, 2022

BE BOLD. Shape the Future.

Acknowledgements

- NMWRRI-SG-2019-112543; NMWRRI-SG-2021-112748
- USDA #2017-68005-26867
- NSF EEC #102968 and #1031346
- Mag Lab at Florida State University (NSF DMR #1644779)
- City of Las Cruces Utilities
- NMSU Collaborators: Jacqueline Jarvis, Mark Chidester, Omar Holguin, Barbara Hunter, Barry Dungan, Umakanta Jena
- NMSU Students: Feng Cheng, Mostafa Dehghanizadeh, Rodrigo Rosalez, Alan Moya, Andrea Loya Lujan, Maya Ramirez, Nick Soliz, Nico Carrera-Little

ReNUWIt

NSF

sodexo

New Mexico EPSCoR

New Mexico Water Resources Research Institute

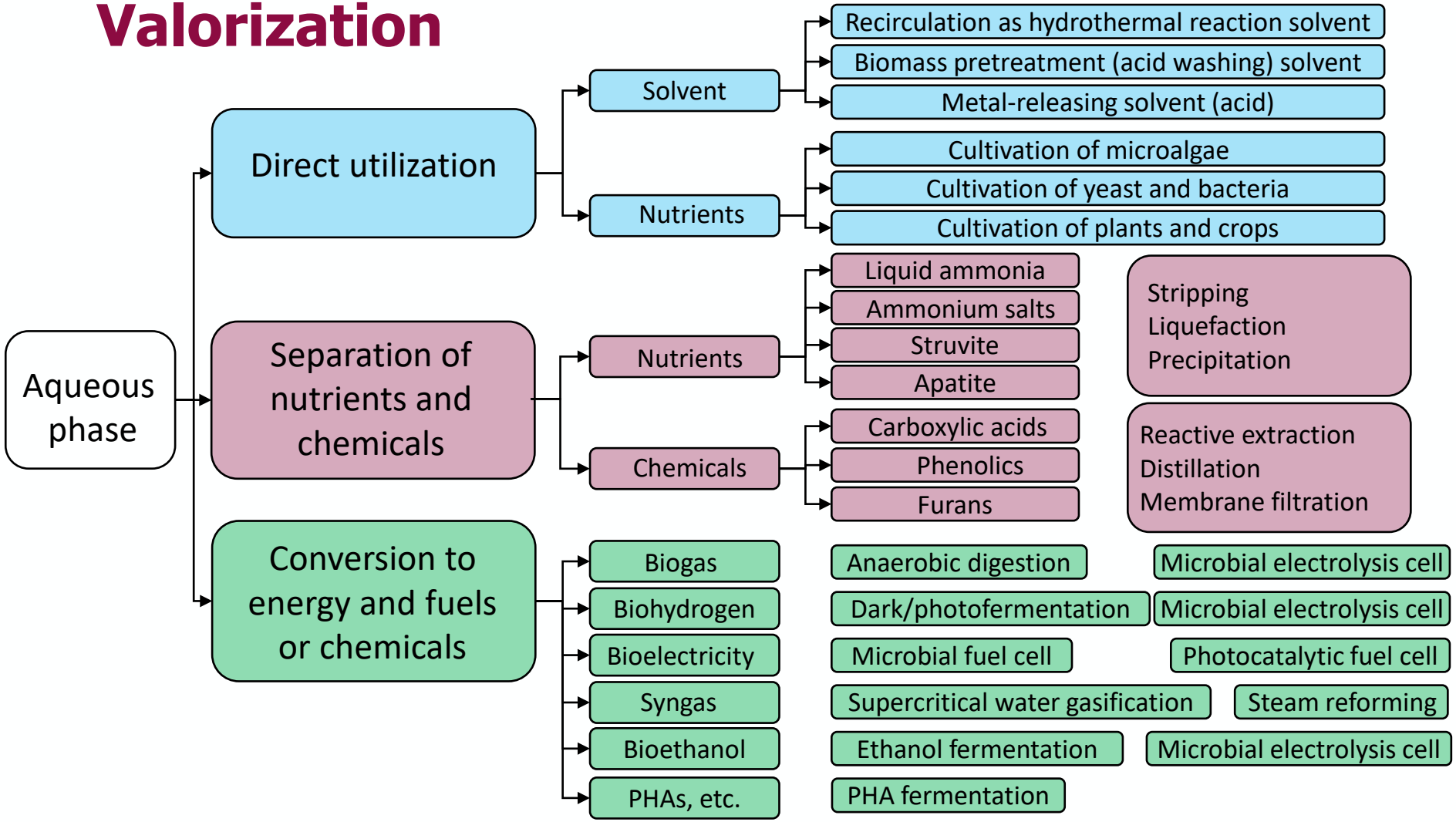
SBAR

SUSTAINABLE BIOECONOMY FOR ARID REGIONS

Outline

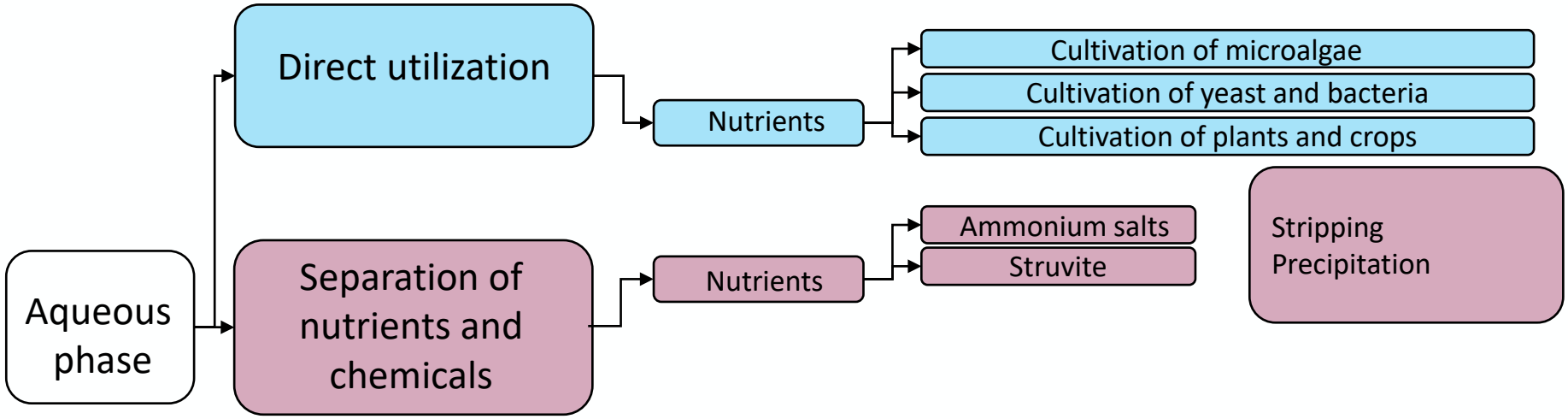
- Potential Uses for the Hydrothermal Liquefaction (HTL) Aqueous Phase
- Aqueous Phase from HTL of Wastewater Treatment Algae for Fertilizers
- Aqueous Phase from HTL of Food Waste for Compost

Aqueous Phase Valorization



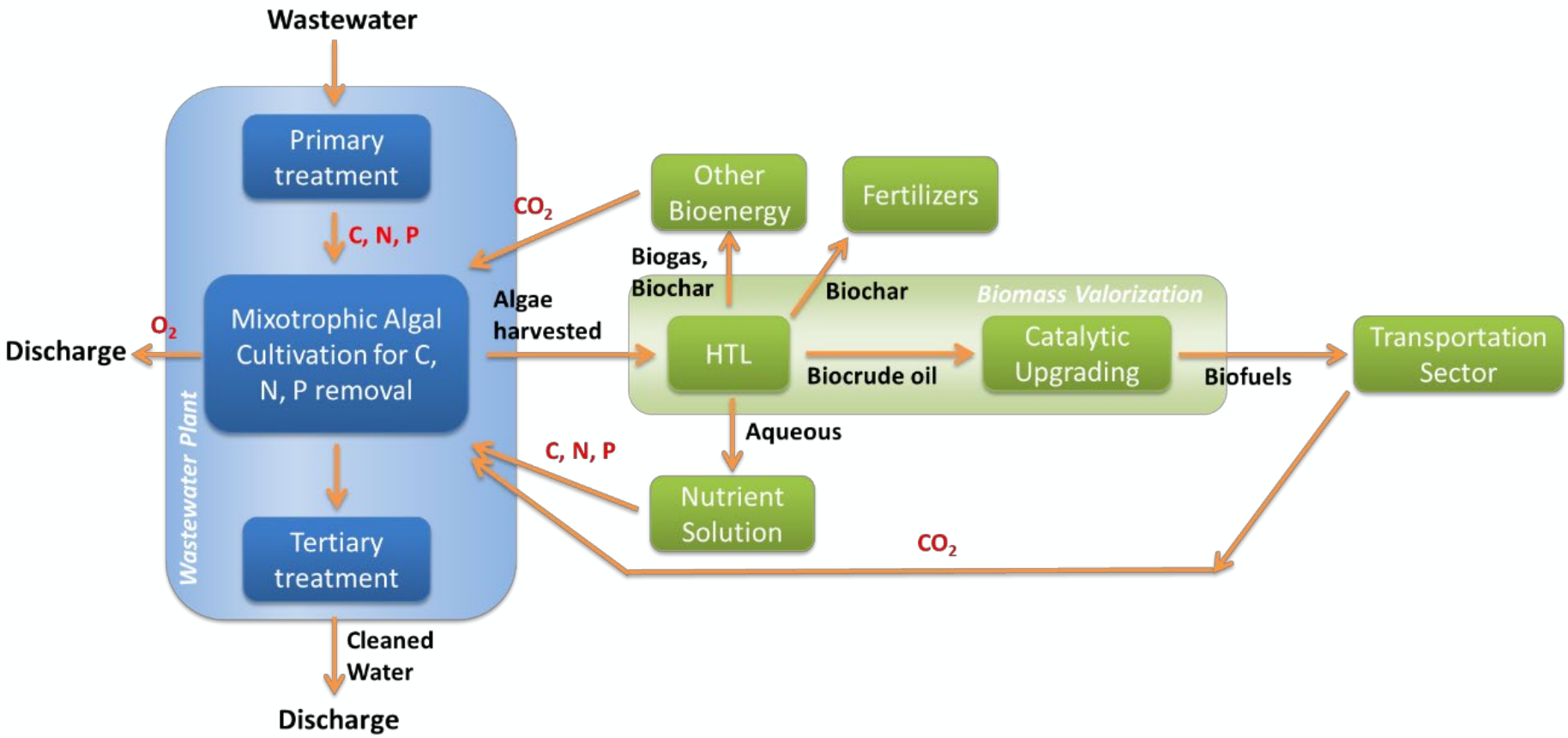
Leng, et al. 2021 *J. Cleaner Production* 294, 126238.

Aqueous Phase Valorization



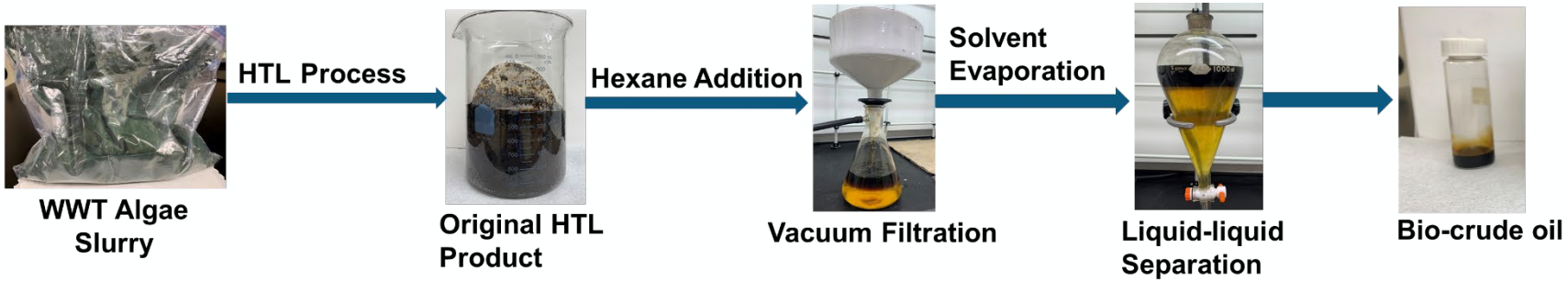
Leng, et al. 2021 *J. Cleaner Production* 294, 126238.

Algal Wastewater Treatment



Abeysiriwardana-Arachchige, et al. 2020 *Algal Research*, 52, 102087.
Cheng, et al. 2019 *Bioresource Technology*, 294, 122184.

Algal Wastewater Treatment



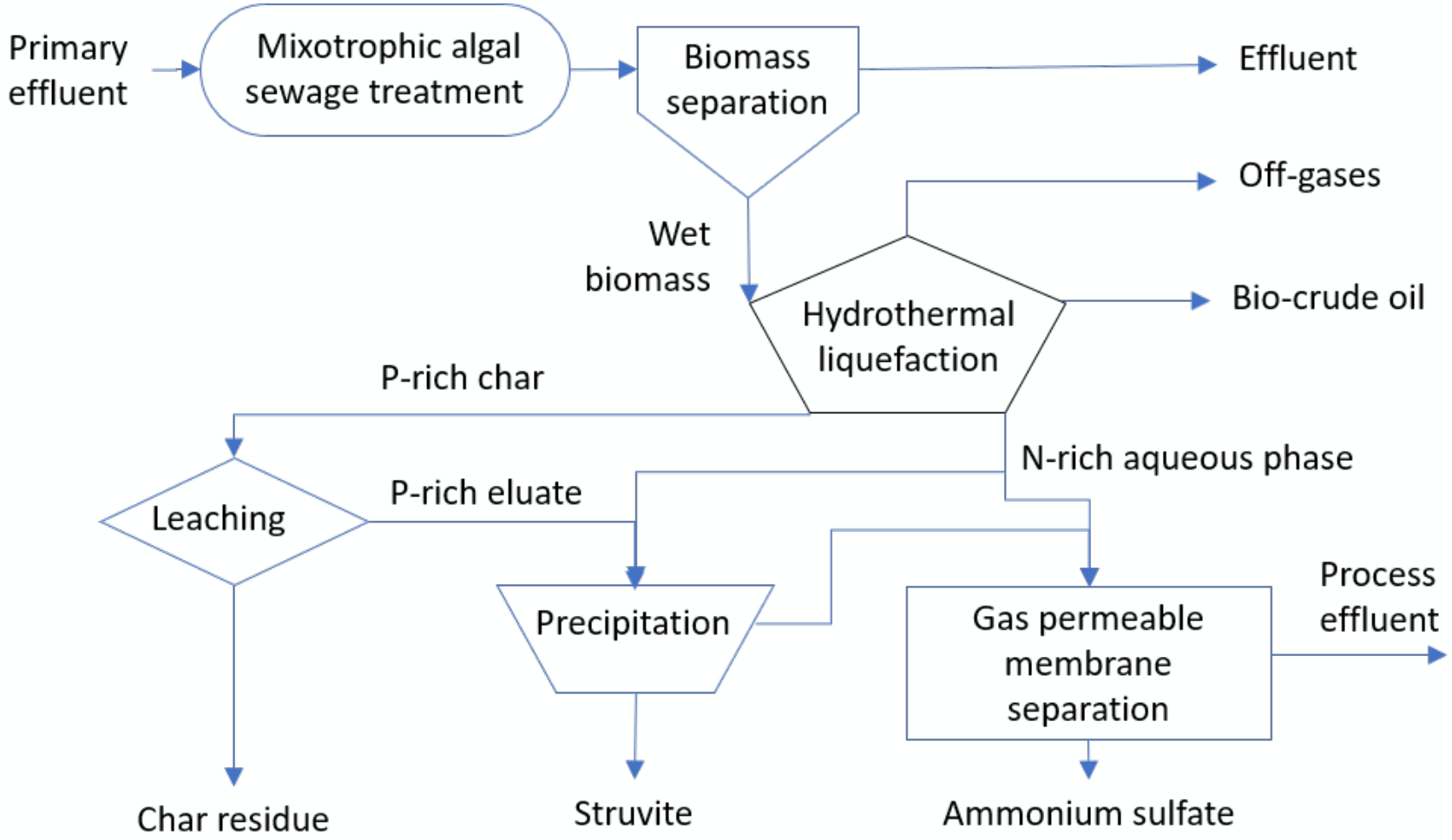
Abeysiriwardana-Arachchige, et al. 2020 *Algal Research*, 52, 102087.
Cheng, et al. 2019 *Bioresource Technology*, 294, 122184.

Aqueous Phase Patterns

- Two strains of *Galdieria sulphuraria* algae
- HTL at 310-350°C, 5-60 min, 5 or 10 wt.% solids
- Yields: 10-25 wt.% dry biomass basis
- pH 8.0-8.8
- C: 4.8-10.7 g/L (3.7-9.6 g/L organic C)
- N: 2.1-5.6 g/L (1.6-4.0 g/L ammonium-N)
- Dissolved salts, carbon, and nitrogen scaled with algal biomass solids loading
- Dilution is needed to recycle

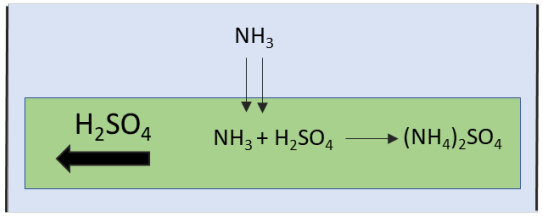
Cheng, et al. 2019 *Bioresource Technology*, 294, 122184.

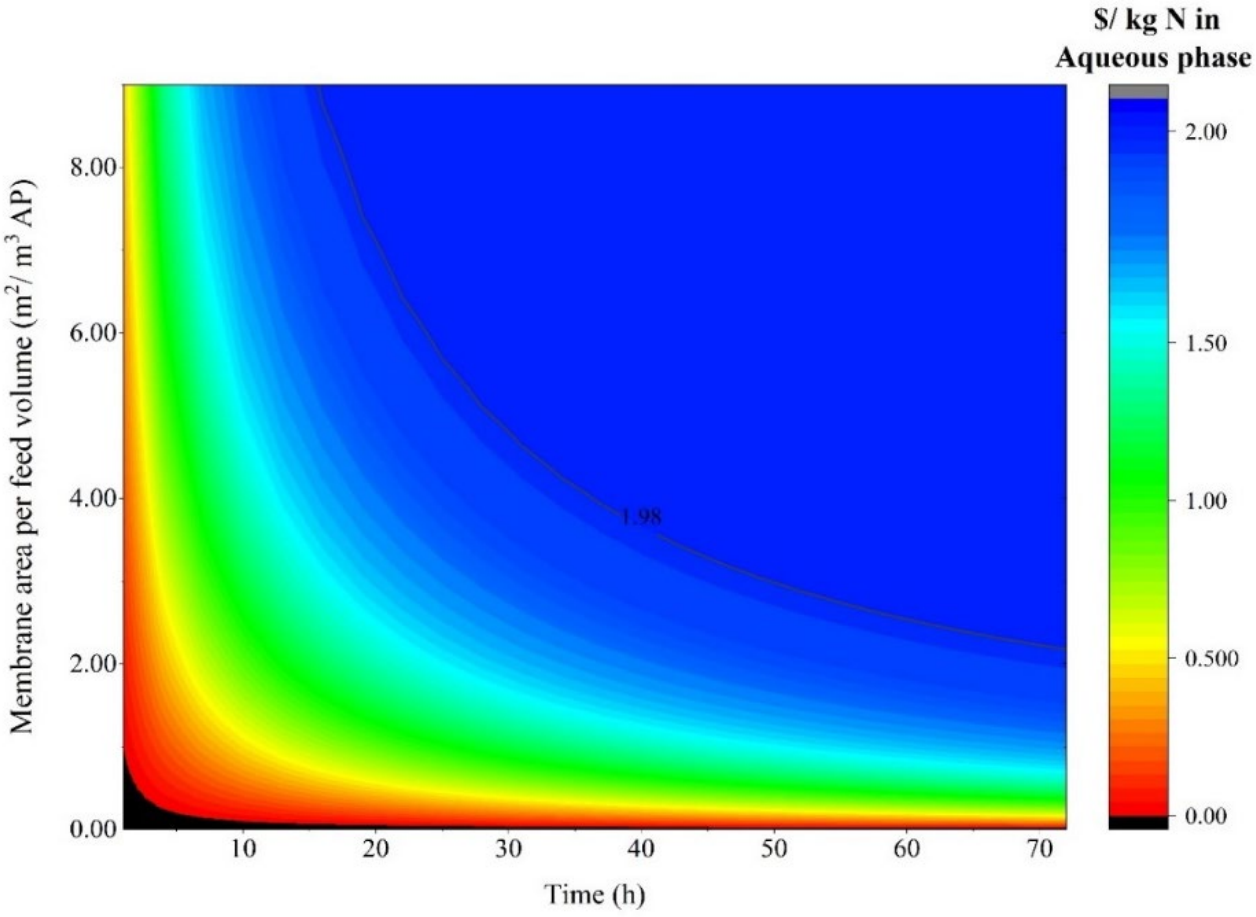
Algal Wastewater Treatment



Abysiriwardana-Arachchige, et al. 2021, *Resources, Conservation & Recycling*, 170, 105552.

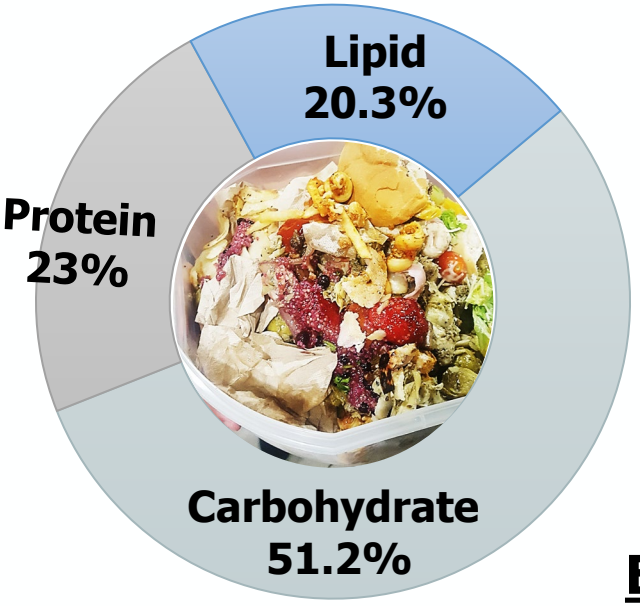
Ammonia Sulfate from Gas Permeable Membrane





Abysiriwardana-Arachchige, et al. 2022, *J. Environmental Chemical Engineering*, 10, 107139.

Food Waste Conversion



Bio-crude oil

Char

Aqueous phase

Experimental Conditions

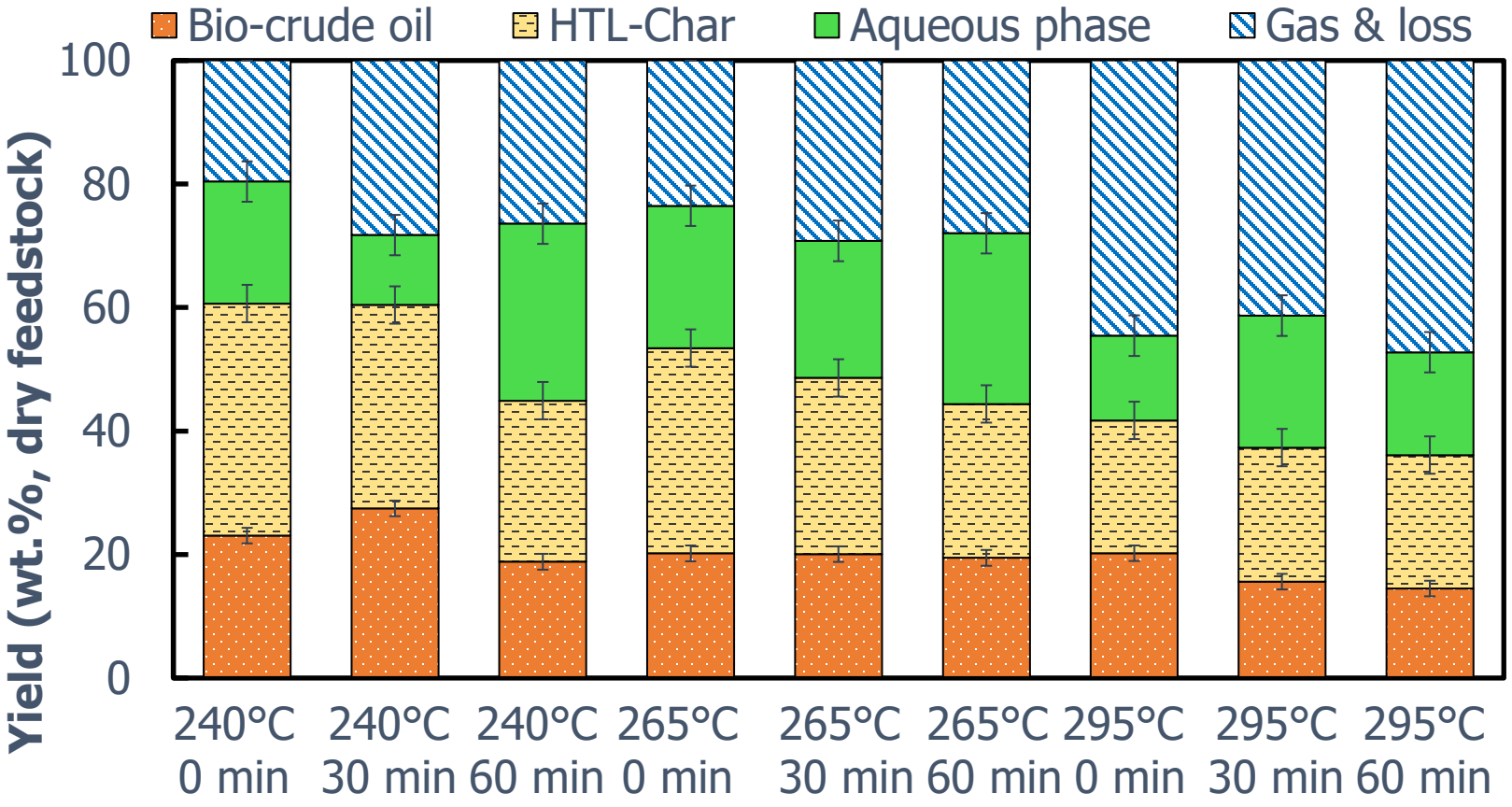
Temperature: 240, 265, 295˚C

Residence time: 0, 30, 60 min

Solids loading: 15 wt.%

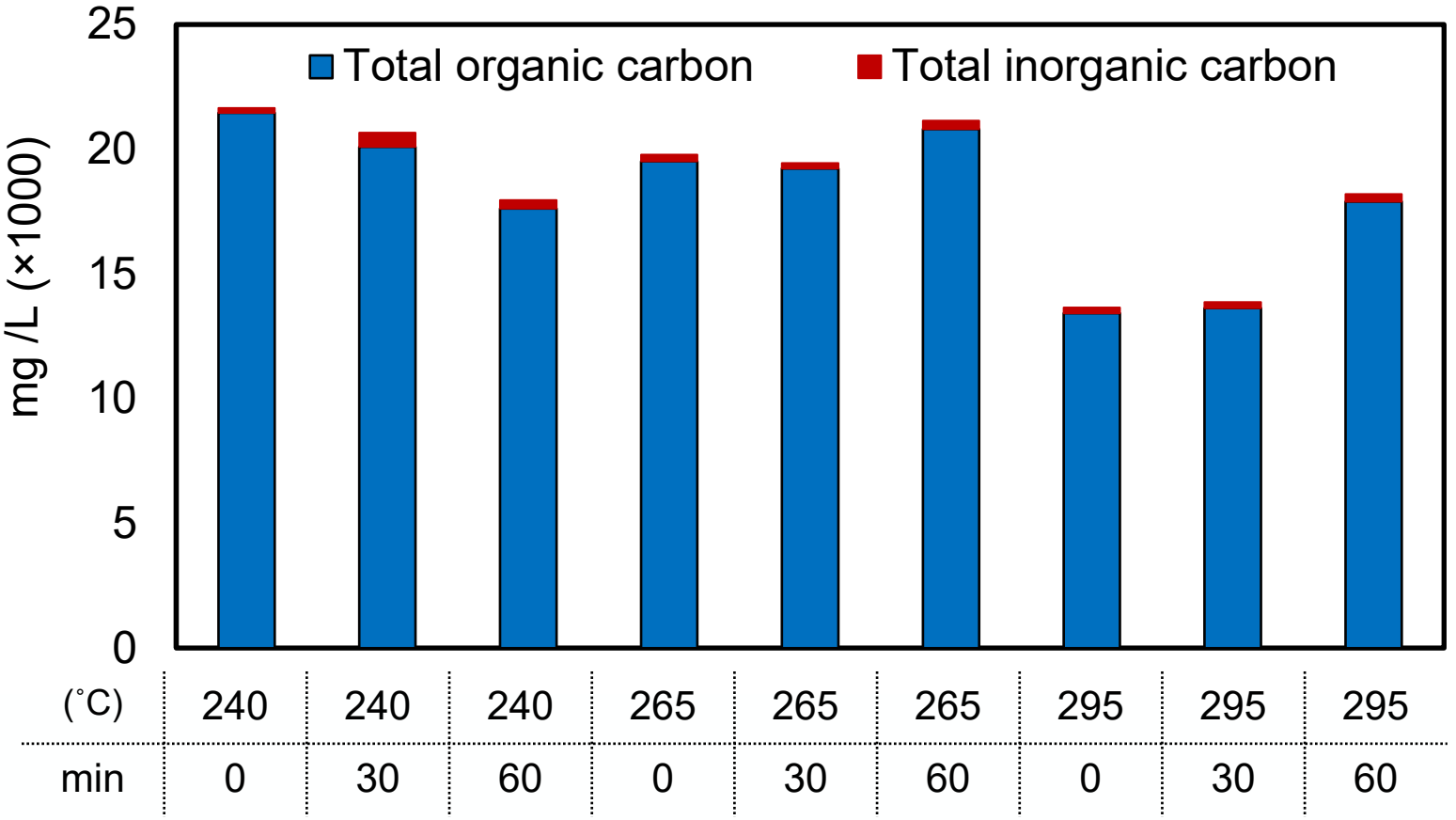
Bayat, et al. 2021 *Front. Sustain. Food Syst.* 5, 658592.

Yields from Food Waste HTL

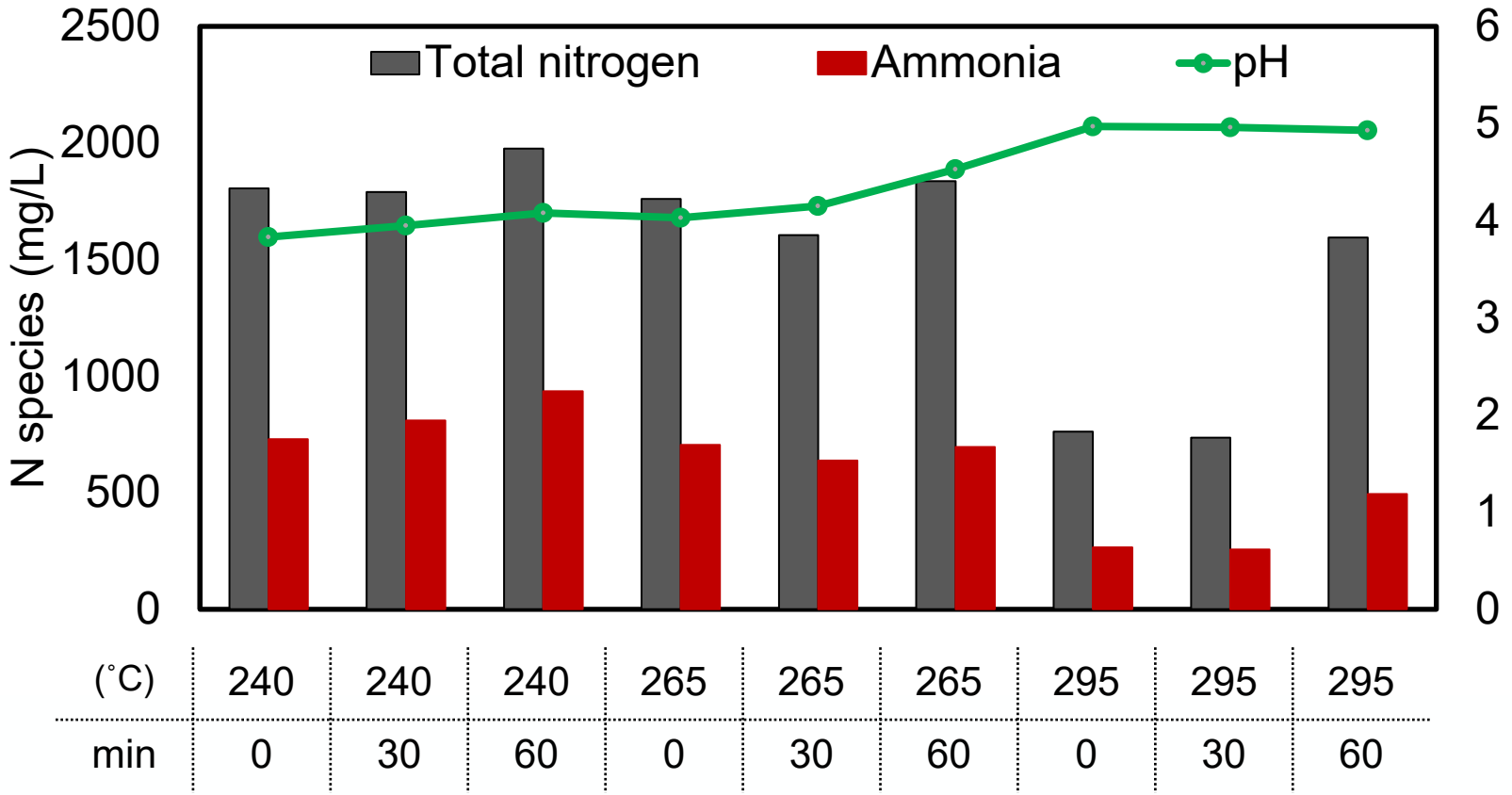


Bayat, et al. 2021 *Front. Sustain. Food Syst.* 5, 658592.

Aqueous Phase C

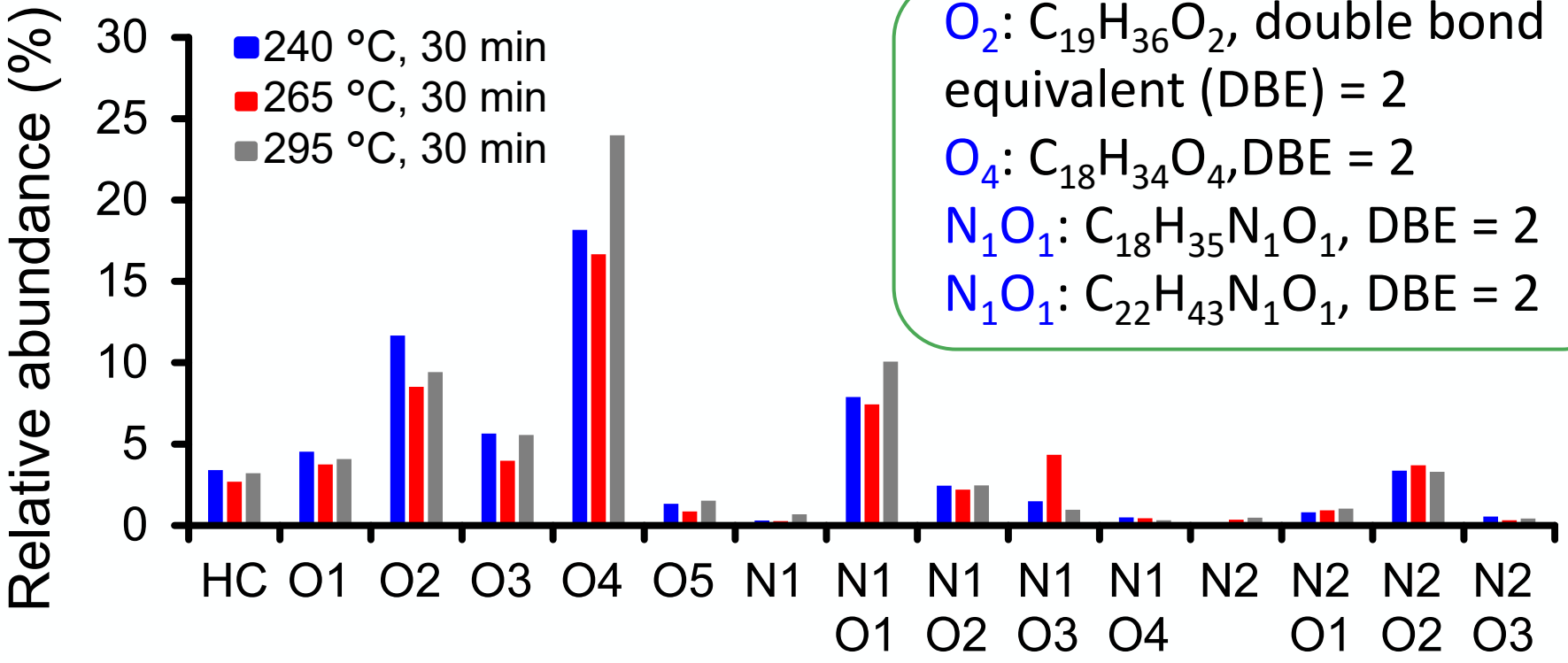


Aqueous Phase N and pH



(˚C)	240	240	240	265	265	265	295	295	295
min	0	30	60	0	30	60	0	30	60

Aqueous Phase by Fourier Transform Ion Cyclotron Resonance Mass Spectroscopy (FT-ICR-MS): Positive Atmospheric Pressure Photoionization (APPI)



O_2: $C_{19}H_{36}O_2$, double bond equivalent (DBE) = 2

O_4: $C_{18}H_{34}O_4$,DBE = 2

N_1O_1: $C_{18}H_{35}N_1O_1$, DBE = 2

N_1O_1: $C_{22}H_{43}N_1O_1$, DBE = 2

HC: hydrocarbons

Aqueous Phase for Compost

140-L Tumbling Composter

Hemp residues

Cattle manure

Water or HTL aqueous phase to maintain 50-70% moisture

Composting

Final compost analysis:
total C and N, pH, electrical conductivity (salinity), available nutrients (Ca, K, Mg), NO_3-N, NH_4-N, P, leachable heavy metals

Measurements: temperature, moisture, degree of aeration: CO_2, CH_4, NO_2

Take Away Messages

- The aqueous phase from HTL needs to be used.
- Use must consider organics, salts, and nutrients.
- N and P recovery should be a co-priority with energy within municipal wastewater treatment and food waste management systems.
- Composting with aqueous phase may be useful for arid regions.

Contact Info

Catie Brewer, cbrewer@nmsu.edu, 575-646-8637