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Biodiesel Production from Food Waste:

Biodiesel production simultaneously with wastewater treatment from mixture of food waste and domestic wastewater using oleaginous yeast

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Introduction

1st Generation
Edible Biomass
Sugar Bean
Sugar Cane
Wheat
Corn

2nd Generation
Non-Edible Biomass
Wood
Straw
Grass
Waste

3rd Generation
Oleaginous Microorganisms
Microalgae
Yeast
Fungi
Bacteria

- less impact on land use
- higher growth rate
- higher productivity
- higher lipid content

(Alalwan et al., 2019, *Renewable Energy Focus*)

Introduction

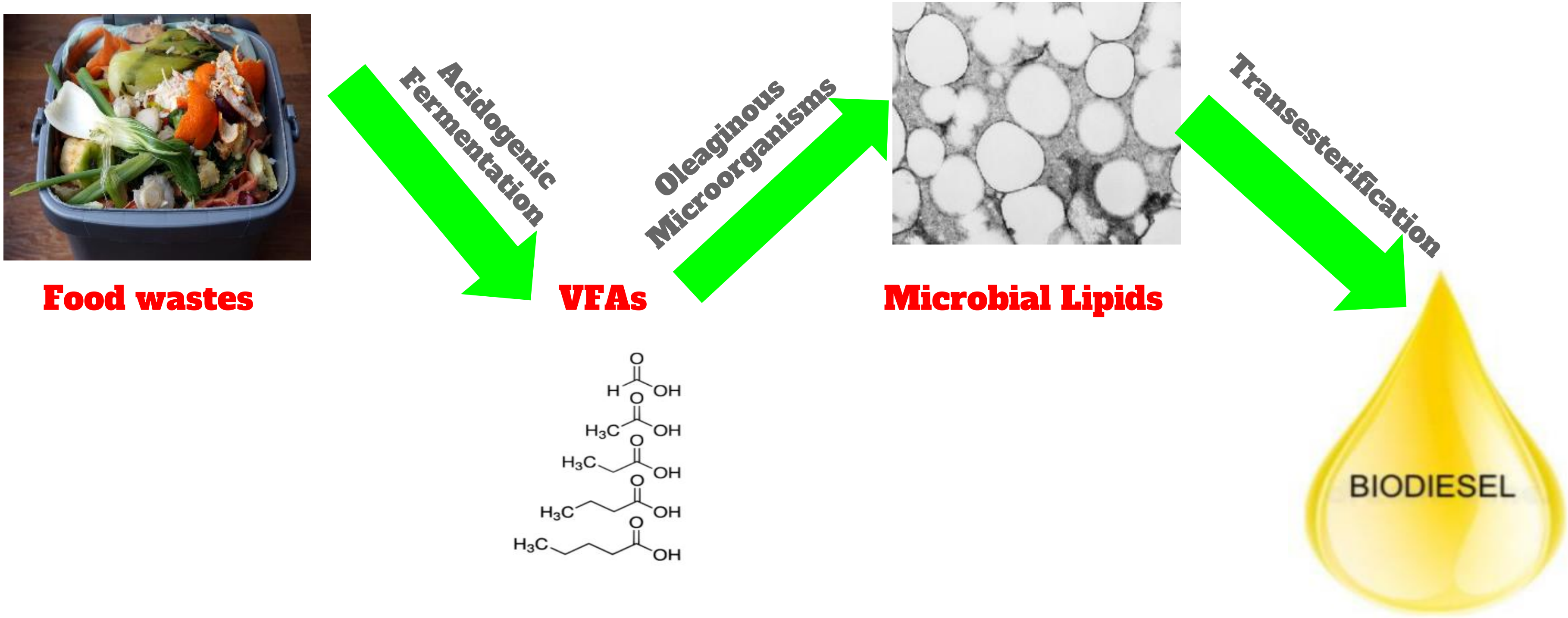
Food wastes

One of promising substrates for biodiesel production.

Rich in organic carbon and nitrogen sources, inorganic mineral salts, and phosphorus and nitrogen.

a. low-cost and no-value resource
b. non-competitive with edible food stuffs
c. huge production (~1.3 billion tons/year) (Gustavsson et al., 2011)

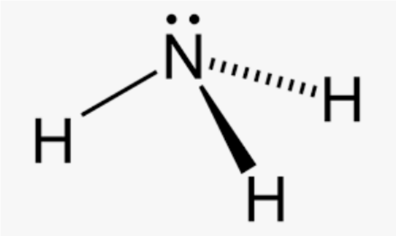
Food waste anaerobic digestion effluent to biodiesel



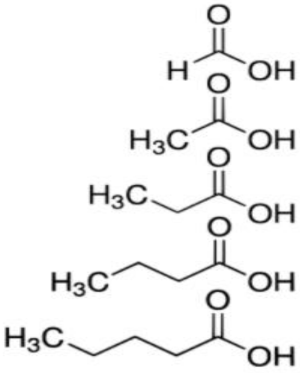
Food waste anaerobic digestion effluent to biodiesel

Affecting Factors

- Low lipid accumulation maybe due to high nitrogen (ammonia nitrogen) content from protein digestion of food waste.



- High VFAs concentrations can inhibit lipid accumulation.



Proper VFAs and ammonia-nitrogen concentrations important

Food waste hydrolysate to biodiesel

Hydrolysis or saccharification is another process to pre-treat food waste to low-molecular-weight organics for utilization by oleaginous microorganisms.

Starch→Reducing Sugar
Organic nitrogen and ammonia→free amino nitrogen (FAN)
etc.

Chemical
e.g., mixing with 1.5-2% sulphuric acid at ~120°C for 30-60 min

Biological
e.g. Commercial glucoamylase & protease or fungal enzyme

Food Waste in Macau SAR

- Daily food waste generation 550.8 tons (DSPA, 2016).
- ~800 g (wet wt) per capita
- In 2020, food waste recycled 414.0 tons (DSEC, 2020).

This value even higher now

Food Waste Recycling Facilities

- Most food waste incinerated.
- High burden for local incineration system.

Food Waste Digestion Effluent

- Using high concentration of soil microbes
- Rapid food waste digestion
- Produce high COD effluent
  - Directly discharged to sewer and mixed with domestic wastewater (sewage)

pH	4.27		
COD (mg/L)	TN (mg/L)	TP (mg/L)	NH_3-N (mg/L)
12,410±185	180±14	231±10	17.33±0.58
Acetic Acid (mg/L)	Propionic Acid (mg/L)	Butyric Acid (mg/L)	Valeric Acid (mg/L)
639±73	176±18	116±10	77±4

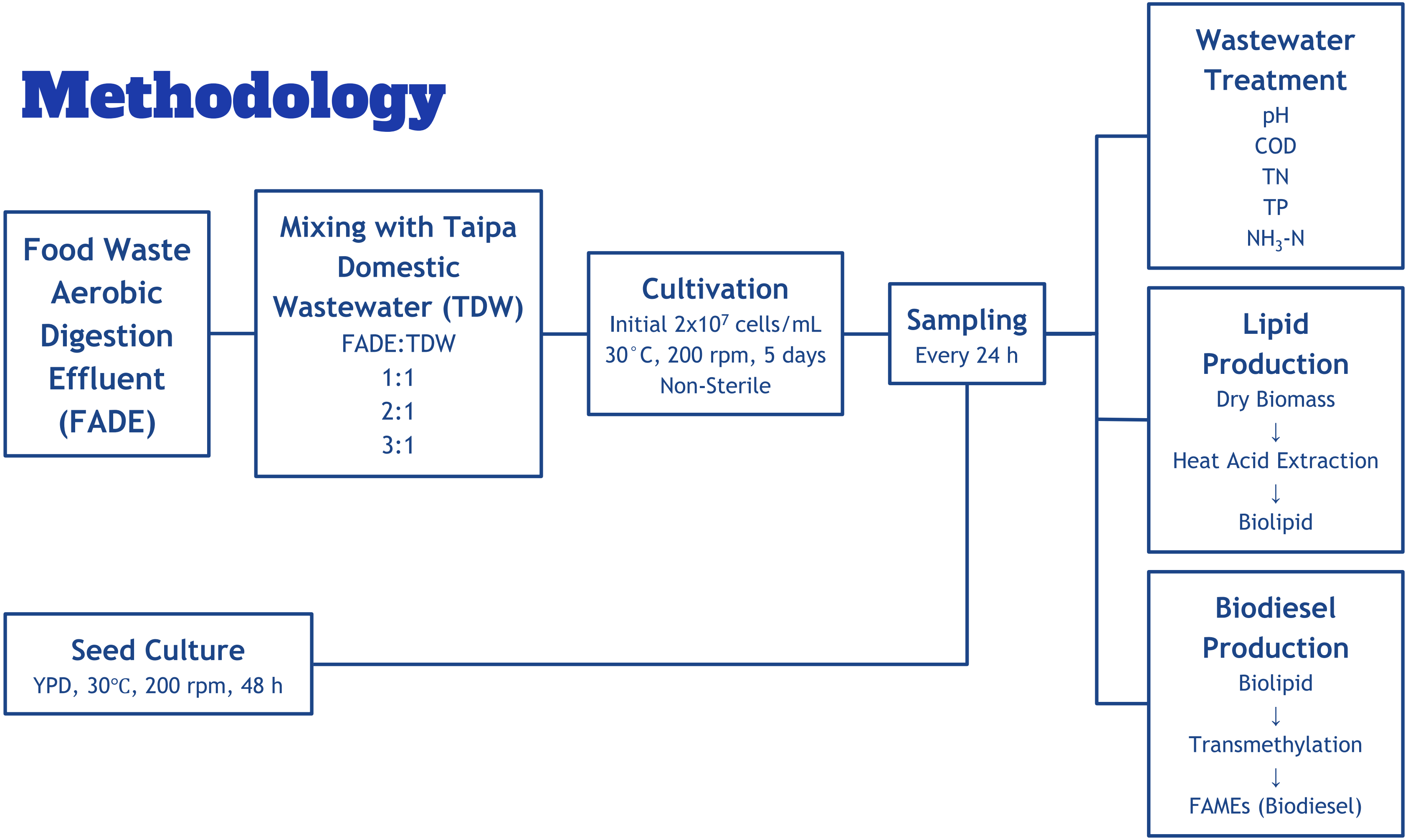
MDT-400 Daesung E&B Co. Ltd.

Aim of This Study

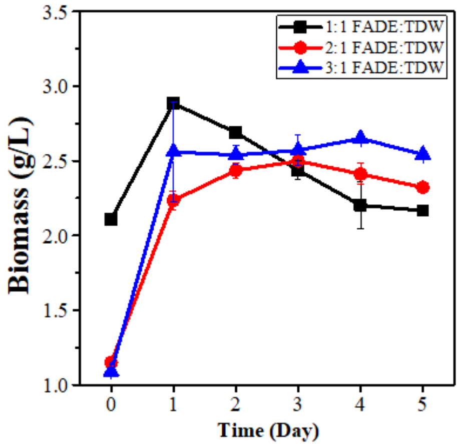
- Energy recovery (biodiesel production) from high strength wastewater (food wastewater)
- Wastewater treatment of food and domestic wastewater mixture
- Determining optimal mixing strategy
- Biolipid production under non-sterile condition using batch culture

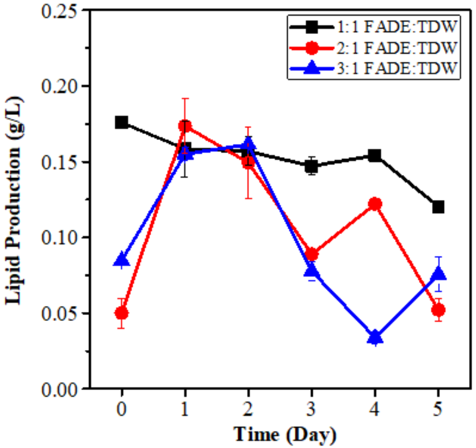
- Trial for large scale energy recovery simulataneously with wastewater treatment in future, after further process optimization

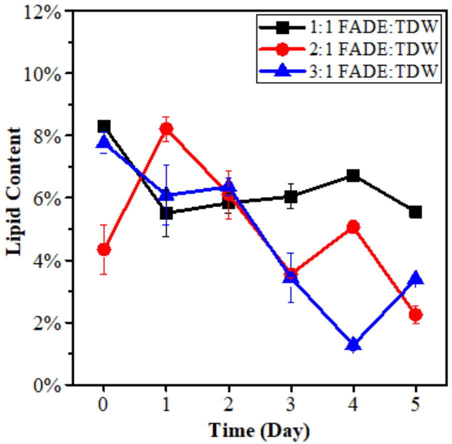
Methodology



Results-Biomass and lipid production



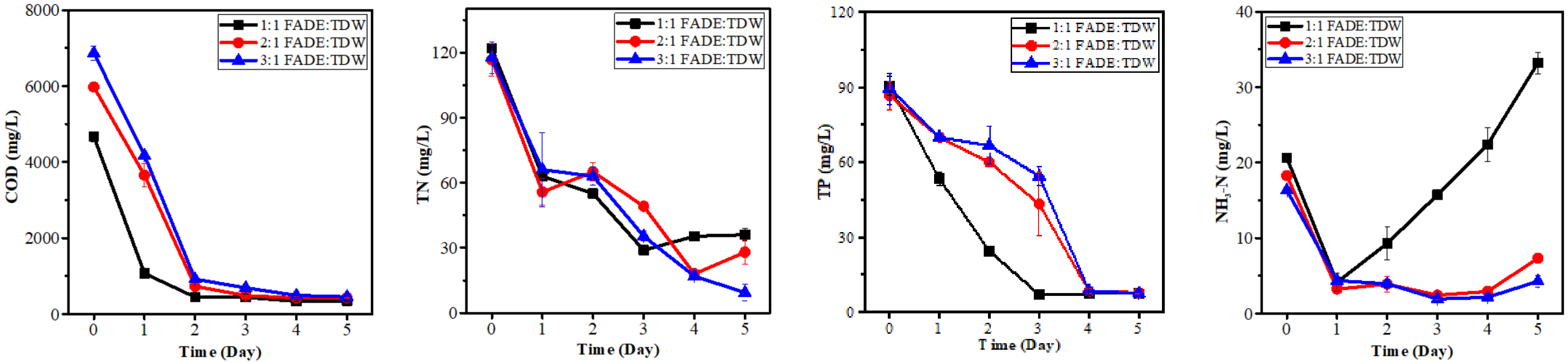




No obvious increase in biomass and lipid production after day 1.
Lipid content decreased during almost whole culture period especially at 3:1 and 1:1 mix ratios.

-Unknown inhibitory compounds in FADE (3:1 mix ratio)
-Limiting carbon source (1:1 mix ratio)

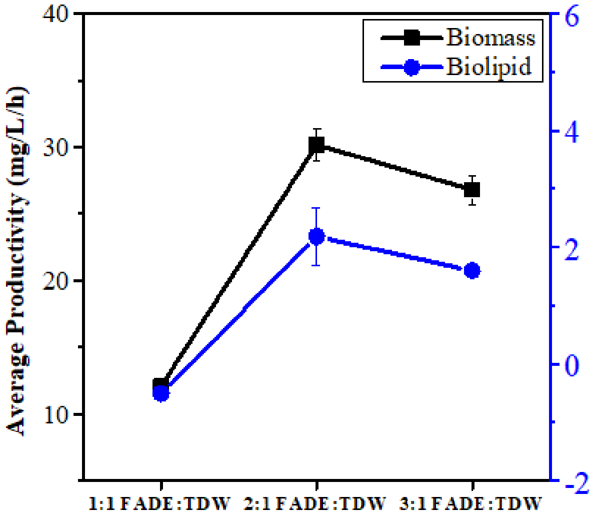
Results-Mixed wastewater treatment

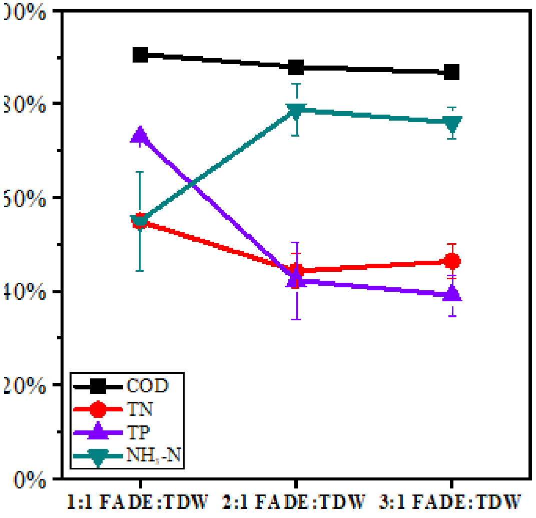


No significant differences in wastewater treatment efficiencies at different mix ratios.
N.B. Ammonia nitrogen accumulation at 1:1 mix ratio.

Results-Optimal mix ratio

For better overall lipid production simultaneously with wastewater treatment efficiency, yeast strain should be harvested on day 2. On day 2:

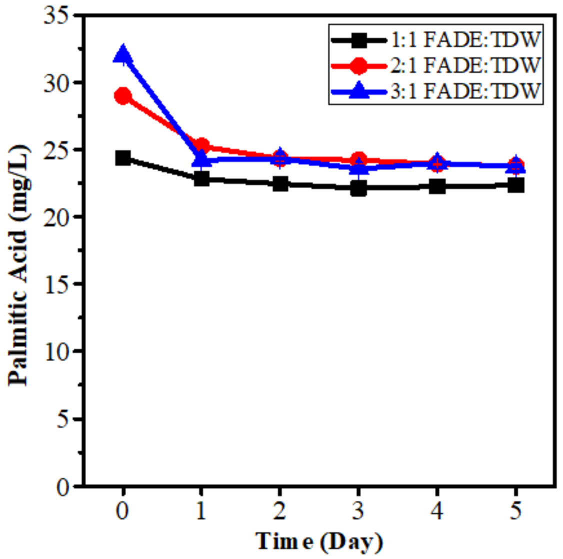


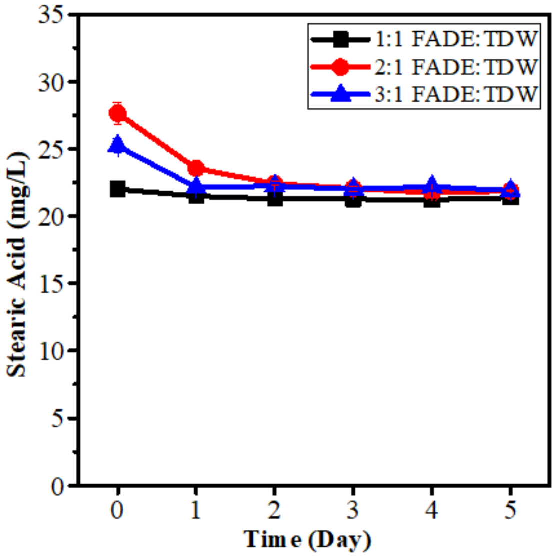


- Both biomass and biolipid productivity optimal at 2:1 mix ratio.
- COD and TP removal decreased with FADE content increased.

Results-LCFAs presence

LCFAs predicted to be one of inhibitory compounds





- Both palmitic acid and stearic acid
  - Low concentrations
  - Only small amounts consumed

Conclusions

- Food waste treatment system effluent should be mixed with domestic wastewater at 2:1 ratio, to more efficiently achieve both lipid accumulation (biodiesel production) and wastewater treatment.
- Yeast strain should be harvested on day 2, before lipid production would decrease because of insufficient carbon source for growth.
- Palmitic and stearic acids (LCFAs) present and hard to be removed.

Further Studies

- More research to identify inhibitory compounds (ammonia N, LCFAs) and relative mechanisms.
- Strategies to remove or mitigate inhibition as well as to enhance lipid production and wastewater treatment.
- Supplementing microelements (Na, Mg, Cu, Zn/Fe, Co, Ni) for enhanced performance.

- Performance comparison between UASB reactor (biogas production by microbial consortium) and airlift reactor (biodiesel production by oleaginous microbes) for food waste (mixture of food/domestic wastewater), including resource recovery (N, P via struvite/vivianite)

Biodiesel Production from Distillery Wastewater

-2017. Cost reduction for the lipid production from **distillery** and domestic mixed wastewater by *Rhodosporidium toruloides* via the reutilization of spent seed culture medium. *Energy*. 136:135-141.

-2016. Evaluation of specific lipid production and nutrients removal from wastewater by *Rhodosporidium toruloides* and biodiesel production from wet biomass via microwave irradiation. *Energy*. 108:185-194.

-2015. Economic cost analysis for biodiesel production from food industry wastewater by oleaginous yeast via direct transesterification. *Renewable Energy and Power Quality Journal*. 13:1-6.

-2014. Optimization of Initial Cell Density and Usage Efficiency of Seed Culture Medium During Lipid Production from **Distillery Wastewater** by *Rhodosporidium toruloides*. *Renewable Energy and Power Quality Journal*. 1(12):130-134.

-2014. Lipid production by a mixed culture of oleaginous yeast and microalga from **distillery** and domestic mixed wastewater. *Bioresource Technology*. 173:132-139.

-2013. Enhancement of Lipid Productivity of *Rhodosporidium toruloides* in **Distillery Wastewater** by Increasing Cell Density. *Bioresource Technology*. 146:301-309.

Biogas Production from Food Waste

-2021. Stimulatory Effect of Magnesium Supplement on Anaerobic Co-digestion of **Food Waste** and Domestic Wastewater. *Journal of Water Process Engineering*. 40. 101773.

-2019. Improved anaerobic co-digestion of **food waste** and domestic wastewater by copper supplementation – microbial community identification and effluent quality analysis. *Science of the Total Environment*. 670:337-344.

-2018. Effect of zinc supplementation on biogas production and short/long chain fatty acids accumulation during anaerobic co-digestion of **food waste** and domestic wastewater. *Waste and Biomass Valorization*. 10:3885-3895.

-2018. Co-digestion of **food waste** and domestic wastewater – copper supplementation to enhance biogas production. *Energy Procedia*. 153:237-241.

-2018. Anaerobic co-digestion of **food waste** and domestic wastewater – Effect of intermittent feeding on short and long chain fatty acids accumulation. *Renewable Energy*. 124:129-135.

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