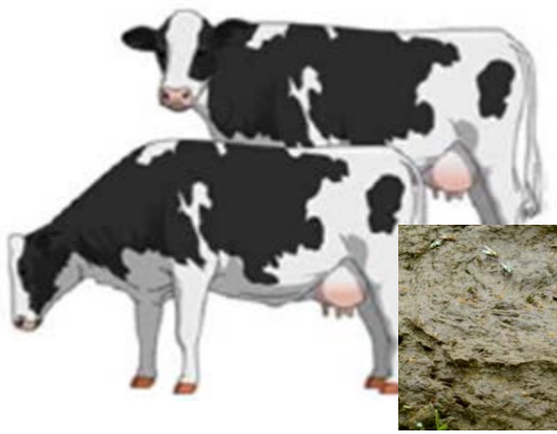
אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

BIDR
The Zuckerberg Institute for
Water Research (ZIWR)

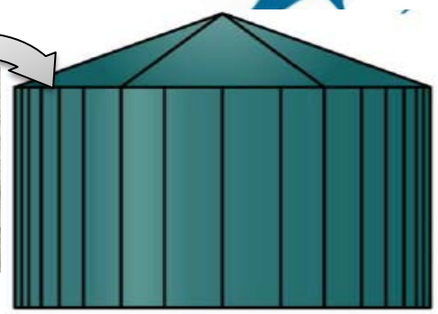
Environmentally sustainable treatment and valorization of manure-based digestate using hydrothermal carbonization

Yonas Z Belete, Aregawi A Gebretsadkan, RY Spitzer, R Posmanik, A Gross

Wet-organic wastes from different streams, e.g. from dairy farms



Biogas

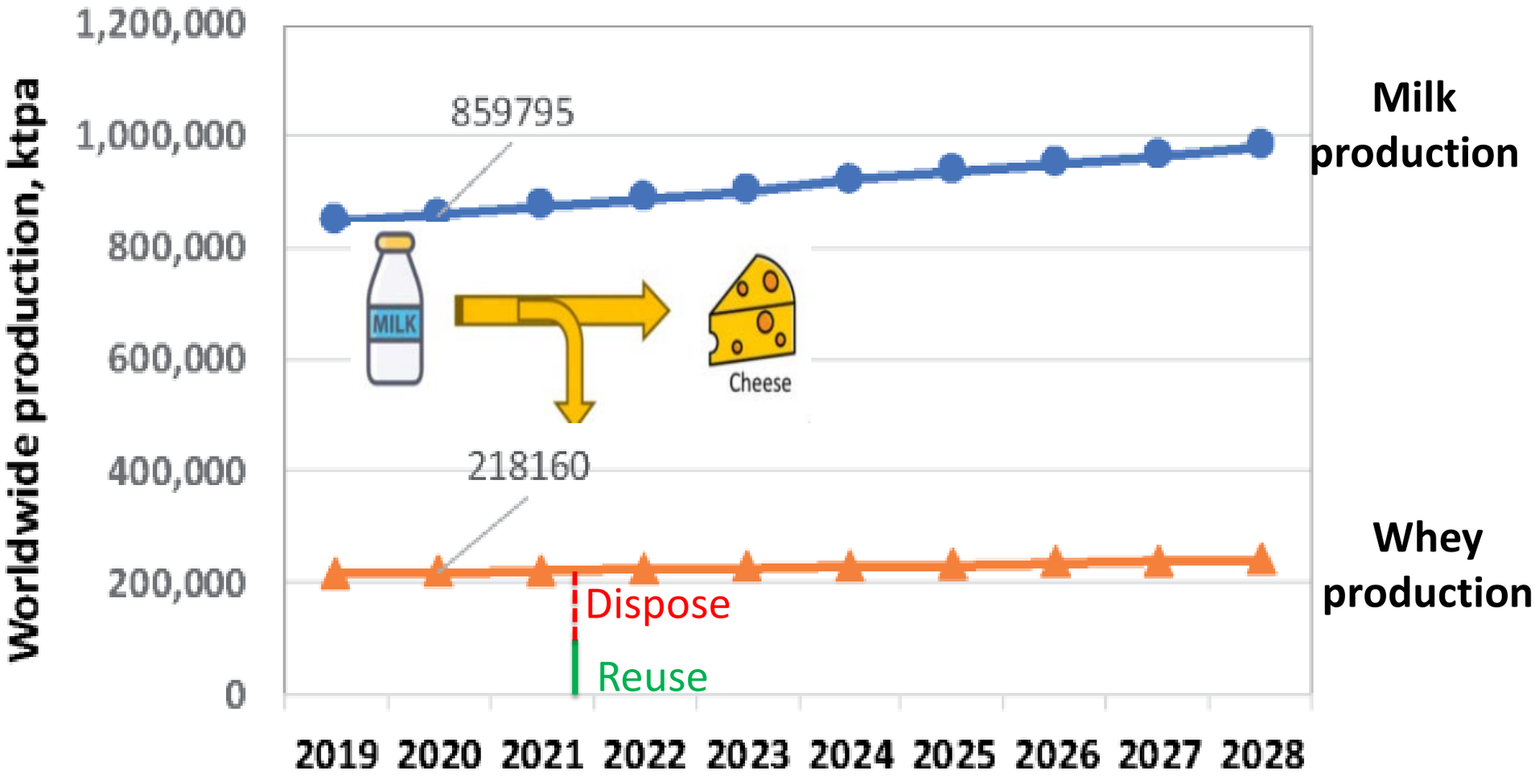


High amount of digestate

Widely used as a soil amendment /fertilizer

Leaching contaminants and nutrients

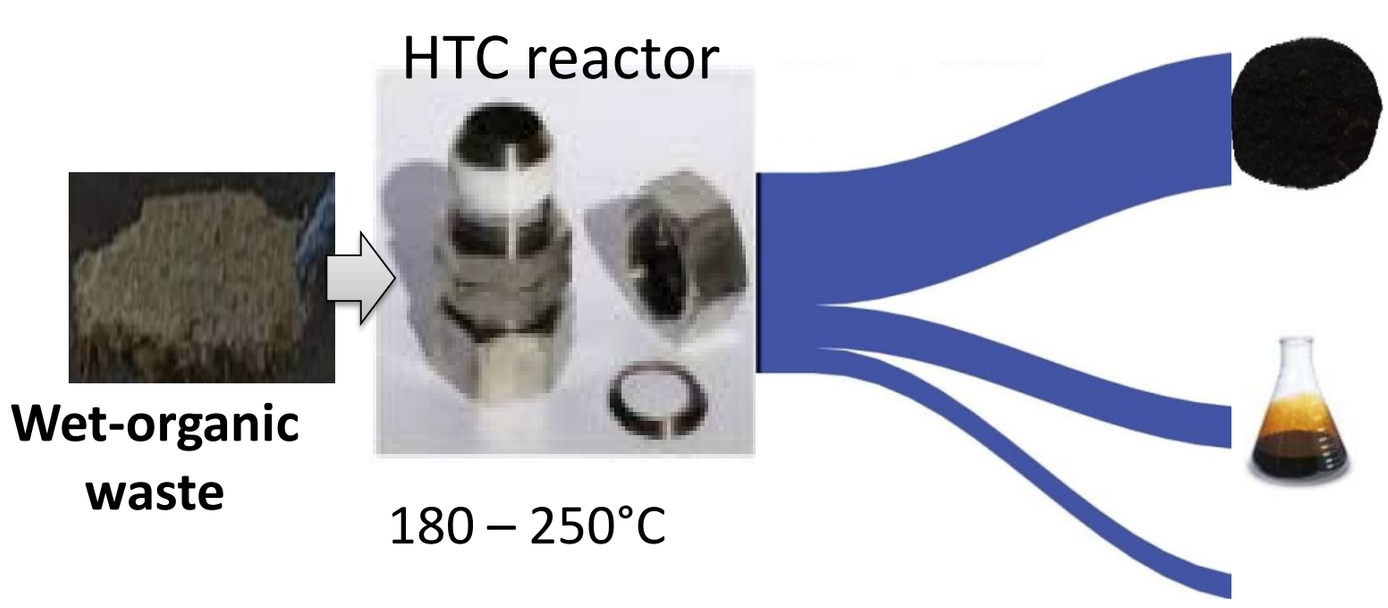
Another waste from a dairy farm is whey.



Pais-Chanfrau et al., 2020; Asunis et al., 2021

Hydrothermal carbonization (HTC)

- Thermochemical conversion process
- Convert wet-organic waste into value-added products
- Accommodate a broader range of feedstocks



Carbon distribution	
50 - 80%	Hydrochar
5 - 21%	Aqueous phase
2 - 7%	Gas phase

Libra et al., 2011; Taufer et al., 2021

Objective

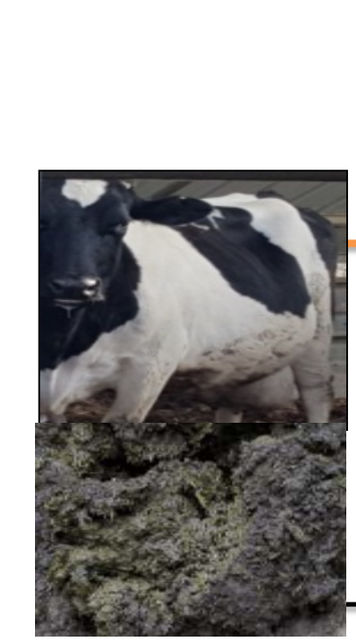
- ❖ Study sustainable treatment and valorization of dairy farm wastes (manure, digestate and whey) using HTC

Specifically

- ✓ Characterize physicochemical properties of the hydrochar and aqueous phase

- ✓ Investigate potential HTC aqueous phase and hydrochar to support plant growth

Experimental design



Cow manure

Digestate+water

Digestate+whey

Manure+water

Manure+whey

HTC

180 – 240°C

Solid : liquid = 1:3

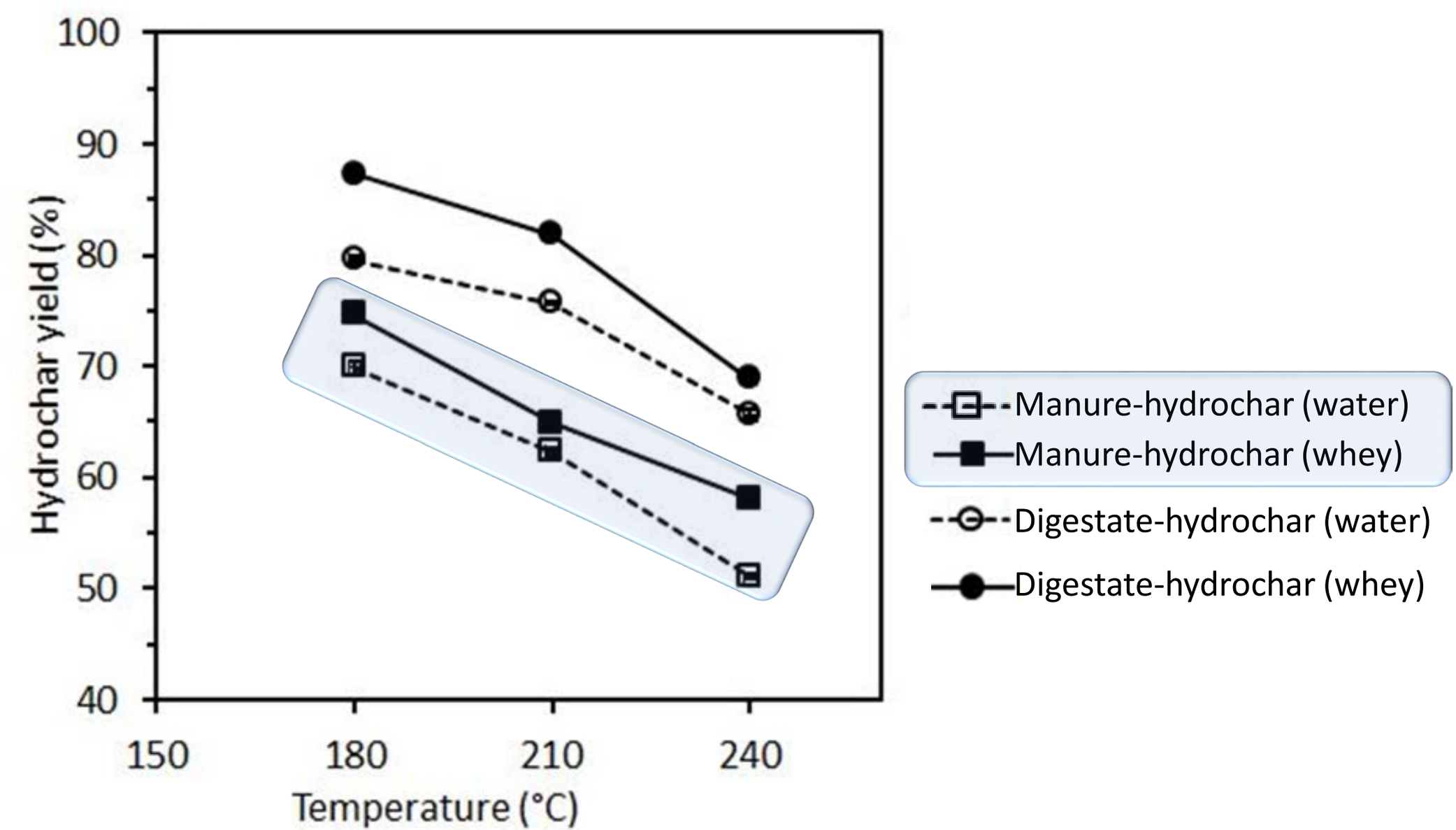
Hydrochar

- **Hydrochar yield,**
- **calorific value,**
- **N and P**

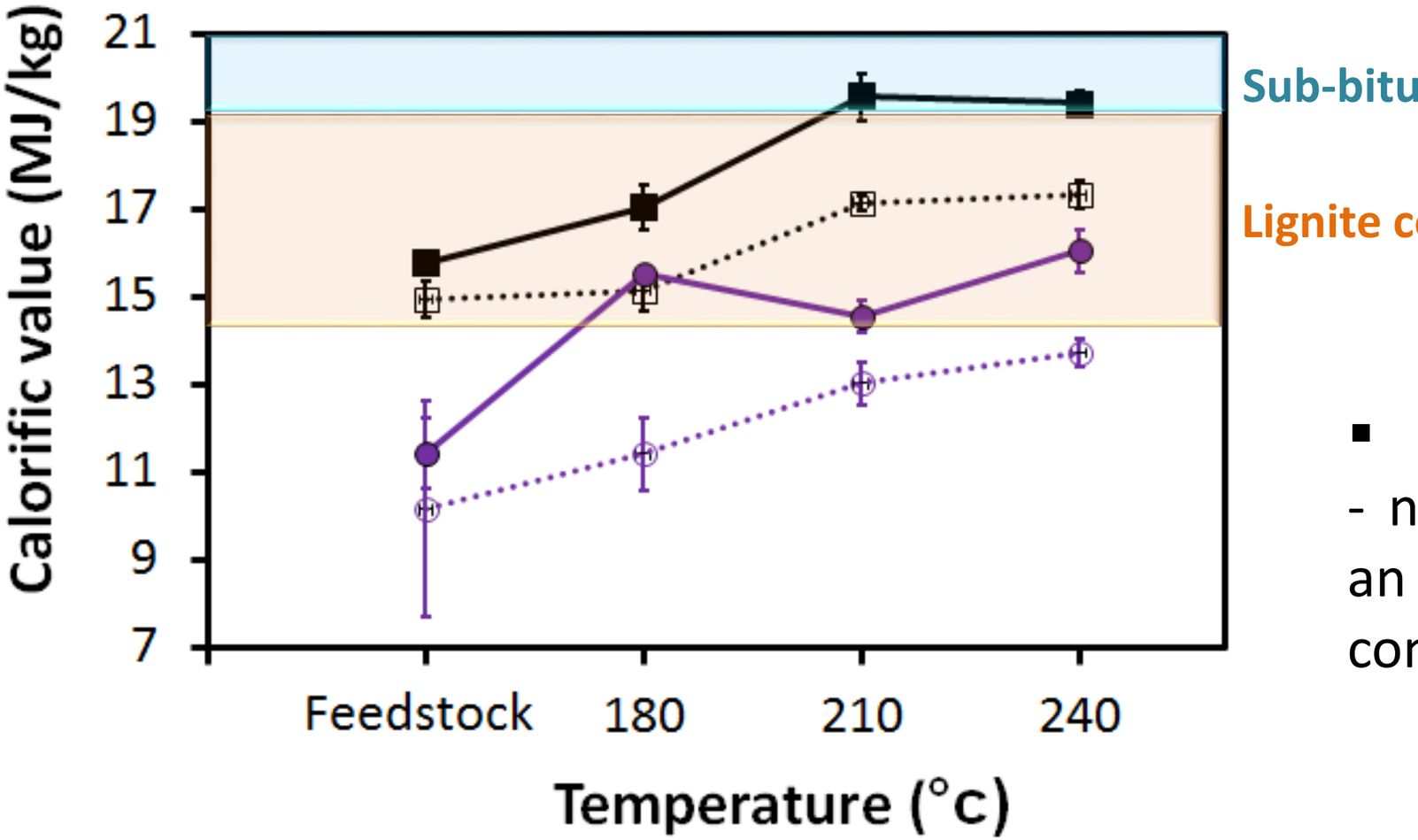
Aqueous phase

- **N, P and K**

- **Addition of whey had a significant effect on the hydrochar yield.**



- **Manure+whey resembles sub-bituminous coal quality which is suitable for combustion**



- **Digestate-hydrochar**

- not favorable for its use as an energy source/low energy content

- **HTC of the digestate (180 – 240 ℃) can produce:**

  ✓ A stable, pathogen-free, and P-rich form of hydrochar.

	Digestate-hydrochar (water)	Digestate-hydrochar (whey)
N(%)	1.8 – 1.9	2.1 – 2.3
P(%)	1.3 – 1.8	1.4 – 1.7

  ✓ Nutrient rich aqueous phase

	Digestate-aqueous phase (water)	Digestate-aqueous phase (whey)
TN (mg/L)	2,354 – 2,719	2,742 – 3,095
K (mg/L)	2,296 – 2,532	4,580 – 5,075
P (mg/L)	148 – 10	414 – 13

2. Investigate aqueous phase and char for pot planter experiment

Digestate +water

Digestate +whey

180 °C for 1 h

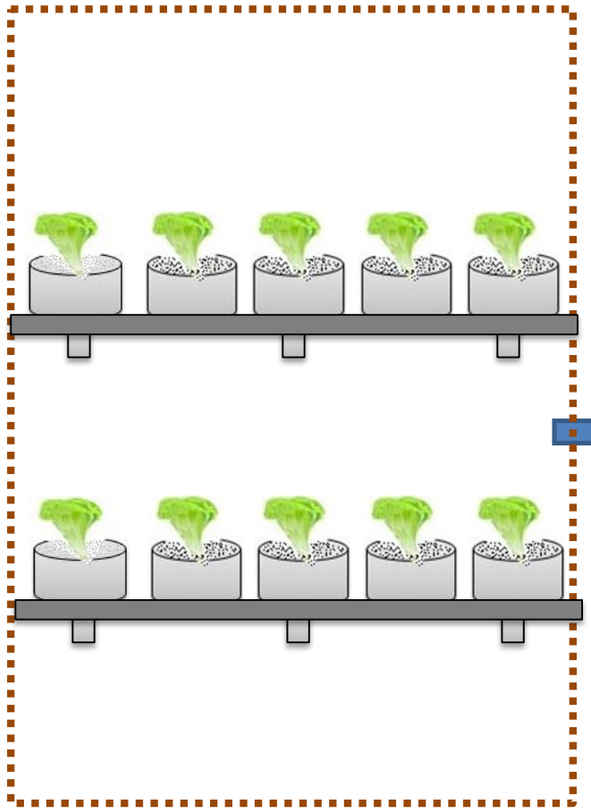
HTC pilot plant reactor (30 L)

Centrifuge

Hydrochar

Aqueous phase

- (-) control
- (+) control



Yield and composition

Characterization

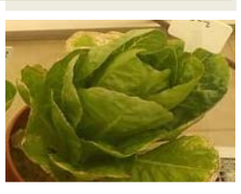
Leaves and roots

Soil and leachate

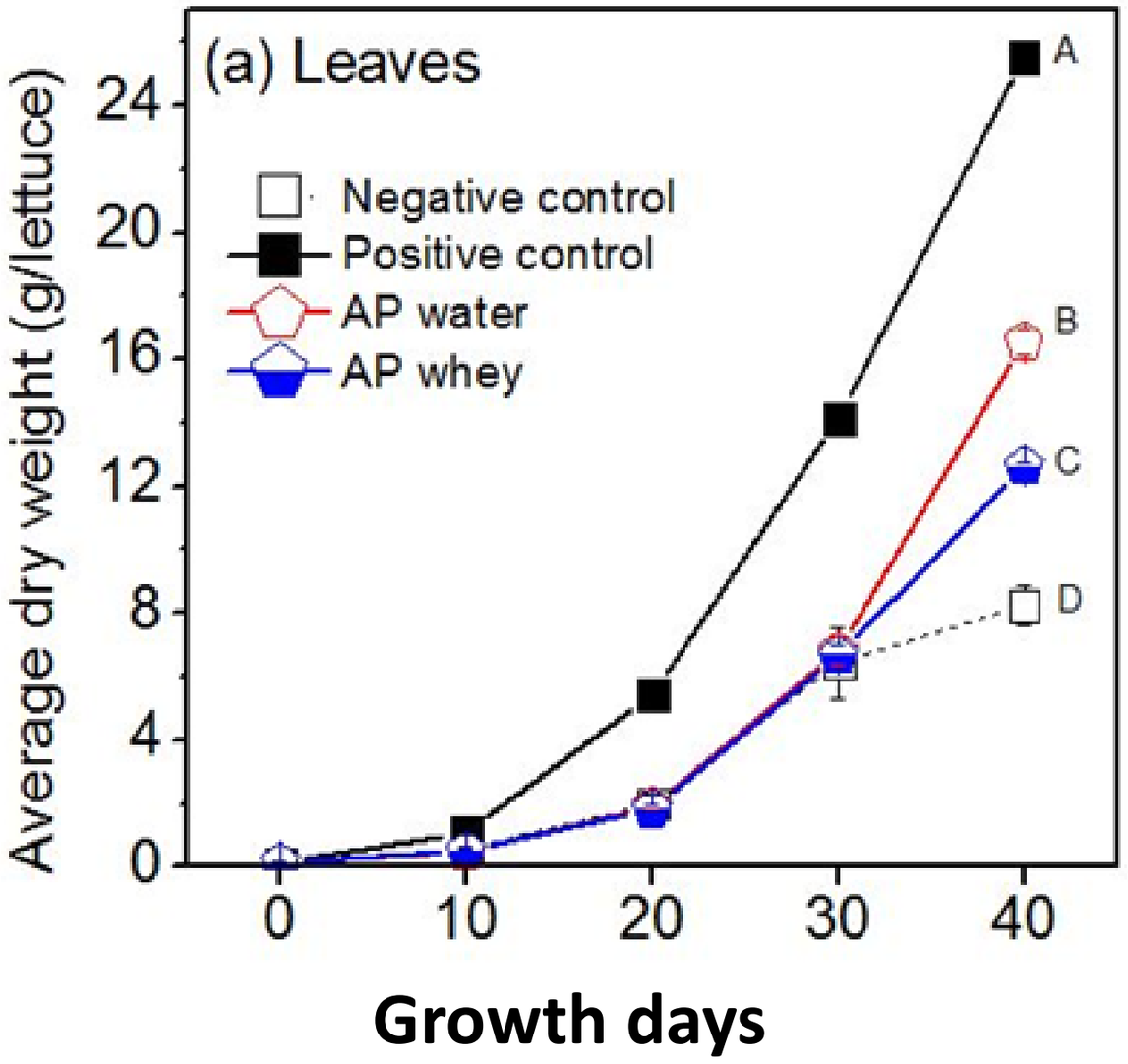
N and P mass balance

Day 0 pot experiment

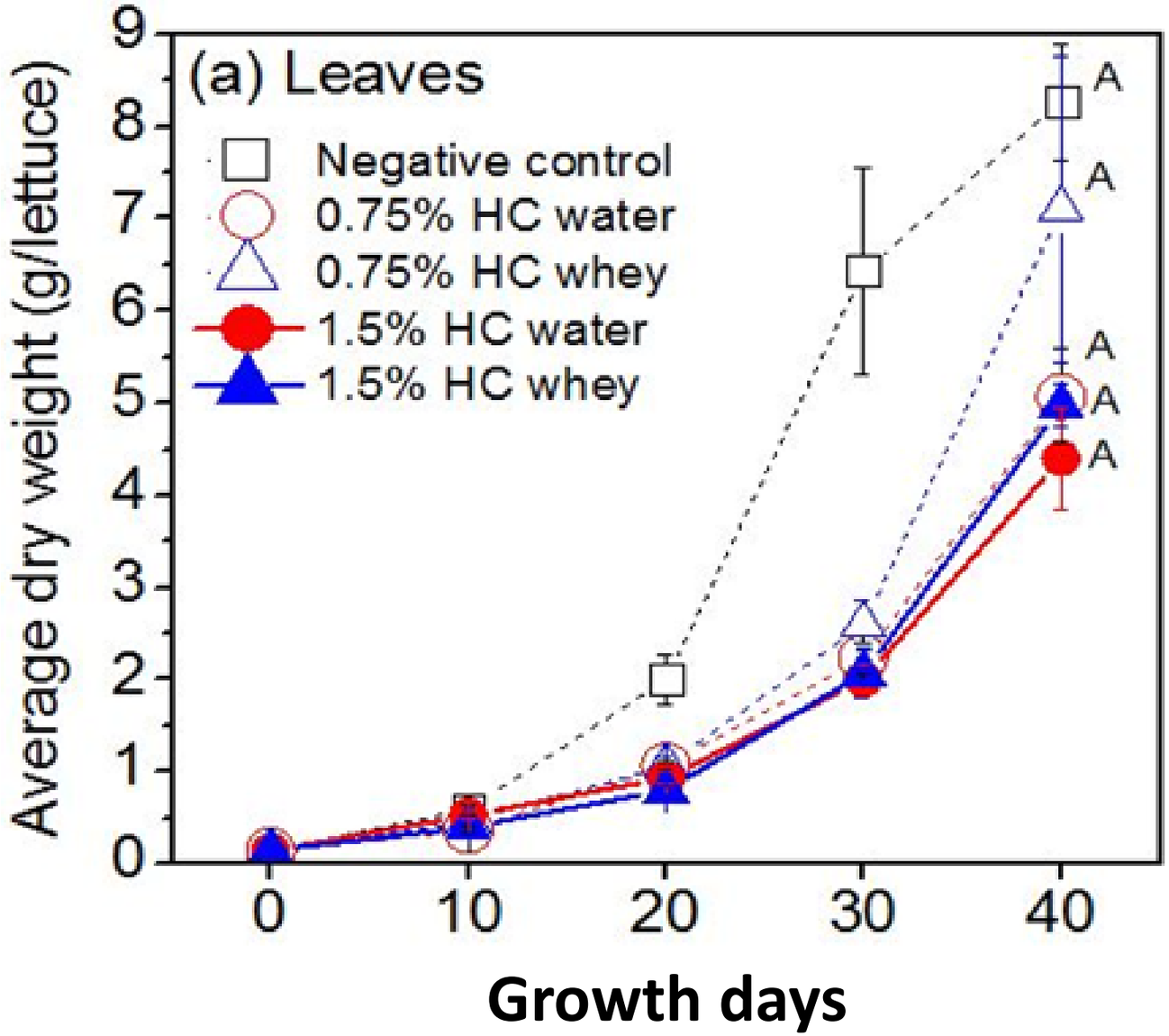
Growth days and yield improvement

Soil sample	day 0	day 10	day 20	day 30	day 40
Negative control					
Positive control					
Digestate-aqueous phase (water)					
Digestate-aqueous phase (whey)					
Hydrochar amended soil					

❖HTC aqueous phases (AP) enhanced lettuce growth.



❖Hydrochar amended soils inhibited the lettuce growth



Take-home message

- Manure derived hydrochar could be used as solid fuel.
- Digestate aqueous phases could be used as liquid fertilizer.
- Digestate hydrochar inhibited the lettuce growth.

Thank you!

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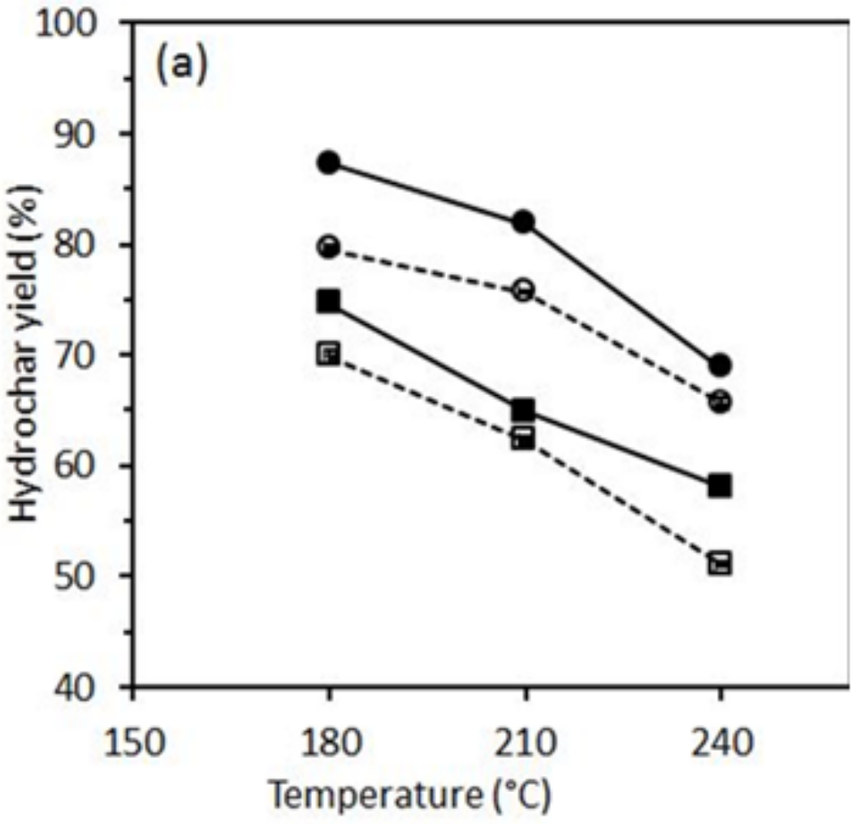
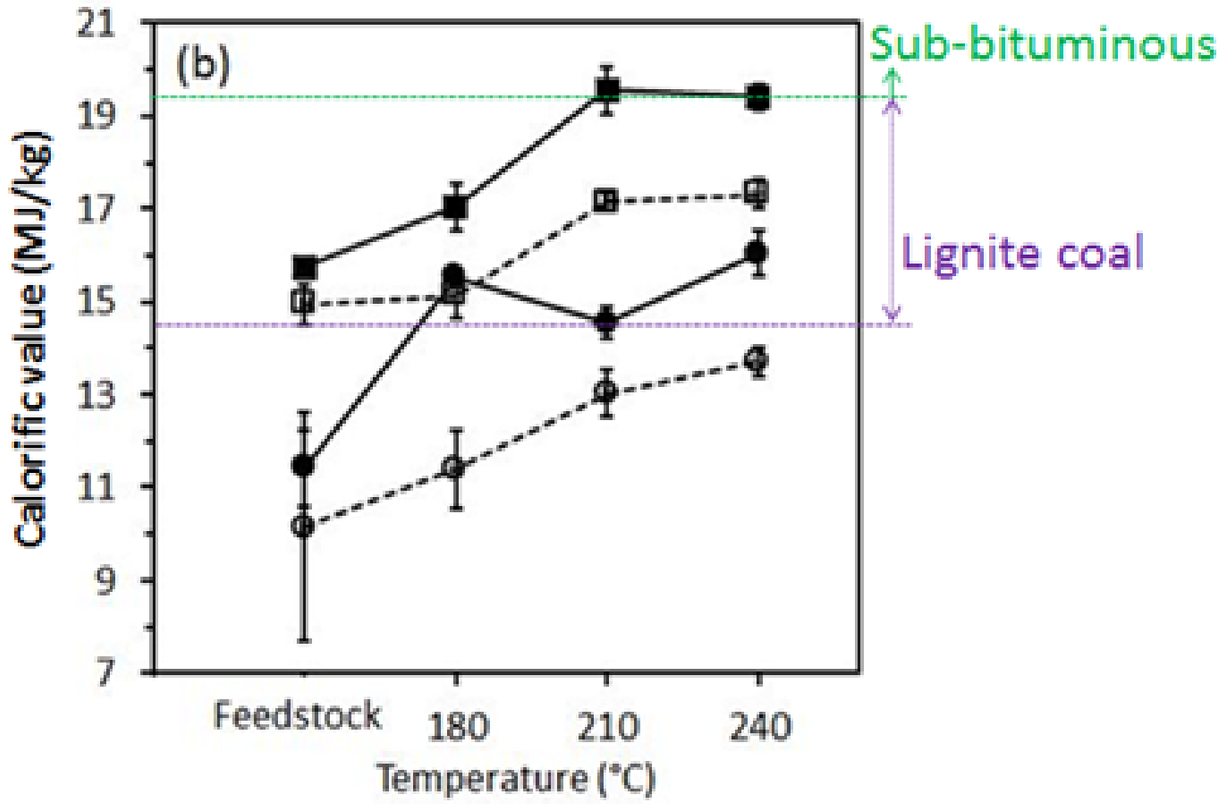
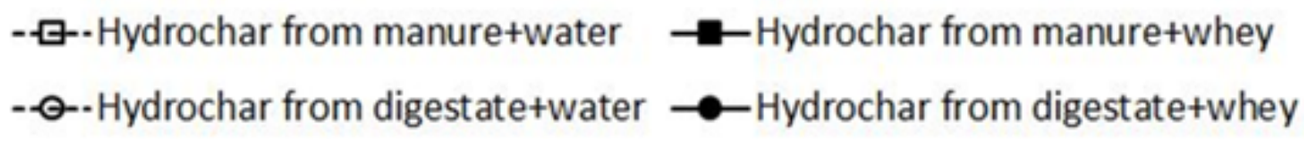


- Manure+whey resembles sub-bituminous coal quality which is suitable for combustion





- Digestate-hydrochar - not favorable for its use as an energy source/low energy content

- **HTC of the digestate can produce:**
  - a stable, pathogen-free, and P-rich form of hydrochar.
  - nutrient rich aqueous phase

	HTC at 180 – 240 ℃			
	Hydrochar (manure+water)	Hydrochar (manure+whey)	Hydrochar (digestate+water)	Hydrochar (digestate+whey)
N(%)	2.4 – 2.6	2.8 – 2.9	1.8 – 1.9	2.1 – 2.3
P(%)	1.2 – 1.5	1.2 – 1.4	1.3 – 1.8	1.4 – 1.7
	HTC aqueous phase			
TN (mg/L)	2500 – 2710	3112 – 3163	2,354 – 2719	2742 – 3095
K (mg/L)	5696 – 6000	7496 – 7904	2296 – 2532	4580 – 5075
P (mg/L)	135 – nd	141 – nd	148 – 10	414 – 13

2. Pot experiment

Digestate +water

Digestate +whey

180 °C for 1 h

HTC pilot plant reactor (30 L)

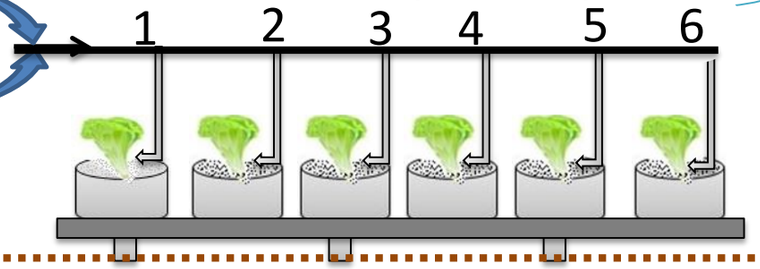
Centrifuge

Hydrochar

as soil amendment

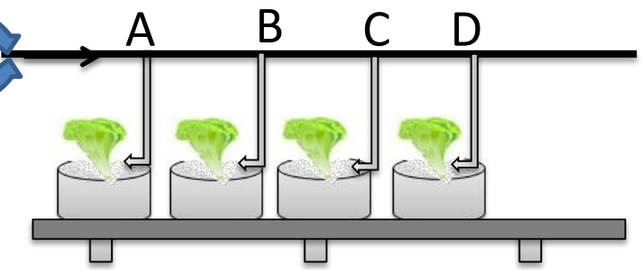
1: Negative control (only sand)
2. Slow release fertilizer
3: Sand with 0.75% water-based hydrochar
4: Sand with 1.5% water-based hydrochar
5: Sand with 0.75% whey-based hydrochar
6: Sand with 1.5% whey-based hydrochar

20 mg N/L



AP

as fertilizer



A: Negative control (only sand, 20 mg/L N)
B: Positive control (only sand, 100 mg/L N)
C: Water-based aqueous phase (100 mg/L N)
D: Whey-based aqueous phase (100 mg/L N)

Characterization

Lettuce (leaves and roots)

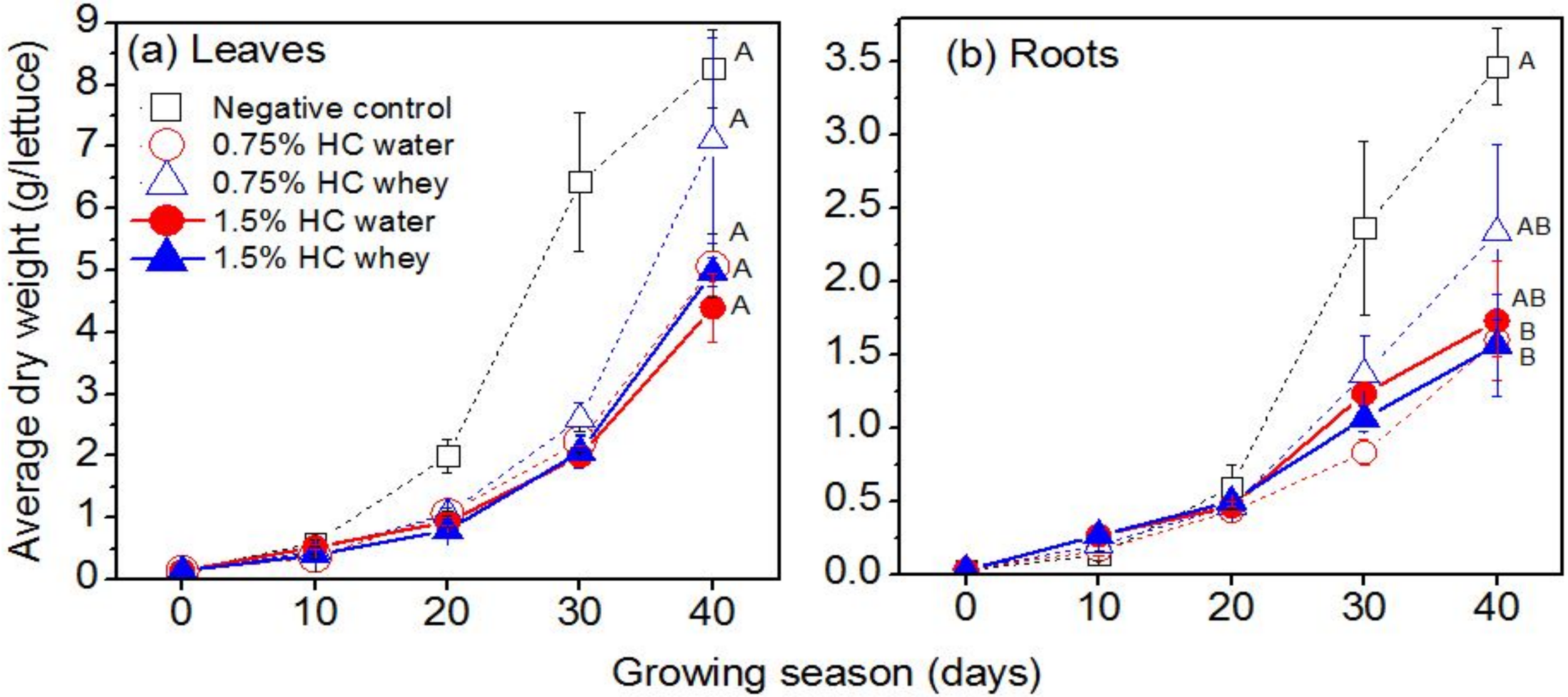
Yield and composition

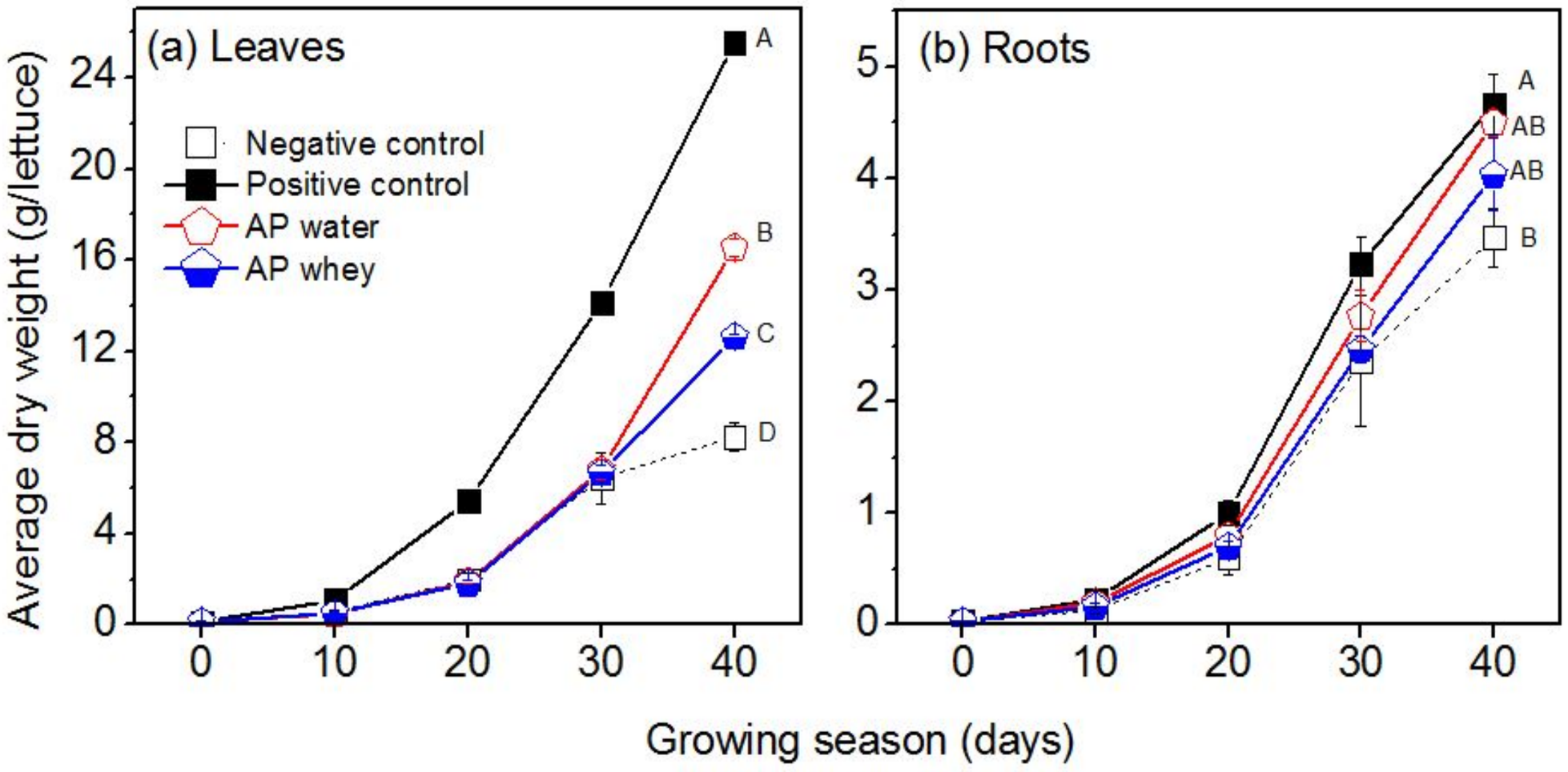
Soil and leachate

N and P mass balance

Sample	Growth days				
	day 0	day 10	day 20	day 30	day 40
Negative control					
0.75% HC water					
1.5% HC water					
0.75% HC whey					
1.5% HC whey					

220 – 600 mL/day
with 20 mg N/L


(a) Leaves
Negative control
0.75% HC water
0.75% HC whey
1.5% HC water
1.5% HC whey
Average dry weight (g/lettuce)
0
1
2
3
4
5
6
7
8
9
A
A
A
A
A
(b) Roots
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
A
AB
AB
B
B
0
10
20
30
40
Growing season (days)


(a) Leaves
(b) Roots
Negative control
Positive control
AP water
AP whey
A
B
C
D
AB
AB
Average dry weight (g/lettuce)
Growing season (days)
0
4
8
12
16
20
24
1
2
3
5
10
30
40