Adsorption of ammonium from AnMBR effluent using activated hydrochar as a potential fertilizer

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Sludge cause impacts such as:

- The risk of nutrient leaching to water bodies
- Impacts soil biodiversity
- Greenhouse gas emissions
Valorization of wet organic sludge

Conventional methods: Anaerobic digestion, composting, incineration, landfilling etc.

Limitations

- Produce product with pathogens.
- Environmental issues such as odor and smell.
- Greenhouse gas emission
- Land consumption.

Thermochemical process

Hydrothermal carbonization (HTC)
Thermochemical conversion of wet biomass into coal like material (hydrochar).

(180 - 250 °C)

Produce sterile product, ecofriendly, no energy intensive process.
Objectives

➤ Investigate the capacity of hydrochar to adsorb \( \text{NH}_4^+ \) from wastewater.

➤ Study potential application of hydrochar and ammonium enriched hydrochar as a soil amendment to enhance plant growth.
Capacity of hydrochar to adsorb $\text{NH}_4^+$ from wastewater

Wastewater rich in $\text{NH}_4^+$

Adsorption

Reduction in $\text{NH}_4^+$ conc.

Treated Wastewater reuse
Experimental design

- **Sludge**
  - **HTC** 210 °C, 4 h, S/W ratio 1:3

- **Hydrochar**
  - **Fenton solution** 50 mM H$_2$O$_2$/Fe(II) 10:1, pH = 4, T=30 min

- **Activated hydrochar**
  - **NH$_4^+$** Low NH$_4^+$ Wastewater

- **Soil amendment**
Mechanism of adsorption

Hydrochar

Electrostatic attractions

Physical adsorption

Cation exchange

$\text{NH}_4^+$
Activated hydrochar significantly reduced NH$_4^+$ conc. in the AnMBR effluent.

Standard for treated wastewater re-use in Israel (Inbar Y, 2007)

$q_e$: 1.8 mg/g  
$q_e$: 2.9 mg/g
Treatments:

1. Sand as a (−) control + 10 mg/L N.

2. Urea as a (+) control.

3. Hydrochar (0.75 wt %).

4. Ammonium enriched hydrochar (N-AHC, 0.75 wt %).

Randomized block design

Lettuce (Lactuca sativa)
Planter experiment set up

Growth period

<table>
<thead>
<tr>
<th>Day 0</th>
<th>Day 10</th>
<th>Day 20</th>
<th>Day 30</th>
<th>Day 40</th>
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Day 20

Day 10

Day 0

Day 30

Day 40
Hydrochar amendment improved soil fertility & enhanced yield

Leaves dry weight (g)

Time (days)

- Sand
- N-AHC
- HC
- Urea
Take home message

- Activated hydrochar is a promising adsorbent for ammonium removal from wastewater.

- Hydrochar amended sand enhanced lettuce yield.
Thank you for your kind attentions!
Hydrochar adsorption from synthetic and AnMBR solution
The graph shows the concentrations of different cations in feed and effluent solutions. The x-axis represents the cations (Ca\(^{2+}\), Mg\(^{2+}\), Na\(^{+}\), K\(^{+}\)) and the y-axis represents the concentrations in mg/L.

- **Ca\(^{2+}\)**: Feed concentration is slightly higher than the effluent concentration.
- **Mg\(^{2+}\)**: Both feed and effluent concentrations are very low.
- **Na\(^{+}\)**: The feed concentration is significantly higher than the effluent concentration.
- **K\(^{+}\)**: The concentrations for both feed and effluent are similar and relatively low.
The graph shows the contact angle (°C) for different samples:

- Sludge
- HC
- AHC
- $\text{NH}_4^+ \text{AHC}$

The contact angles for HC and AHC are significantly higher compared to Sludge and $\text{NH}_4^+ \text{AHC}$.