AQUAPONIC SLUDGE DIGESTION FOR ORGANIC REDUCTION AND NUTRIENTS MINERALISATION IN UASB REACTORS

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Introduction

One loop aquaponics

Fish tank → Mechanical filter → Biofilter → Sump → Pump → Hydroponic beds
Low concentration of mineral elements in solution

- Macroelements: N, P, K, Ca, Mg, S
- Microelements: Fe, B, Cu, Zn, Mn, Mo
Nutrients lost by sludge spillage

- Fish tank
- Mechanical filter
- Biofilter
- Sump
- Pump
- Hydroponic beds

Sludge

Contents:
- Introduction
- Formula
- Aerobic vs Anaerobic
- UASB performances
- UASB effluents
- Perspectives
Sludge digestion for mineral elements recovery

Introduction

Fish tank → Mechanical filter → Biofilter → Sump → Pump → Hydroponic beds

Sludge digestion in bioreactor → Macro and microelements mineralised
Formula used for COD – TS reduction:

\[
\eta_{TS} = 1 - \frac{\Delta TS + T_{TS\ out}}{T_{TS\ in}}
\]

where \(\Delta TS\) is the TS inside the reactor at the end of the experiment minus the TS inside the reactor at the beginning of the experiment, \(T_{TS\ out}\) is the total TS outflow and \(T_{TS\ in}\) is the total TS inflow.
Formula used for elements mineralisation:

\[ NR = \frac{DN_{out} - DN_{in}}{TN_{in} - DN_{in}} \]

Where \( NR \) is the nutrient recovery at the end of the experiment in percent, \( DN_{out} \) is the total mass of dissolved nutrient in the outflow, \( DN_{in} \) the total mass of dissolved nutrient in the inflow, and \( TN_{in} \) the total mass of dissolved plus undissolved nutrients in the inflow.
Aerobic vs Anaerobic sludge digestion in simple reactors

ZHAW$^1$, ULg$^2$ and WUR$^3$

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Anaerobic vs Aerobic sludge digestion in simple reactors
Anaerobic vs Aerobic elements mineralisation performances

Introduction

Formula

UASB performances

UASB effluents

Perspectives
UASB performances

ULg: one set
WUR: two sets
pH in reactors

- **UASB performances**
- **pH of the UASB reactors**
  - NaHCO₃ added
  - Days: 0 to 40
  - Lines: WUR UASB I, WUR UASB II, ULg UASB

- **pH of the EGSB reactors**
  - Days: 0 to 40
  - Lines: WUR EGSB I, WUR EGSB II, ULg EGSB

- **pH of the control reactors**
  - Days: 0 to 40
  - Lines: WUR Aerobic, WUR Anaerobic, ULg Aerobic, ULg Anaerobic
VFA in reactors

**WUR Reactors (excl. UASB I)**

- **WUR UASB II**
- **WUR EGSB II**
- **WUR Anaerobic**
- **WUR Aerobic**

**ULg Reactors**

- **ULg UASB**
- **ULg EGSB**
- **ULg Anaerobic**
- **ULg Aerobic**

Graphs showing the total VFAs (mmol/L) over days for WUR and ULg reactors, with different reactors and conditions represented by different colors.
Sludge organic reduction performances

UASB performances

Introduction

Formula

Aerobic vs Anaerobic

UASB effluents

Perspectives
Sludge reduction and mineralisation performances

UASB performances

Introduction
Formula
Aerobic vs Anaerobic
UASB performances
UASB effluents
Perspectives
• **N mineralisation:** protein degradation

  ![Amino Acid Structure](image)

  \[ \text{NH}_4^+ \]

• **P, K, Ca, Mg mineralisation:** solubilisation low pH of precipitated minerals

  - Struvite: \((\text{NH}_4)\text{Mg}(\text{PO}_4) \cdot 6(\text{H}_2\text{O})\)
  - Calcium phosphate, Hydroxyapatite: \(\text{Ca}_5(\text{PO}_4)_3(\text{OH})\)

**UASB performances**

**Introduction**

**Formula**

**Aerobic vs Anaerobic**

**UASB effluents**

**Perspectives**
TS and COD in effluents comparison
Macroelements in UASB effluents compared to hydroponics

- S
- Mg
- Ca
- K
- P
- NO₃-N
- TAN

Effluent Concentration (mg/L)

- WUR UASB I
- WUR UASB II
- ULg UASB
- Hydroponics
Microelements in UASB effluents compared to hydroponics
Two-step digestion + post-treatment?

Fresh sludge → UASB
- pH 6.5 – 7.5
- Organic reduction
- N mineralisation
- Biogas

UASB effluents → Acid reactor
- pH 4.5 to 5.5
- Macro and microelements mineralisation

Post-treatment

Introduction → Formula → Aerobic vs Anaerobic → UASB performances → UASB effluents → Perspectives
Decoupled AquaPonic System: DAPS

Hydroponics

UASB + Sludge mineralisation

Introduction

Formula

Aerobic vs Anaerobic

UASB performances

UASB effluents

Perspectives
Thank you for your attention!