NITRIFICATION-DENITRIFICATION OF RAW MUNICIPAL WASTEWATER WITHOUT RECIRCULATION, USING ENCAPSULATED MICROBIAL SYSTEMS

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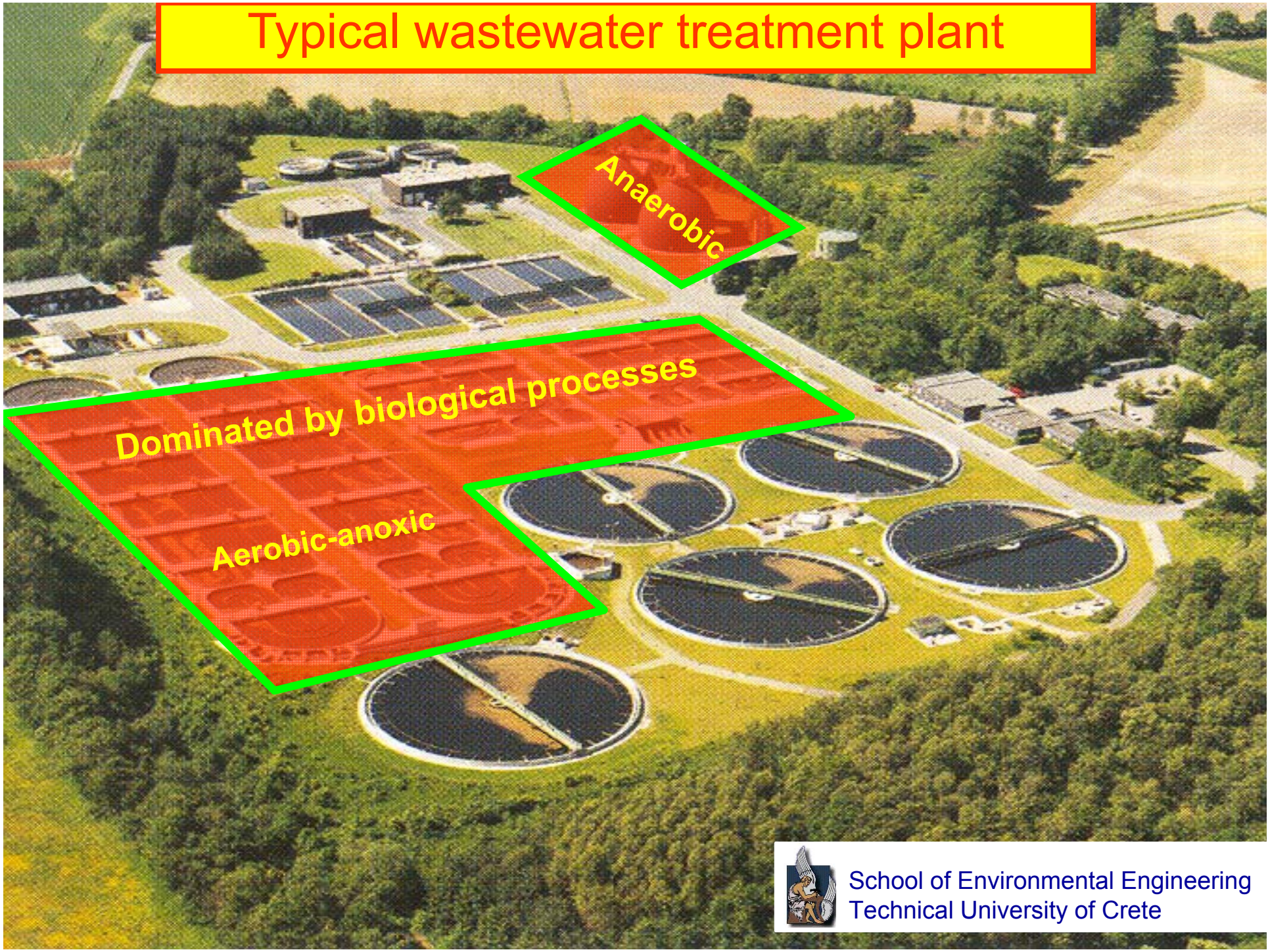
Typical wastewater treatment plant



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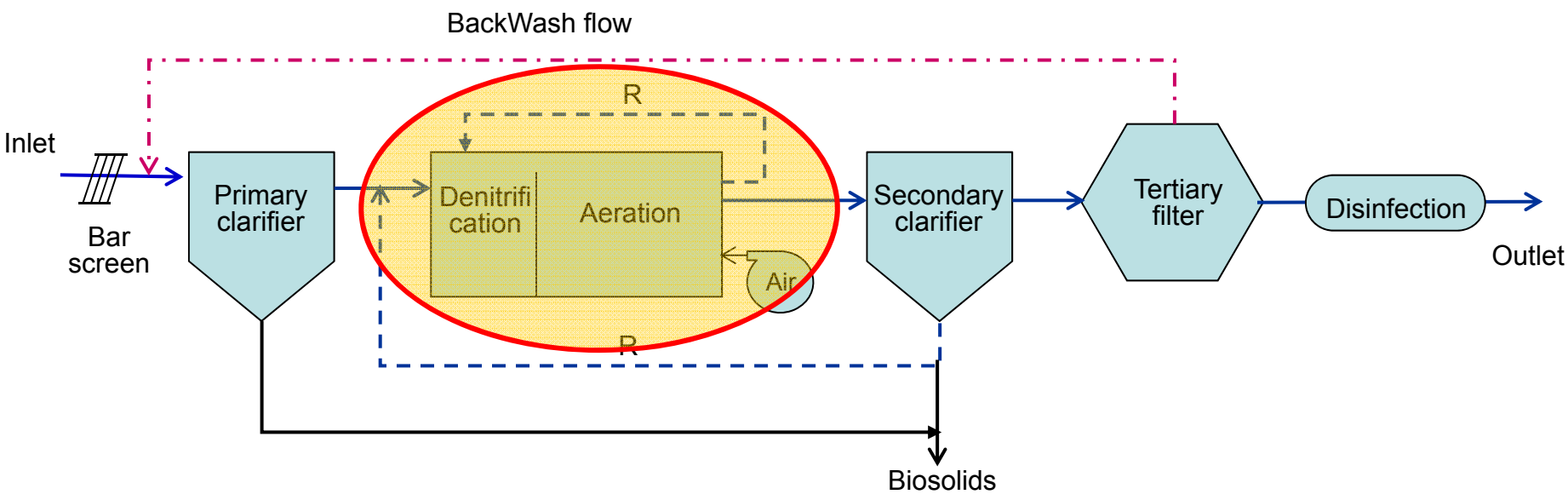
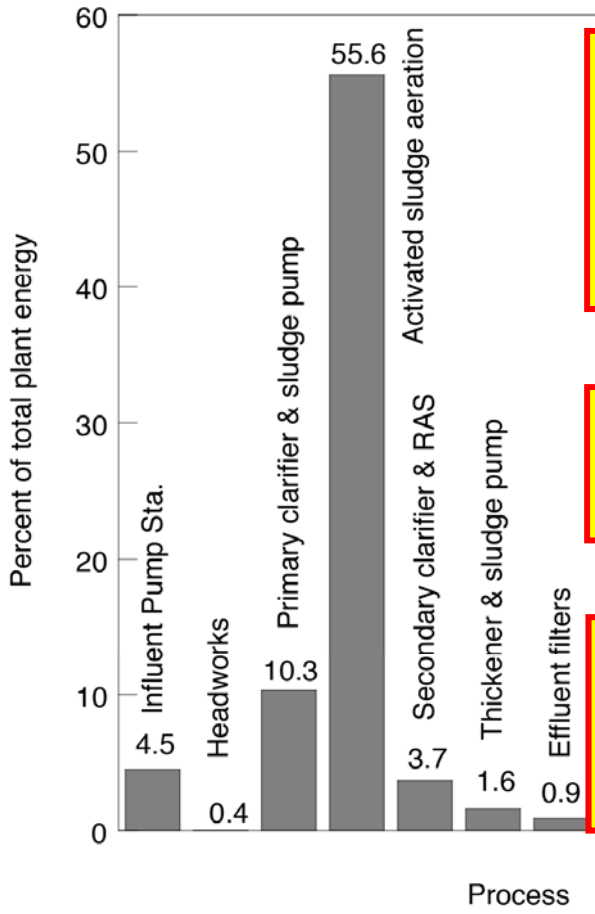
Conventional activated sludge process with nitrfication/denitrification



Energy distribution in conventional municipal wastewater treatment plant

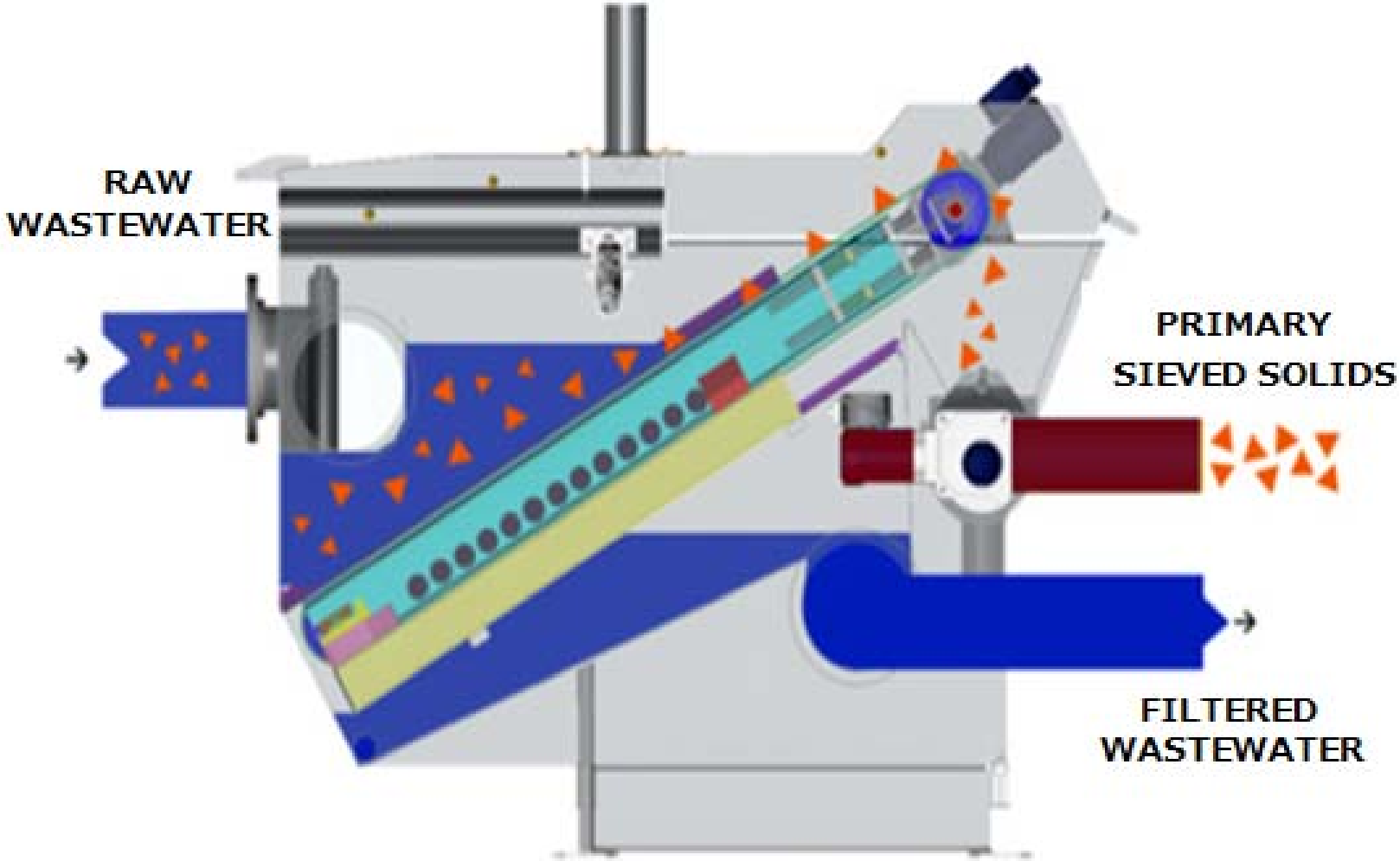


Energy requirements in an issue of increased concern, as about 0.5-0.7 kWh/m^3 are required for treatment

Aprox. 60% of the energy consumption is used for aeration

Aprox. 12% of the energy consumption is used for primary sludge management

Microscreen - Operating principle

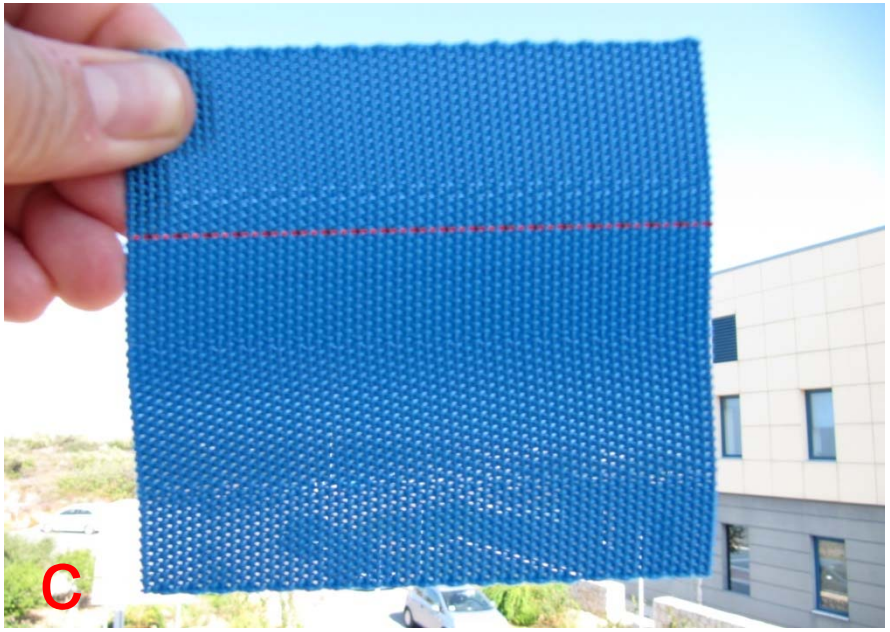


Microscreen

a. Microscreen with open housing

b. Sludge removal (~45% TS)

c. Microscreen cloth (100-350µm openings)



Microscreen (Patra, Greece)

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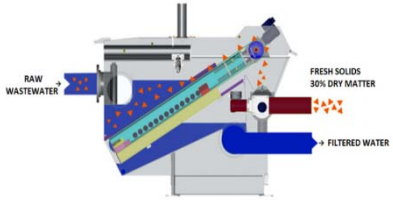
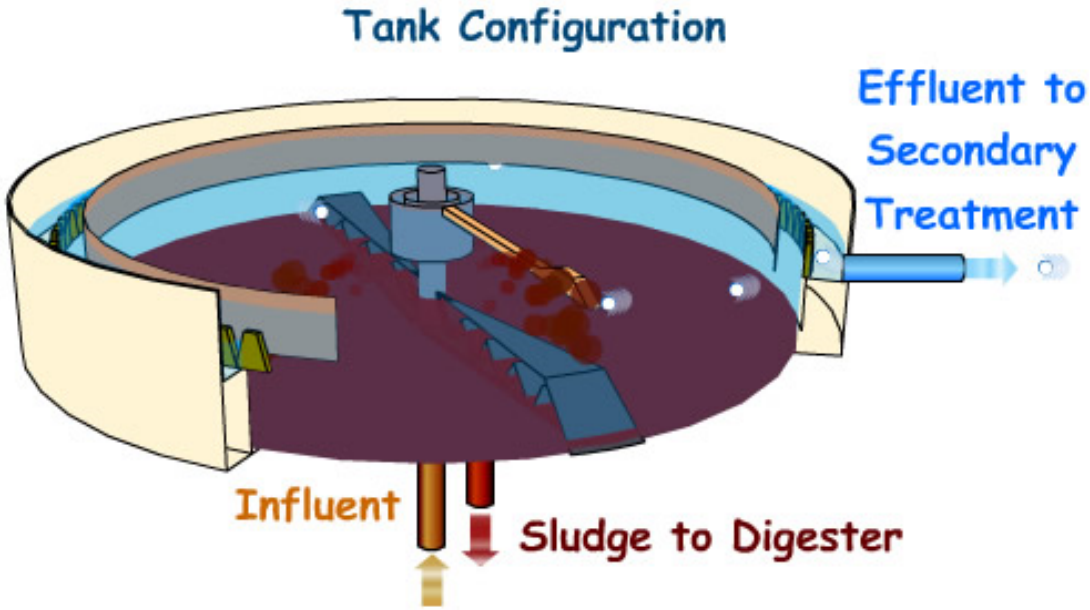
Footprint requirements

Wastewater flow: 4000m^3/d:
Microscreen footprint: 4 m^2
Clarifier footprint: 82 m^2





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Upflow sand filters, Adelanto, California
(15000 m3/d)
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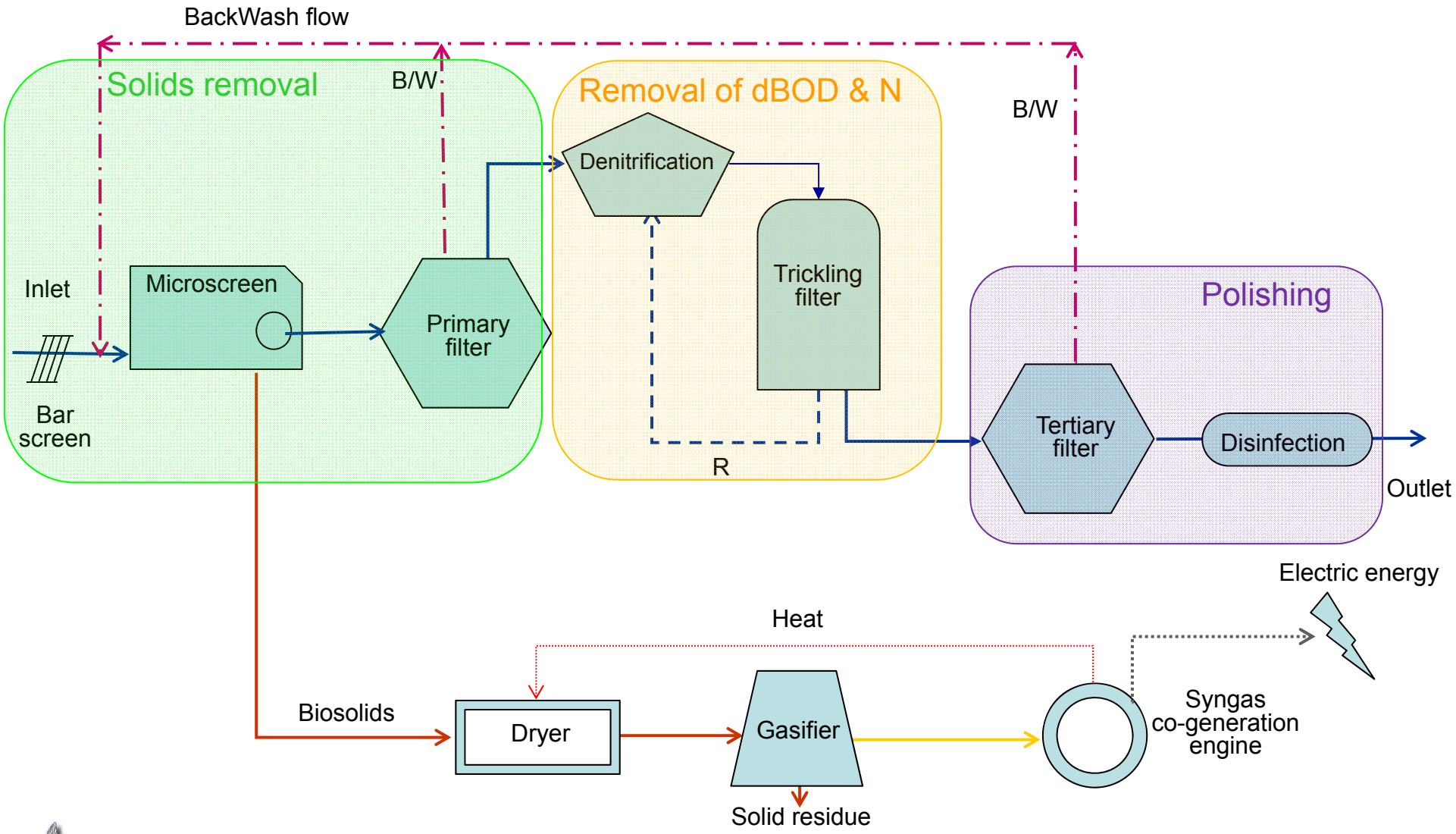
Upfront solids removal (USR) process with biosolids gasification



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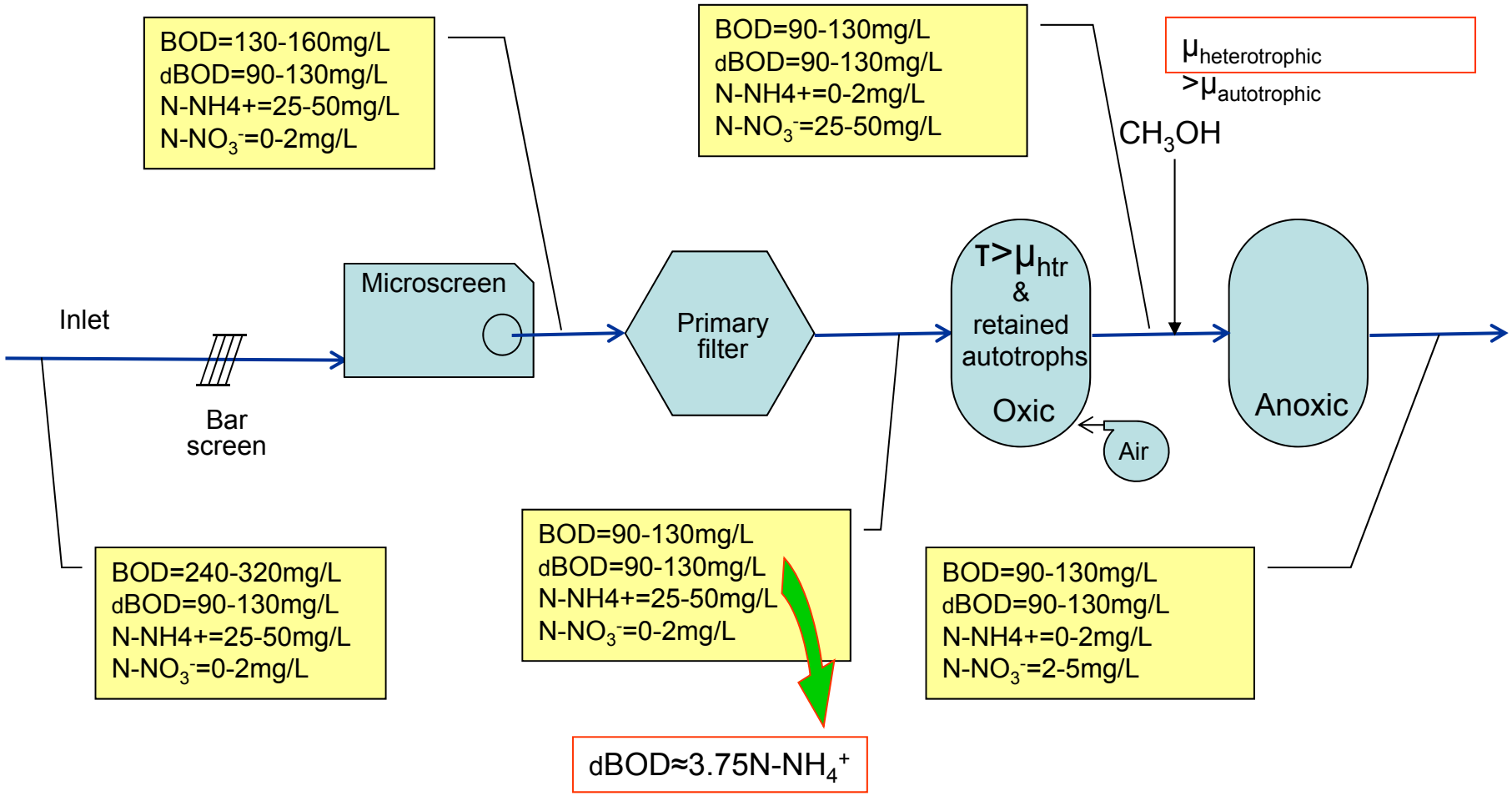
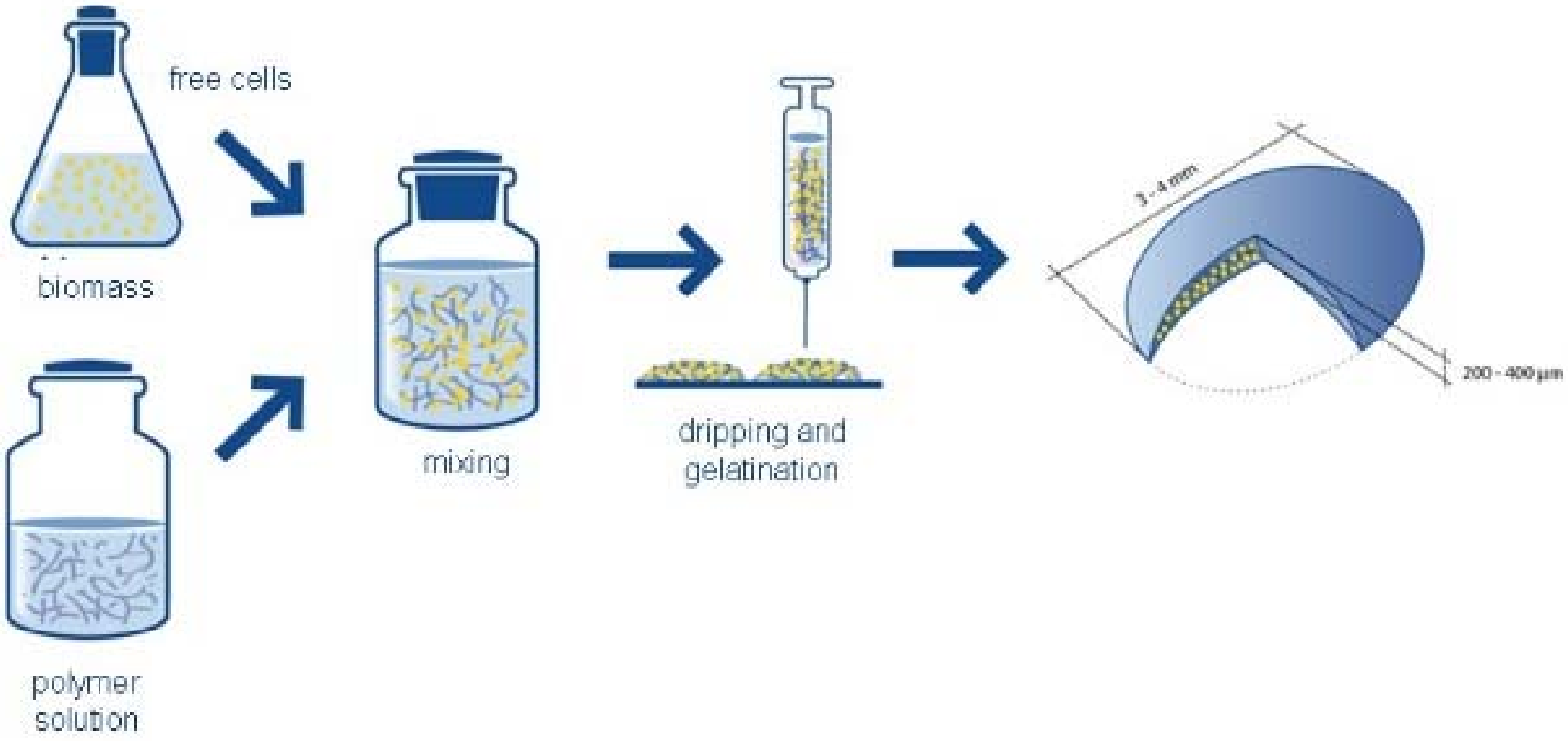
Upfront solids removal (USR) process with biosolids gasification



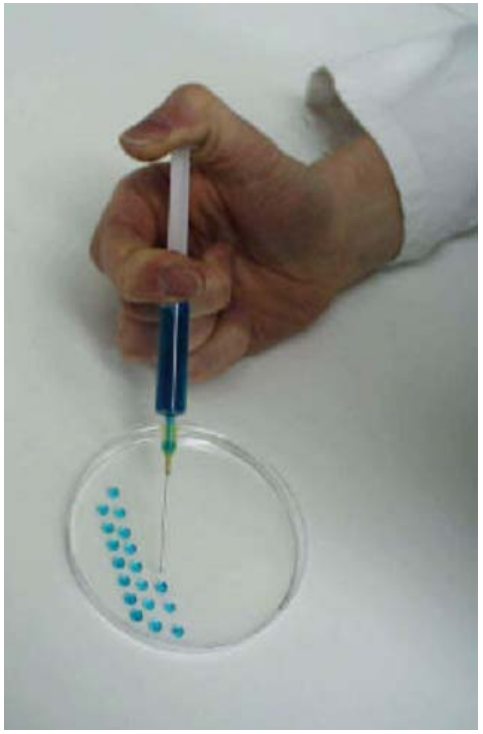
Scope of work

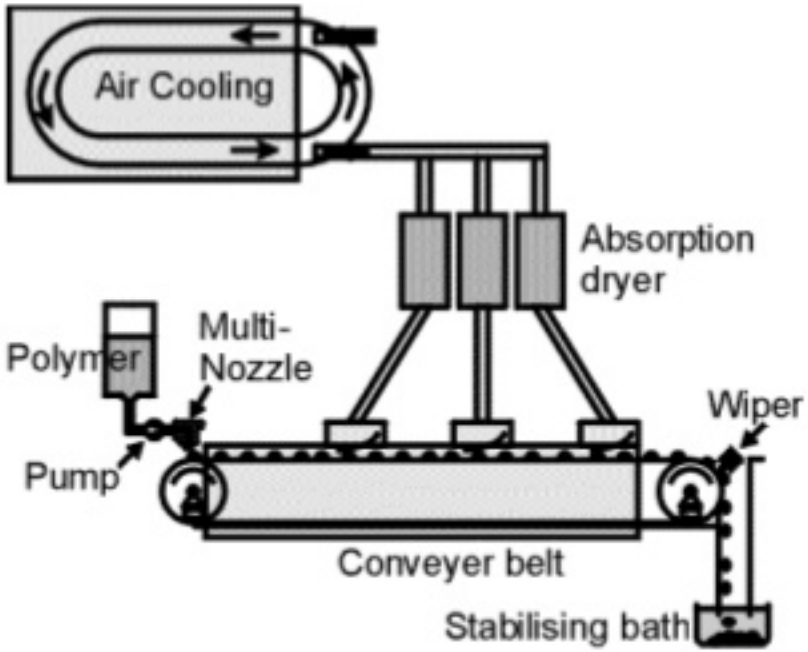
- Investigate the performance of **encapsulated** microbial systems for nitrification/denitrification
- Examine the feasibility of **“once through”** nitrification/denitrification system, with no need for addition of external carbon source
- Investigate the appropriate **hydraulic retention time** for selective nitrification without BOD oxidation
- Calculate the required **reactor volume**

Biomass encapsulation process

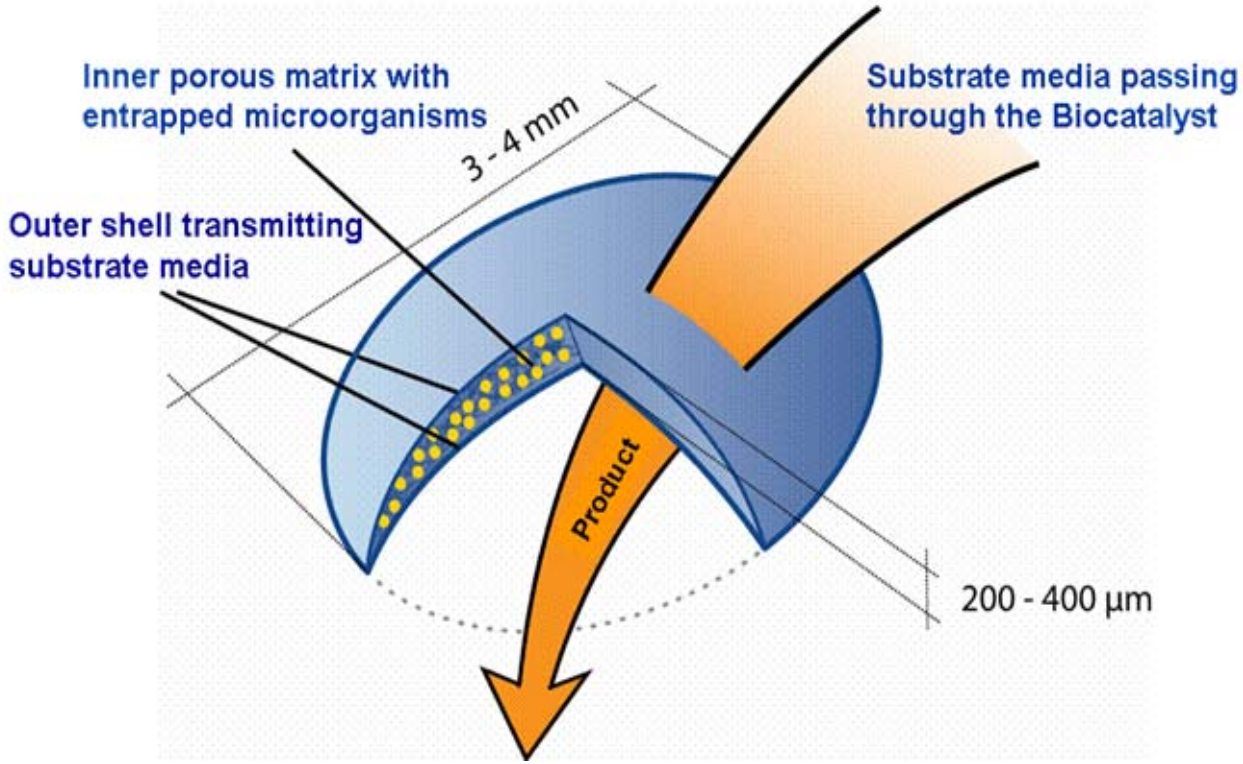


Biomass encapsulation process

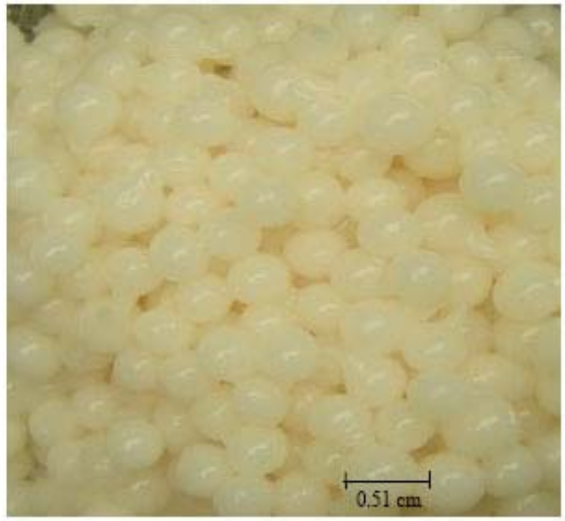




Lens shape encapsulated biomass



Encapsulated biomass



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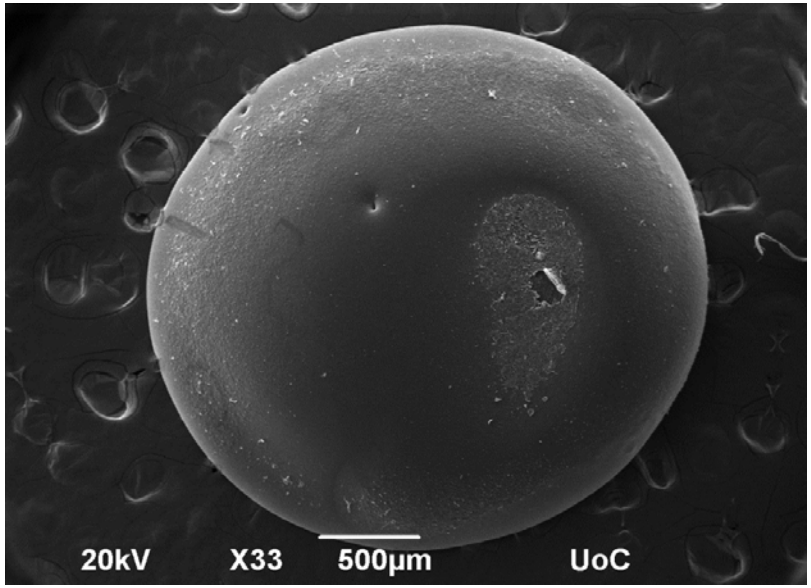
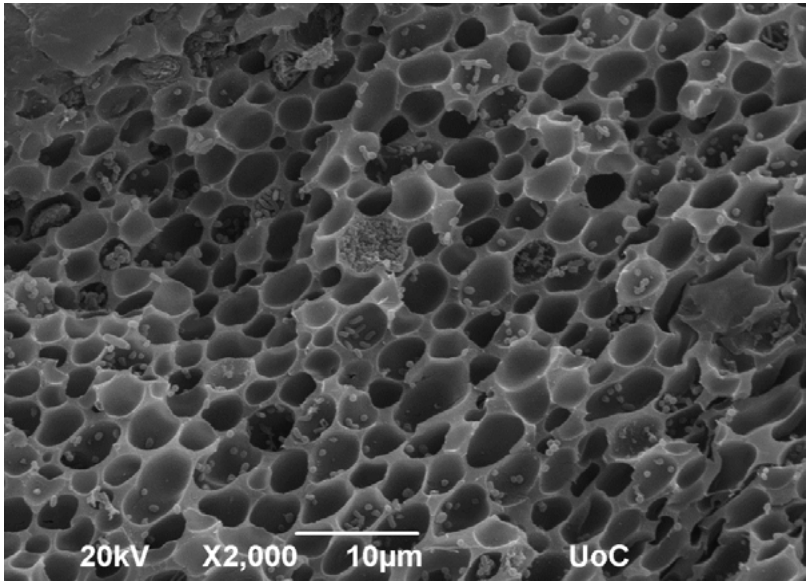
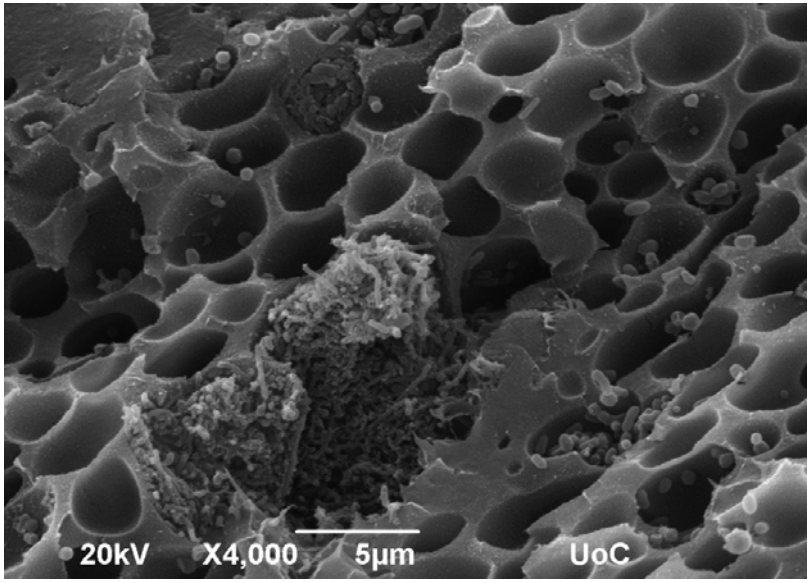
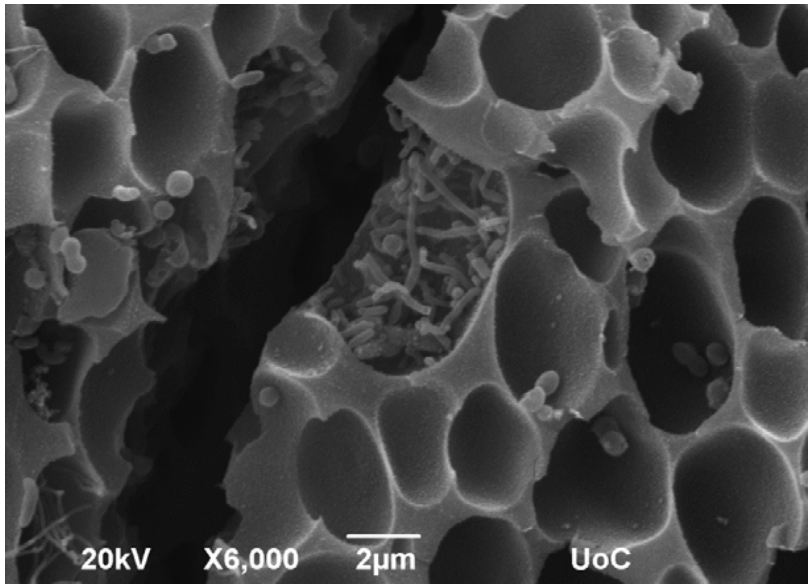
Lentikats Biocatalyst – Nitrification bacteria

Nitrosomonas europaea and *Nitrobacter winogradskyi*



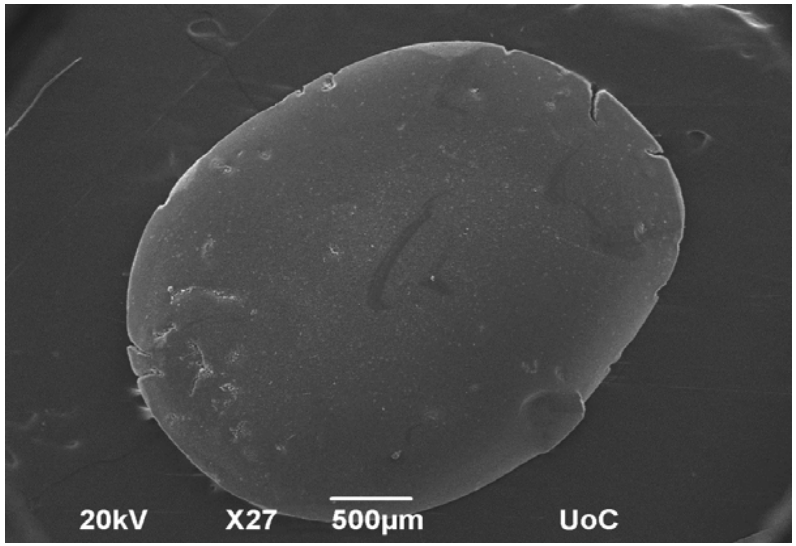


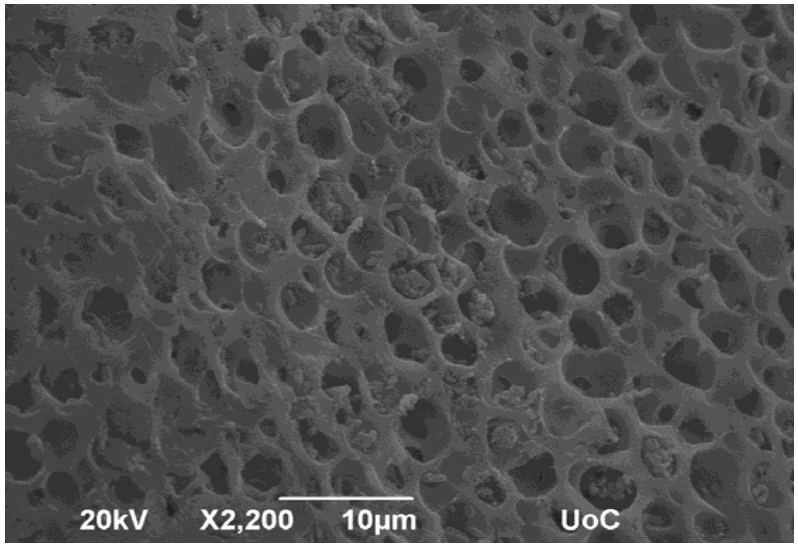


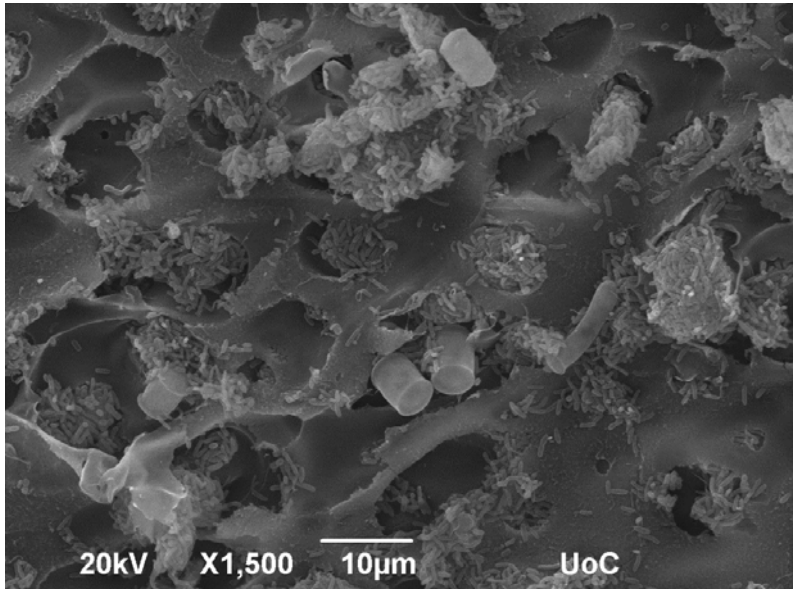


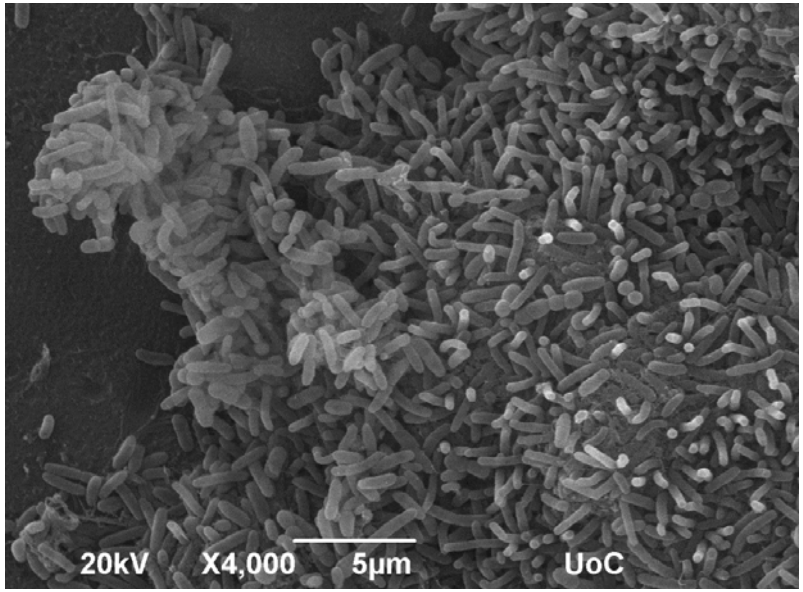
Lentikats Biocatalyst – Denitrification bacteria

Paracoccus denitrificans and *Pseudomonas fluorescens*





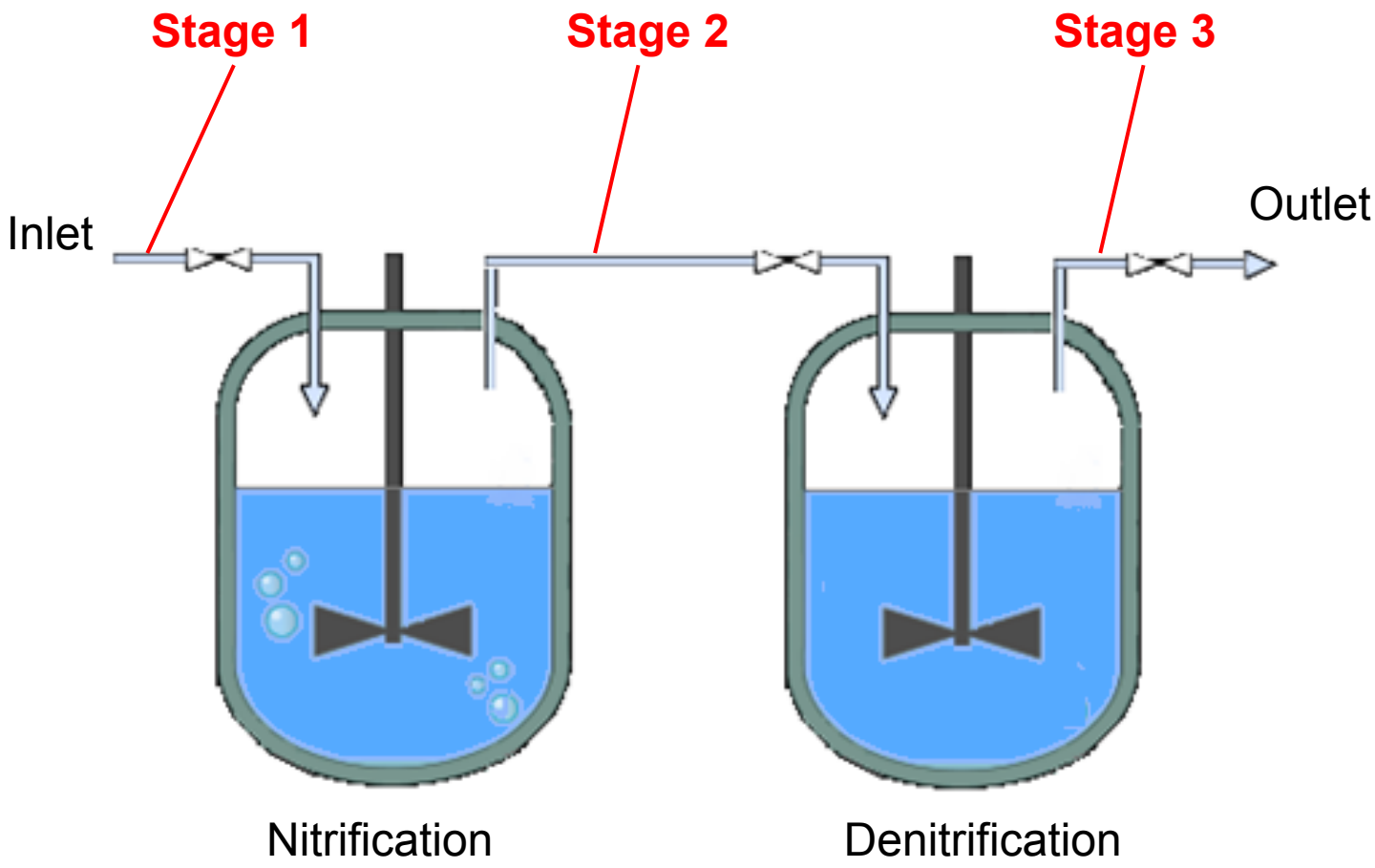




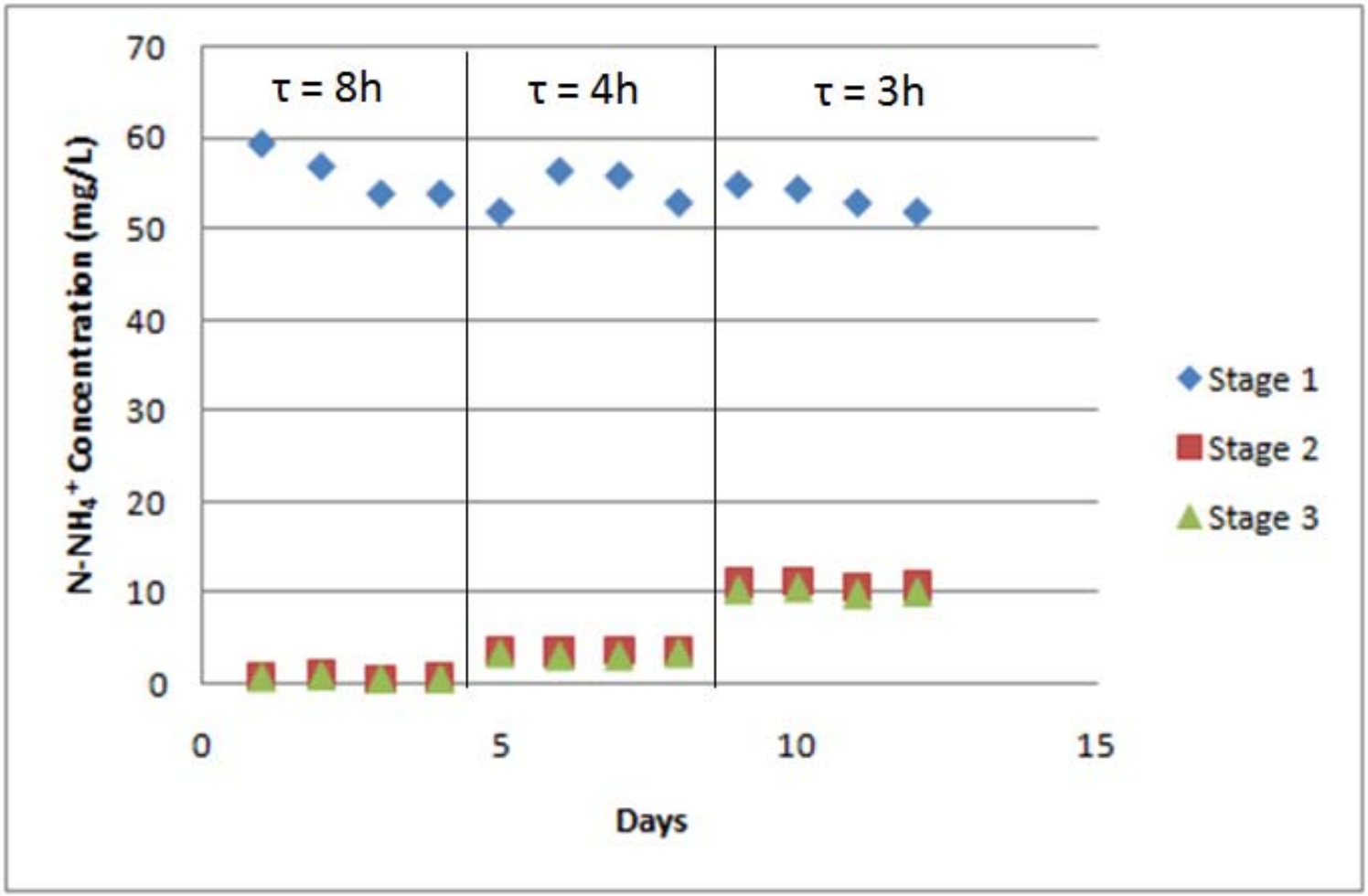
Nitrification/Denitrification dual CSTR system

Examined bioreactors

Nitrification/Denitrification bioreactors system



Nitrification/Denitrification CSTR system



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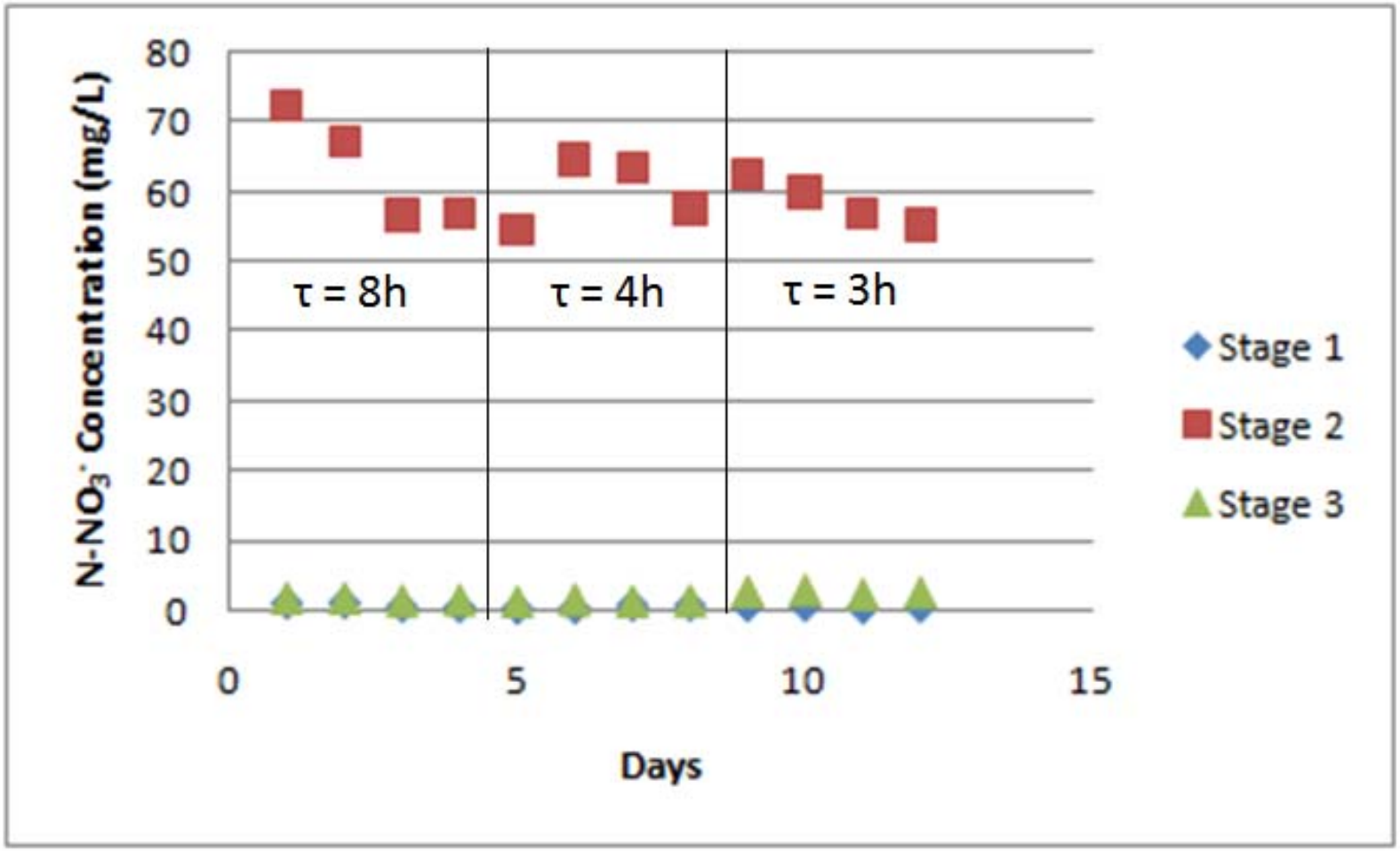
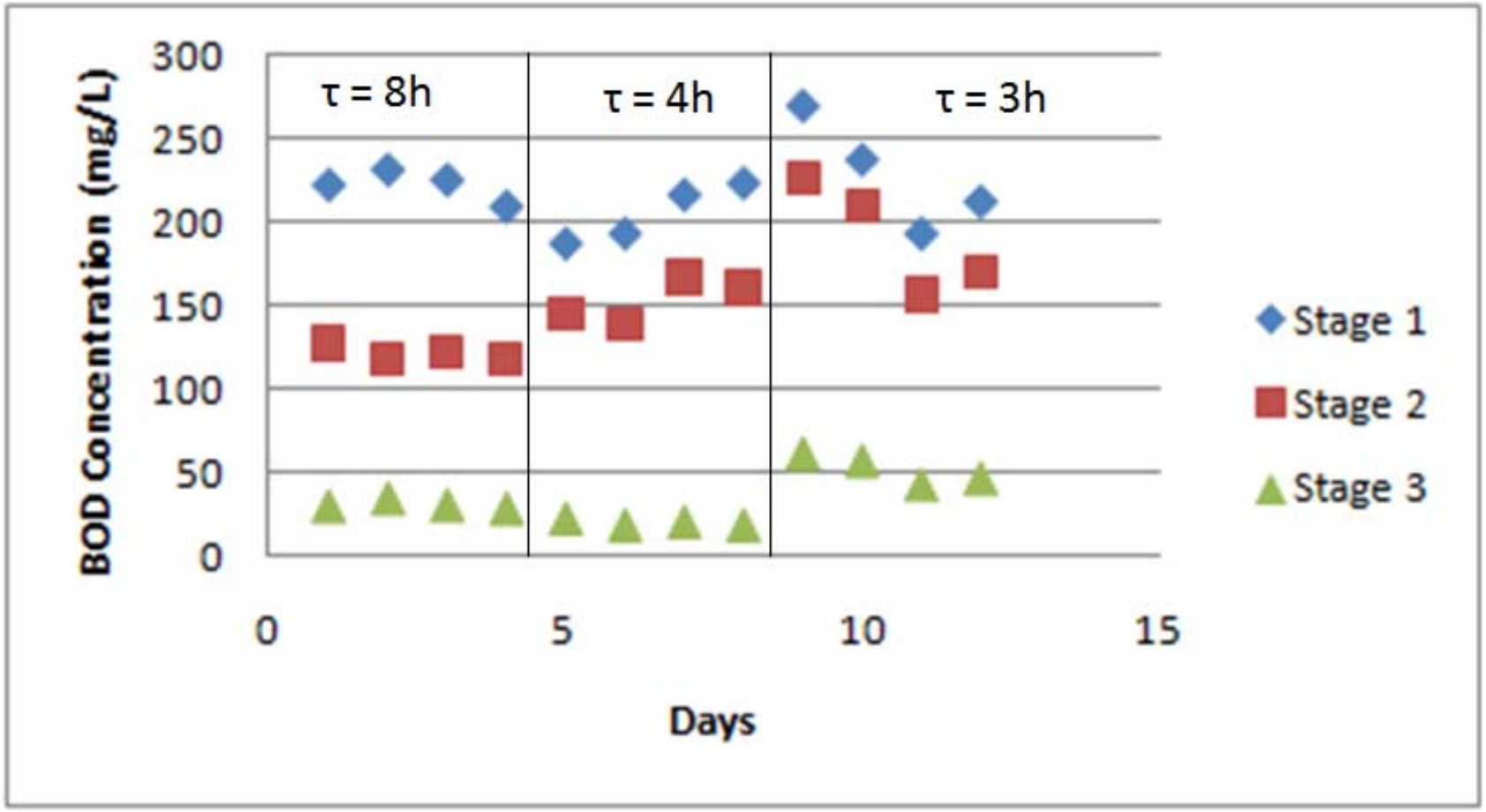
Nitrification/Denitrification CSTR system

- Nitrate as nitrogen removal rates: 95% - 98%



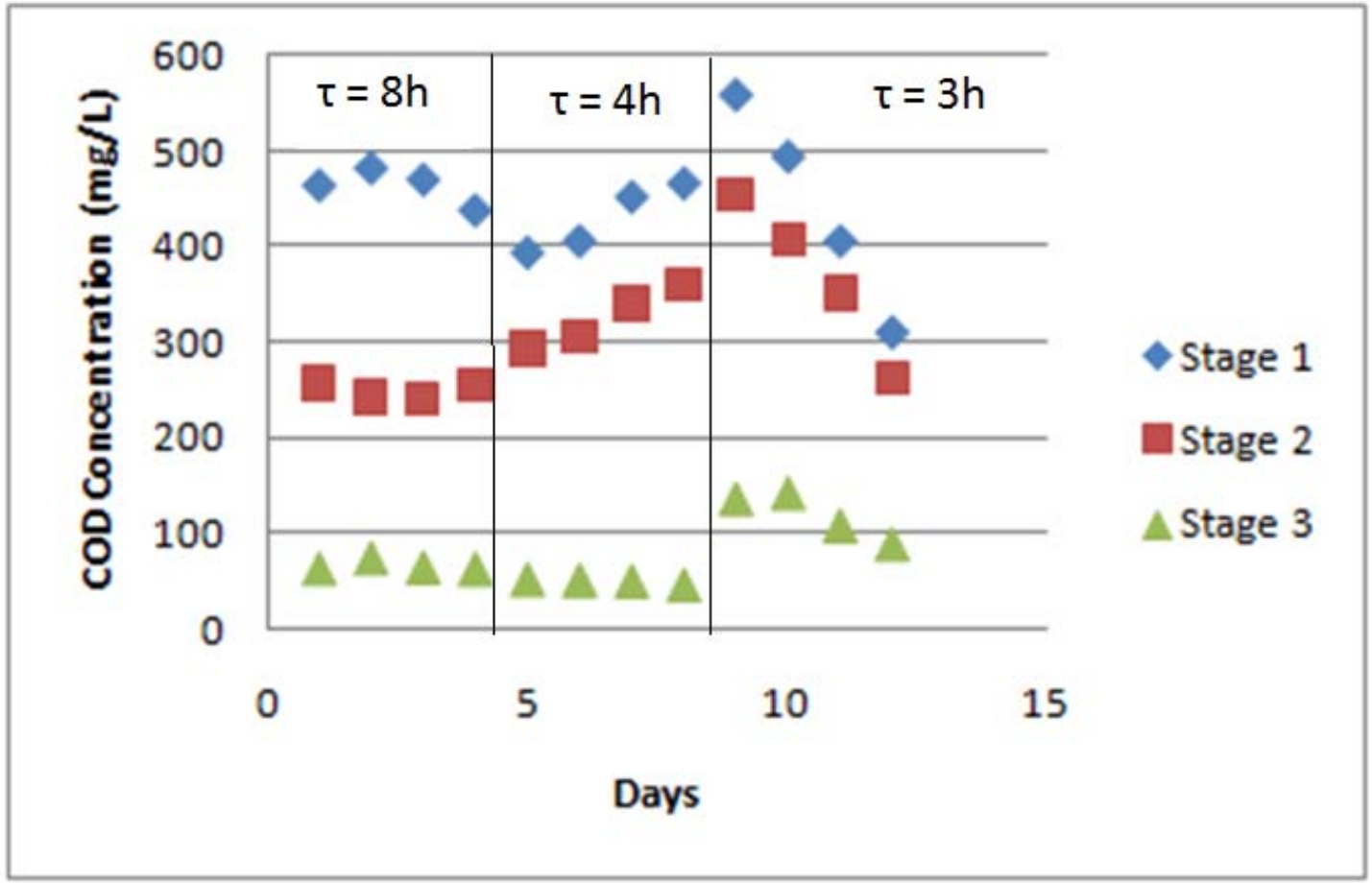
Nitrification/Denitrification CSTR system

- BOD removal rates: 73% - 90%



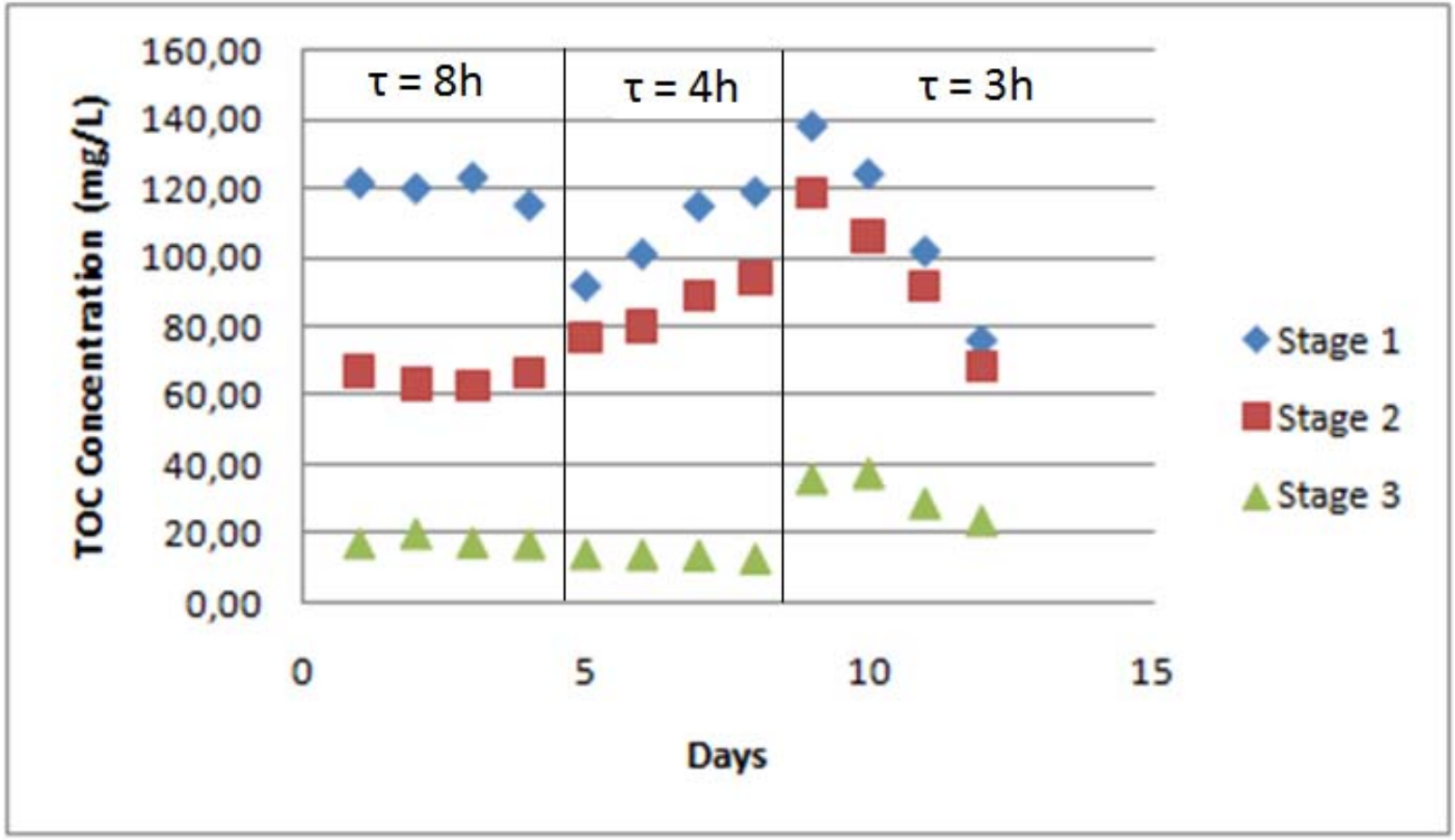
Nitrification/Denitrification CSTR system

- COD removal rates: 70% - 89%



Nitrification/Denitrification CSTR system

- TOC removal rates: 70% - 89%



Comparisson of encapsulated/free biocatalyst

- **Nitrification reaction rates:**
  - *Activated sludge system:* 0.21 $gNH_4^+\text{-}N_{removed}/(g_{nitrifiers}\cdot d)$
  - *Encapsulated biocatalyst:* 0.23 $gNH_4^+\text{-}N_{removed}/(g_{nitrifiers}\cdot d)$

- **Denitrification reaction rates:**
  - *Activated sludge system:* 0.23 $gNO_3^-\text{-}N_{removed}/(g_{denitrifiers}\cdot d)$
  - *Encapsulated biocatalyst:* 0.25 $gNO_3^-\text{-}N_{removed}/(g_{denitrifiers}\cdot d)$

Encapsulated system contained about 16 times more nitrification or denitrification microorganisms per volume, compared to activated sludge system

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At about 16 times saving space from nitrification/denitrification tanks

Conclusions

- Once through nitrification/denitrification process can be achieved using encapsulated biocatalysts

- BOD_5, NH_4^+-N and NO_3^--N outlet concentrations are below the limits imposed Directive 98/15/EC, especially for the lower hydraulic retention times.

- The reactor volume for nitrification/denitrification may be reduced by 16 times, if encapsulated systems are used

- The system also saves pumping energy, while there in no need for the use of external organic carbon

Thank you for your attention!

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