ESR 2.4

Nutrient removal in wastewater using microalgae

M. Sc. Carlo Pozza
Urban Water and Waste Management

Universitätsstr. 15
45141 Essen

carlo.pozza@uni-due.de
www.uni-due.de/SiwAwi

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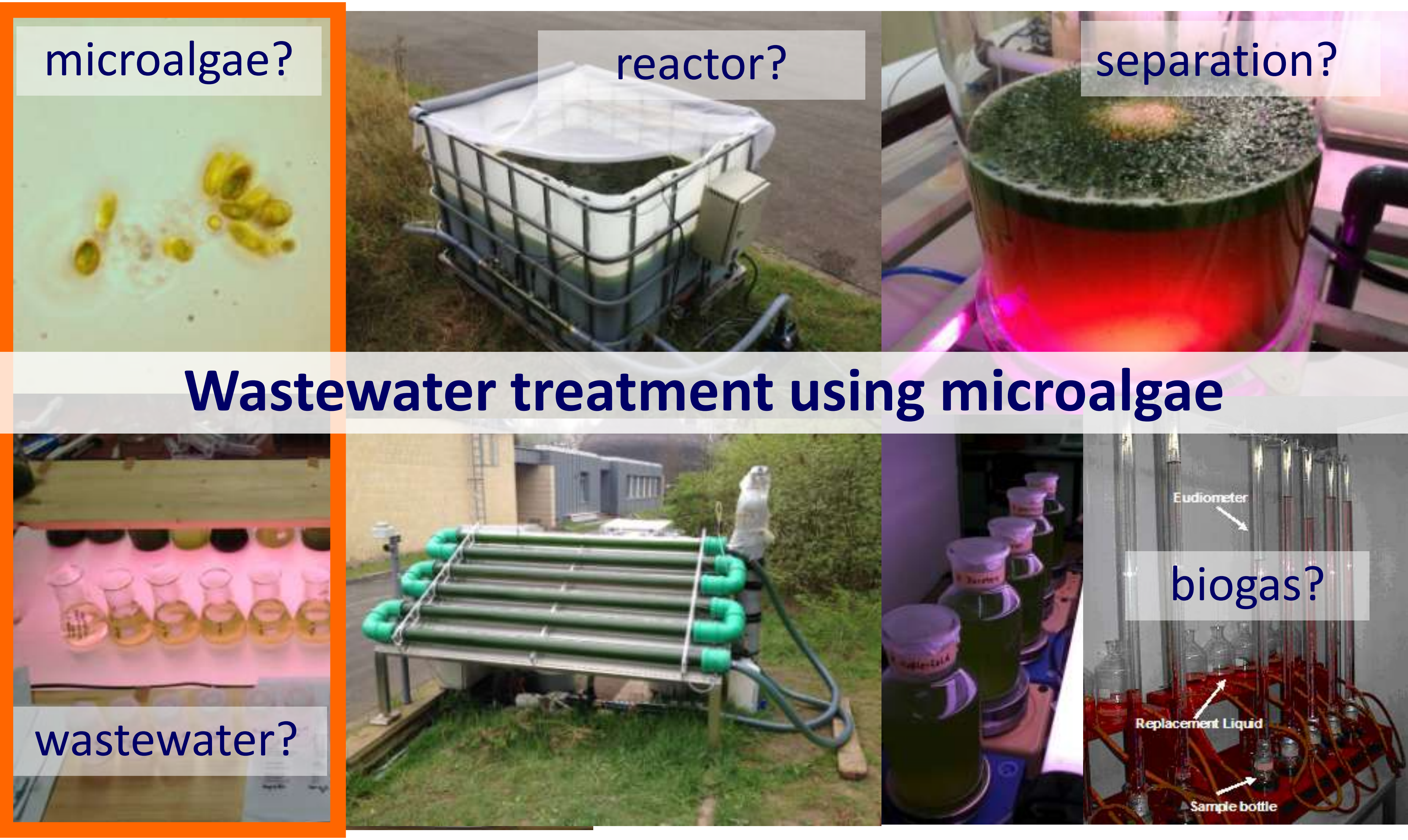
Presentation summary



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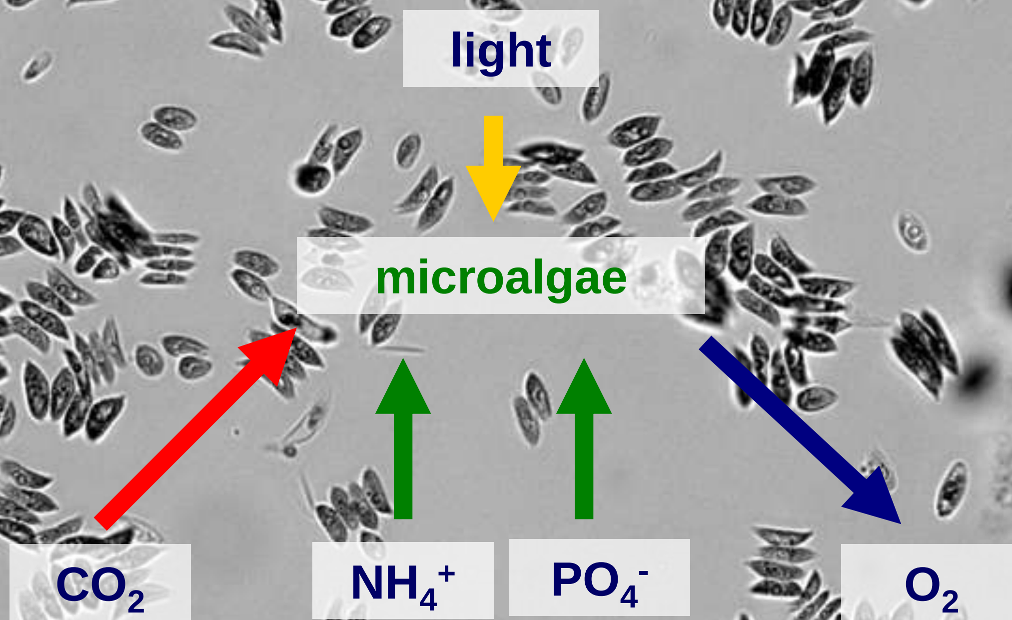
Microalgae and artificial wastewater



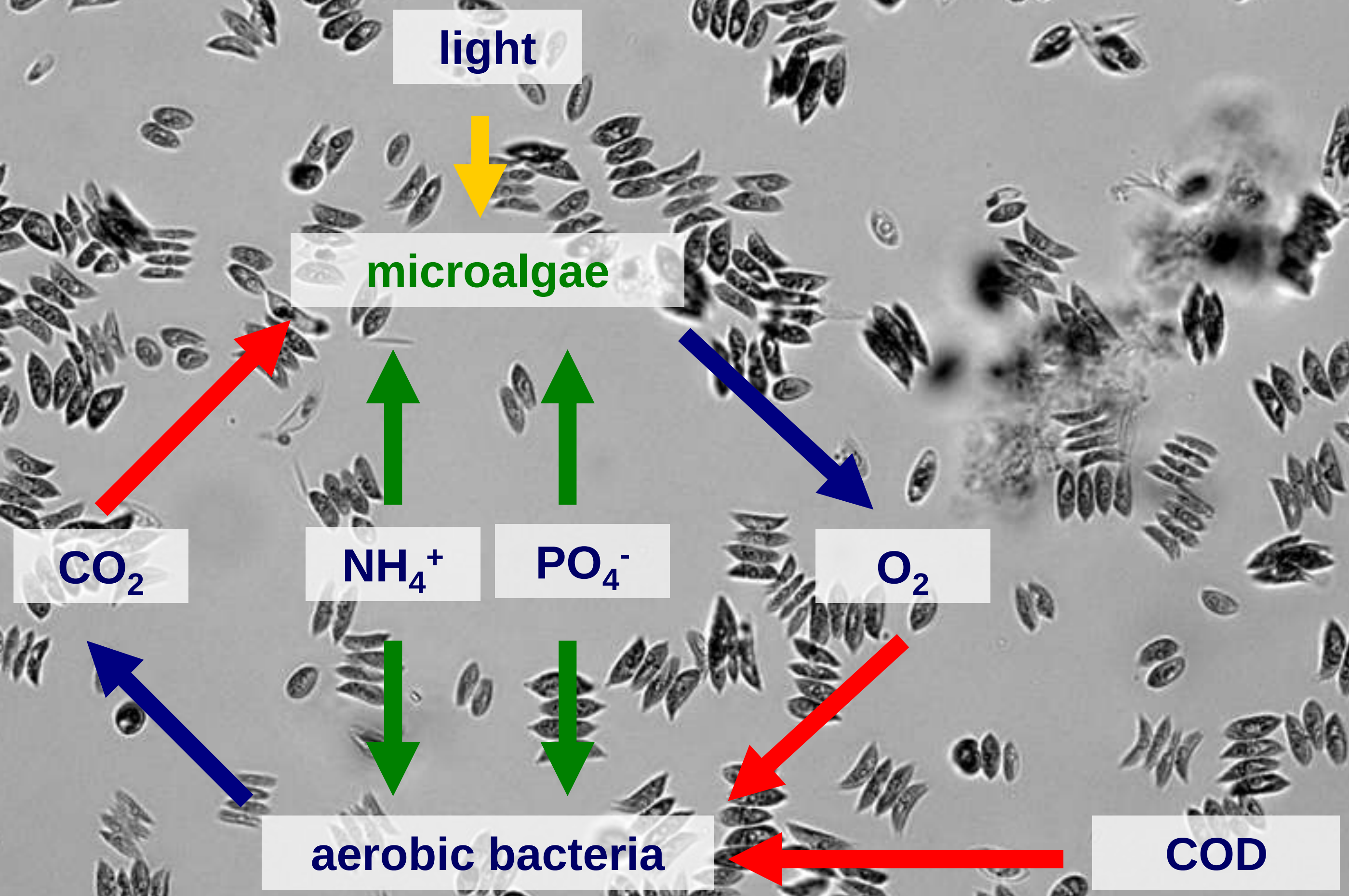
Microalgae grow naturally in wastewater

Microalgae remove N and P during their growth

(proteins are 45-60% of microalgae dry weight)

5,2-6,4 mg NH_4-N/L/d 45-65 mg TSS/L/d	*Scenedesmus* sp. (Park et al. 2010)
2,3 mg NH_4-N/L/d	*Chlorella* sp. (Wang et al. 2009)

Microalgae and real wastewater



Synergic effects (O_2 production (bacteria); rising of the pH for metals and phosphorus precipitation, ammonia volatilization)

Algal-bacteria biomass
20-25 mg NH_4-N/L/d (Gutzeit et al. 2005)
27 mg N/L/d (Van der Hende et al. 2010)

Wastewater Treatment Plant of Dorsten (DE)

For microalgae is interesting the nutrient removal in wastewater with low organic carbon content. Where the conventional active sludge treatment is more difficult.

Centrate of the sludge thickening	
Parameter	**Concentration**
COD (mgO_2/L)	**150-200**
DOC (mgC/L)	**90-150**
TN (mgN/L)	**500-900**
NH_4-N (mgN/L)	**400-700**
NO_2-N (mgN/L)	**0-0,5**
NO_3-N (mgN/L)	**0-2,0**
Total phosphorous (mgP/L)	**15-40**
C/N ratio	**0,1-0,4**
N/P ratio	**25-33**

Microalgae selection

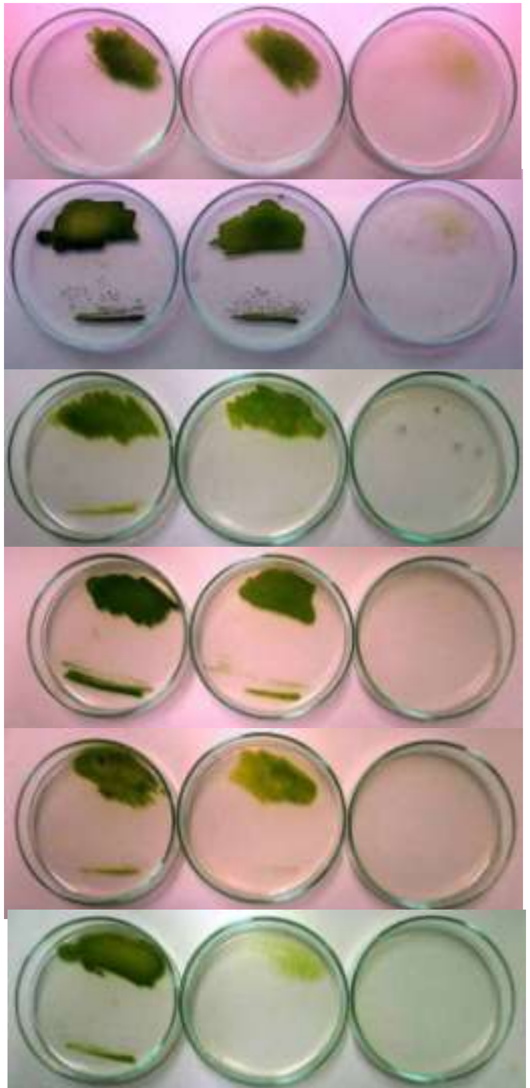
Centrate of Dorsten
COD = 210 mg O_2/L
NH_4-N = 842 mg N/L
TP = 49,3 mg P/L

Petri Dishes
Agar 1,5%
Ampicillin 200 mg/L
Microalgae (200 µL)

16:8 light/night cycle
40-60 µmol/m^2/s

% of the Centrate in the media

25% 50% 100%



Dorsten native mixture from Centrate (*Scenedesmus* sp. and *Chlorella* sp.)

Mix of *Chlorella sp.* and *Scenedesmus sp.*

***Scenedesmus* sp.**

***Chlorella* sp.**

Dorsten native mixture from urban wastewater (*Scenedesmus* sp. and *Chlorella* sp.)

Scenedesmus obliquus

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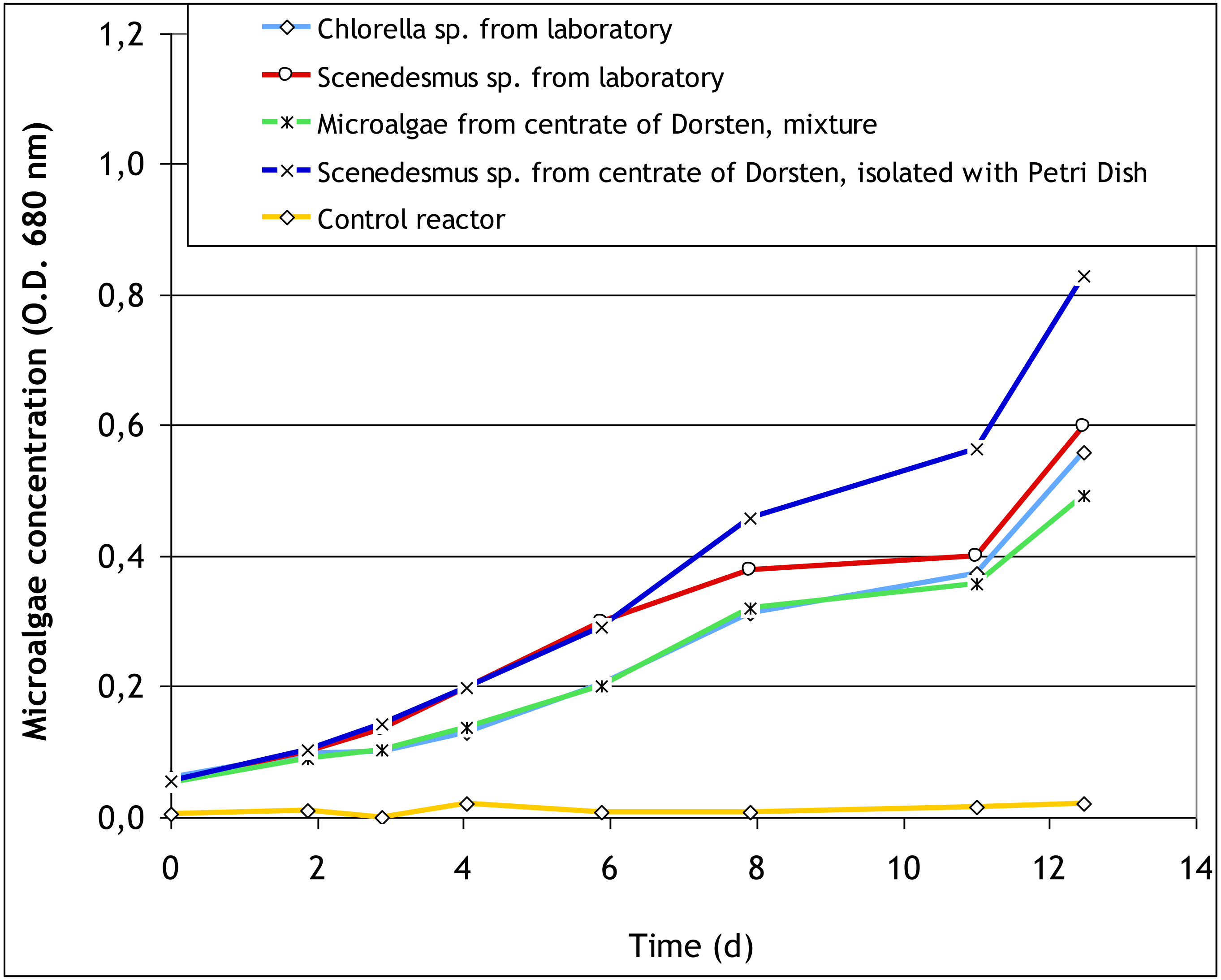
Microalgae selection

Reactor volume: 1 L
Stirred, pH controlled to 8
bubbling CO_2

Illumination:
20:4 light/night cycle
50-70 µmol/m^2/s

Dorsten centrate: 50 mL
Starting concentrations:
DOC = 9,1±5,3 mg C/L
TN_b = 50,0±5,1 mg N/L
NH_4-N = 31,2±3,3 mg N/L
PO_4-P = 4,5±0,5 mg P/L



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Microalgae selection

Nutrient removal

TN_b removal (%)

30% *Chlorella* sp.

56% *Scenedesmus* sp.

71% Dorsten mix from centrate

94% *Scenedesmus* sp. isolated from the centrate with Petri dish

Biomass production

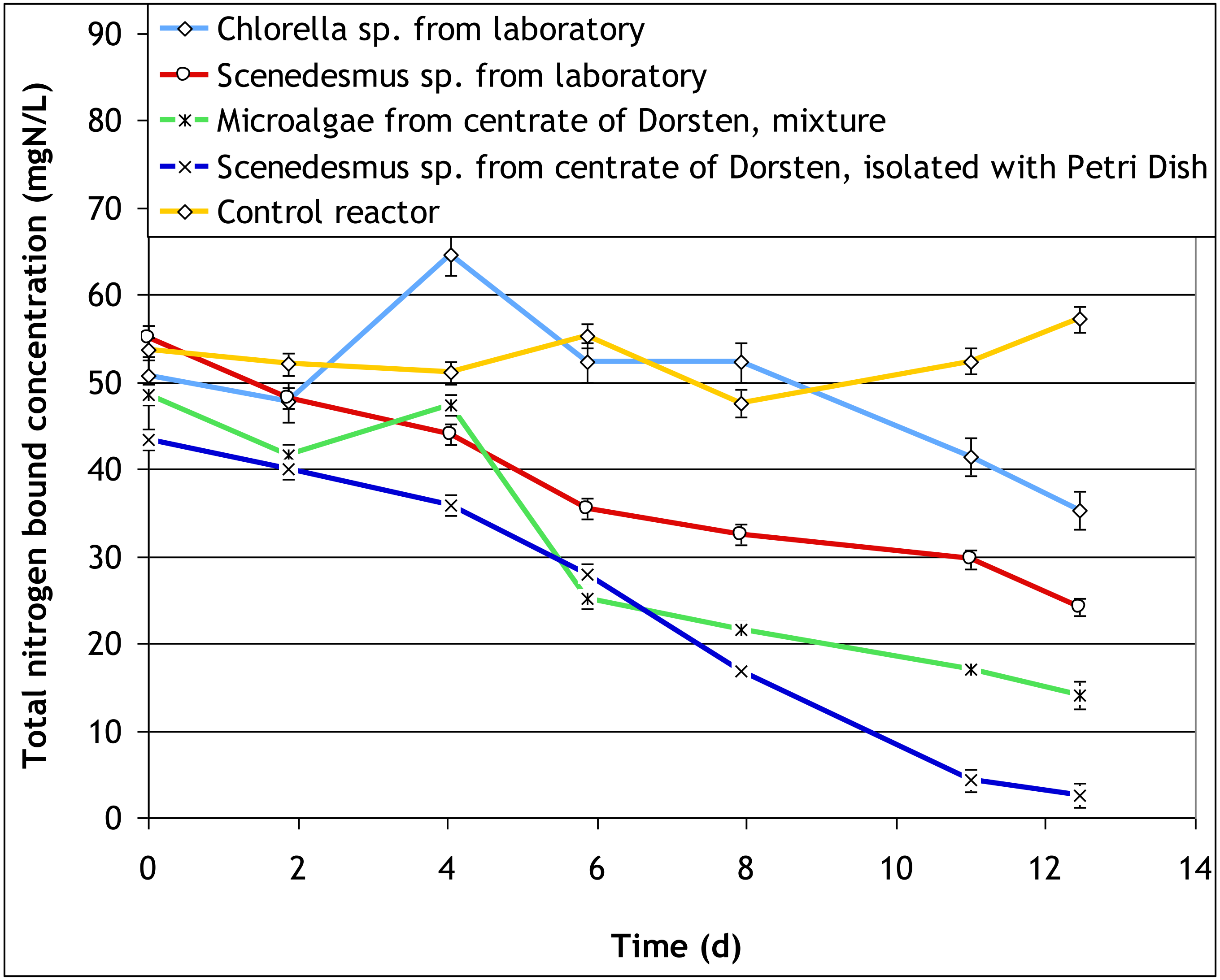
(mg TSS/L)

171 *Chlorella* sp.

260 Scenedesmus sp.

182 Dorsten mix from centrate

400 *Scenedesmus* sp. isolated from the centrate with Petri Dish



Wastewater treatment using microalgae

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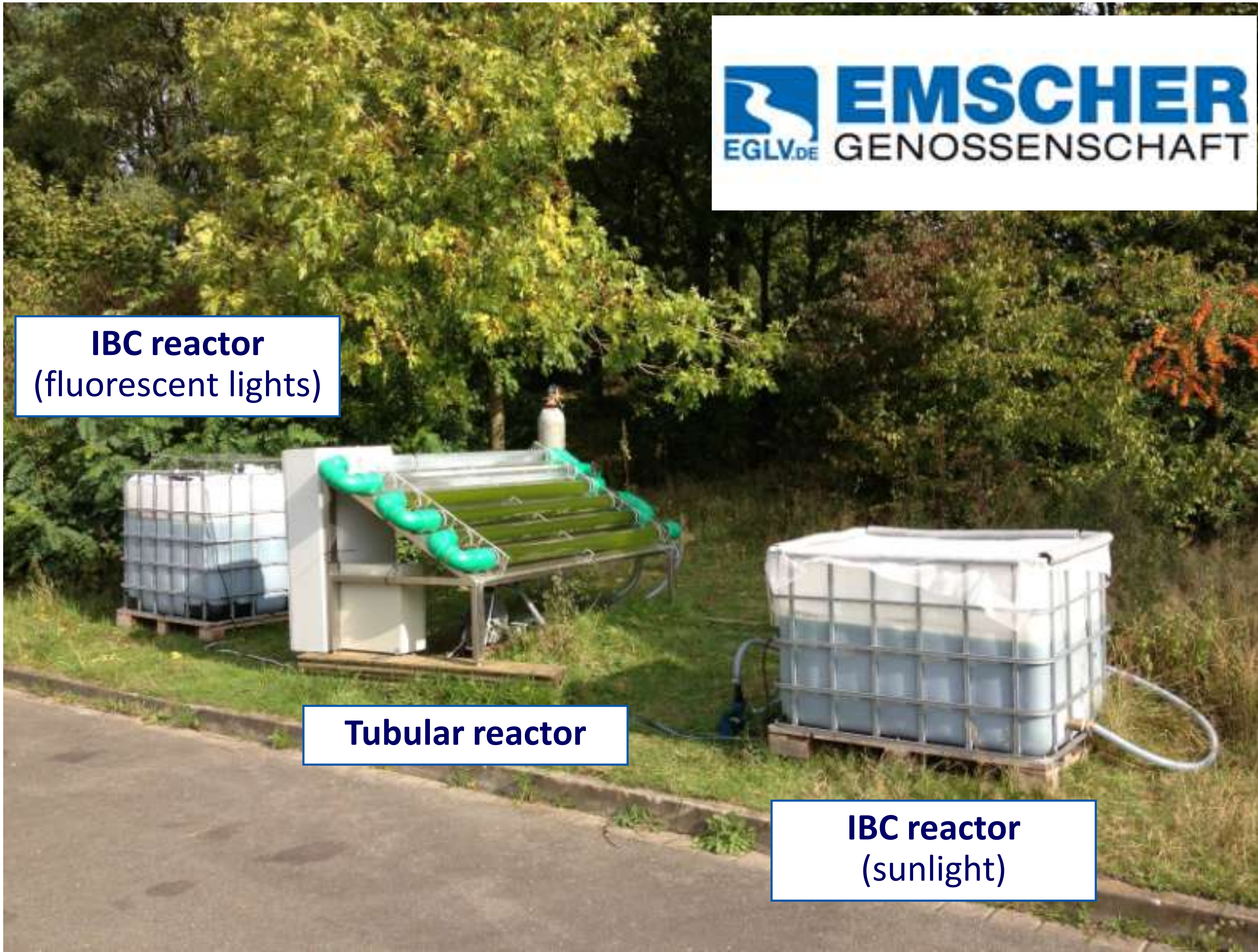
Photobioreactors in the WWTP of Dorsten



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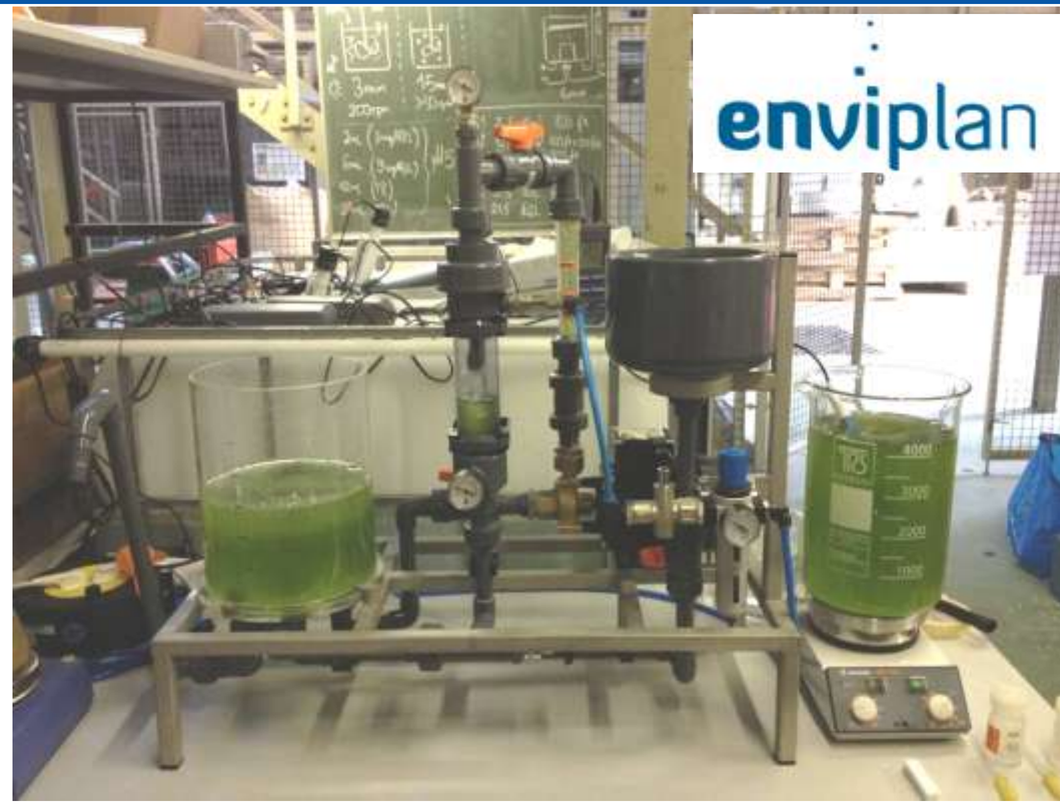
Harvesting of microalgae



Coagulation

3 min, 200 rpm, $Al_2(SO_4)_3$

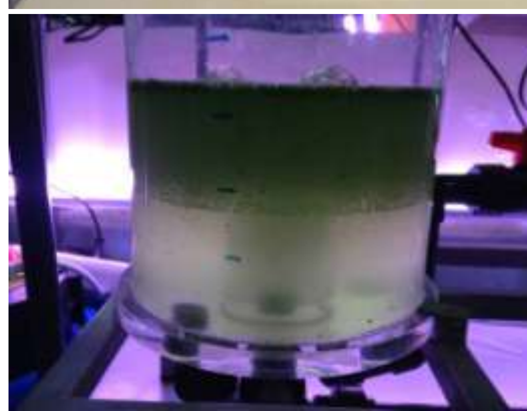
Flocculation

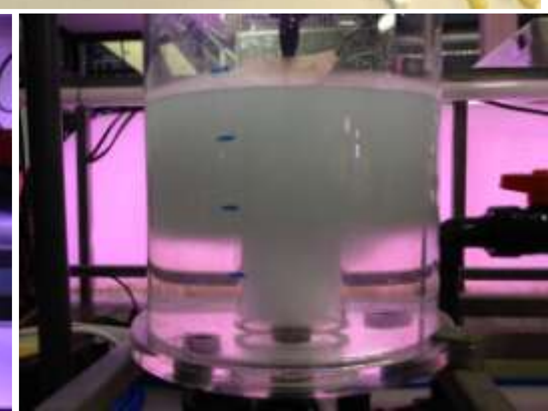
15 min, >50 rpm

Flotation

10 min, with microbubbles (30-40 µm) using:

enviplan® LAB-FLOAT 20





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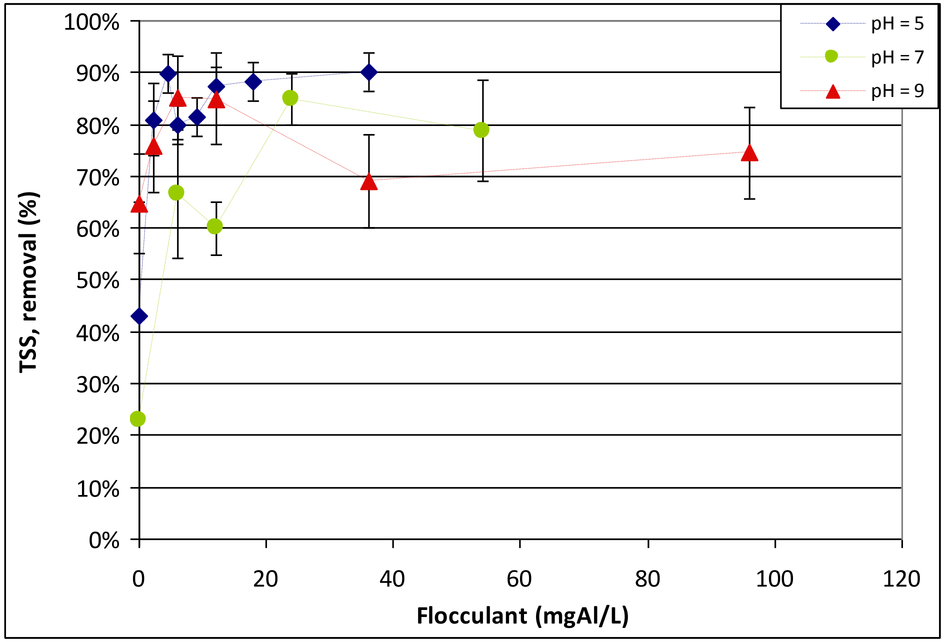
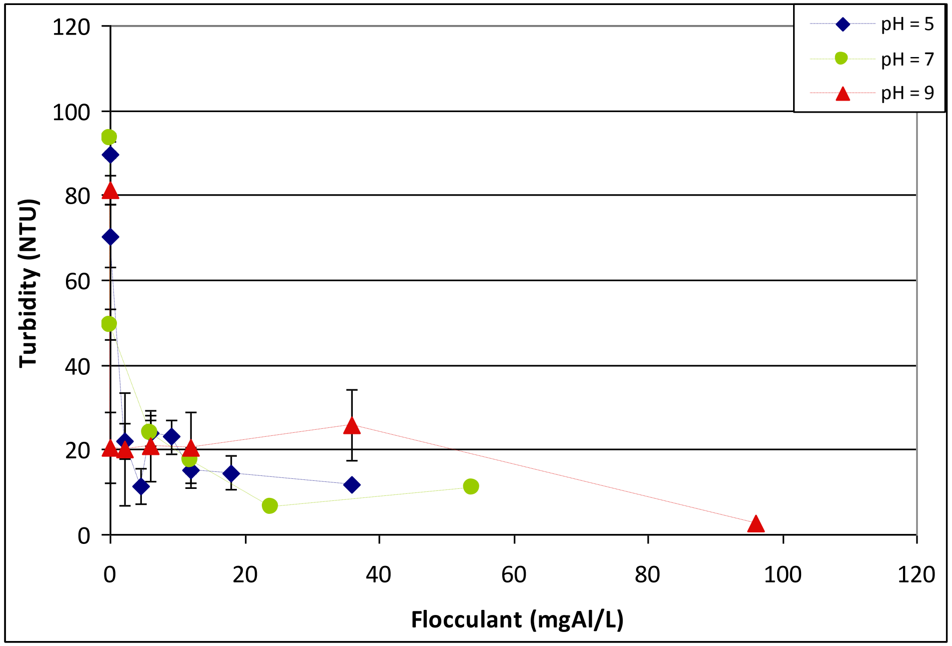
Results

Flocculant: $Al_2(SO_4)_3$
Different pH: 5, 7, 9
Different dose: from 0 to 90 mg Al/L

Microalgae concentration 100-150 mg TSS/L

With pH=5 and 5-20 mg Al/L
TSS removal: 85-90%
Turbidity removal: 80-95%





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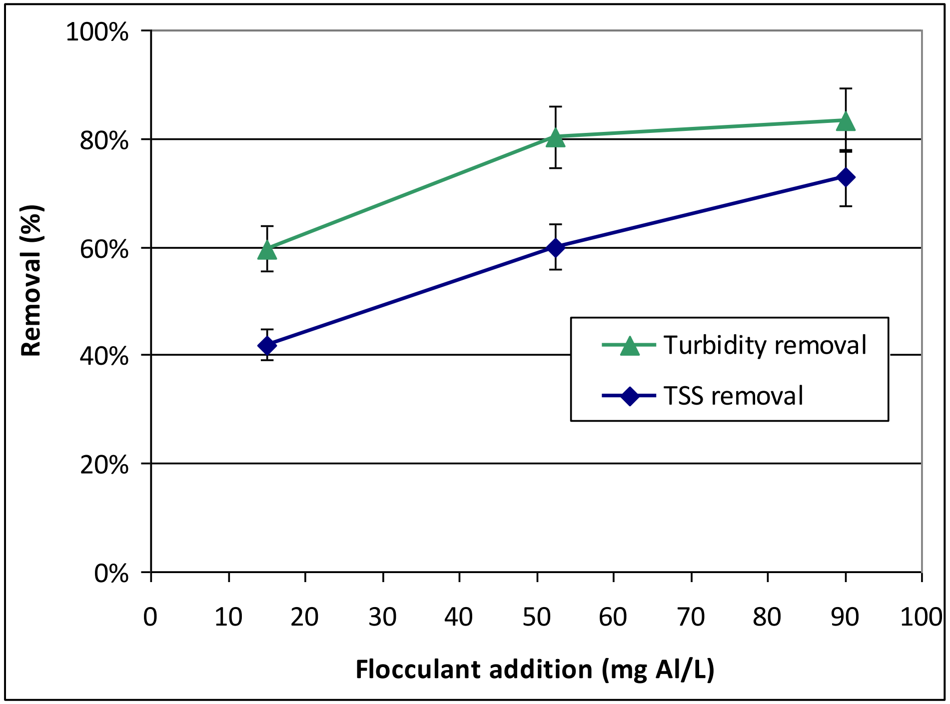
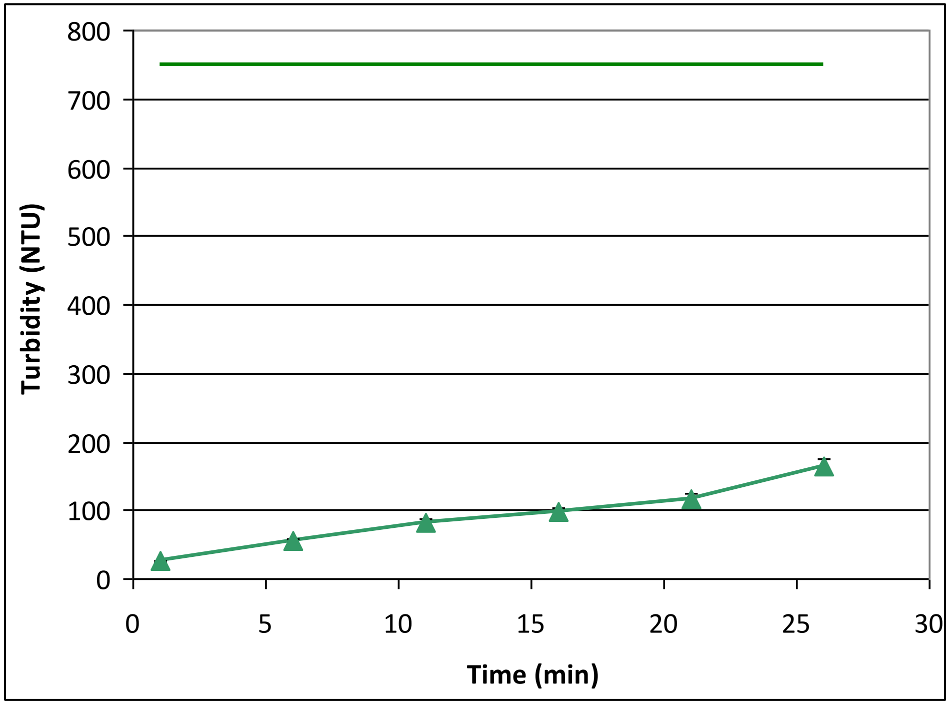
Results with the tubular photobioreactor

Experiment condition:
Flocculant: $Al_2(SO_4)_3$ dose: from 20 to 90 mg Al/L / pH= 5
Microalgae concentration = 890 mg TSS/L / Turbidity = 750

Single experiments
With pH=5 and 90 mg Al/L
TSS removal: 75%
Turbidity removal: 80%

Experiment in continuo (9,6 L/h)
pH=5 and 90 mg Al/L
Turbidity removal: 78-84%





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Biogas production

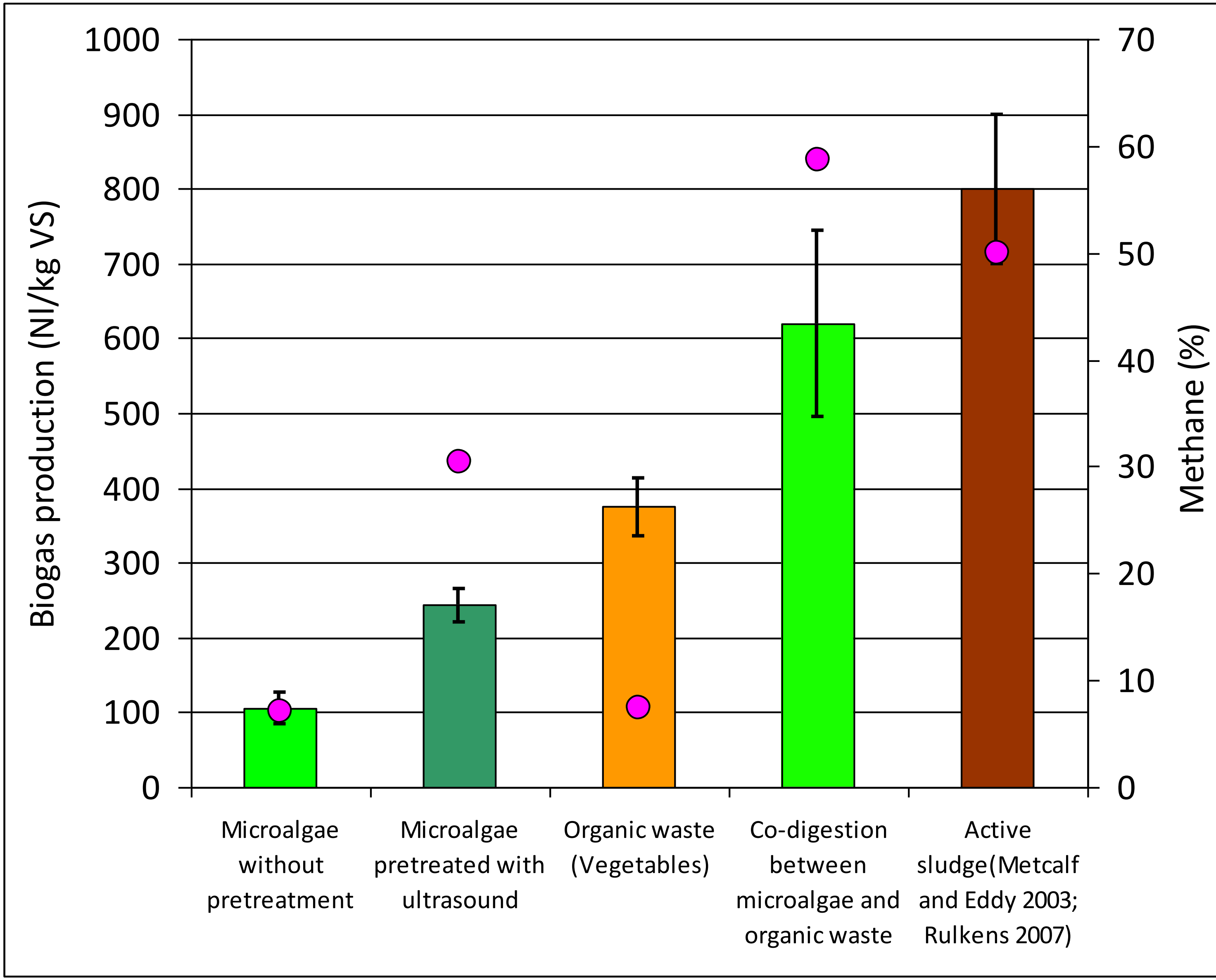
Standard test:

VDI 4630 (GB21)

Co-digestion ratio 1:1

Microalgae

Vegetable waste



Conclusions

- Microalgae are effective in wastewater treatment especially in wastewater where the C/N ratio makes the conventional treatment difficult
- Different type of reactor (or illumination) has different performance in nutrient removal
- The produced microalgae can be separated from the liquid phase and digested to produce energy.

Thank you for your attention

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