REMTECH EXPO
21-25 SEPTEMBER 2020
digital edition

Session 14

EFFLUENTS AND WASTEWATERS: CHALLENGES IN MANAGING ODORS AND MICROPOLLULANTS

25 September

RemTech Expo Digital Edition 2020 (21-25 September)
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Removal of nitrogen and phosphorus by microalgae isolated from wastewater of HERA-Ferrara sewage treatment plant

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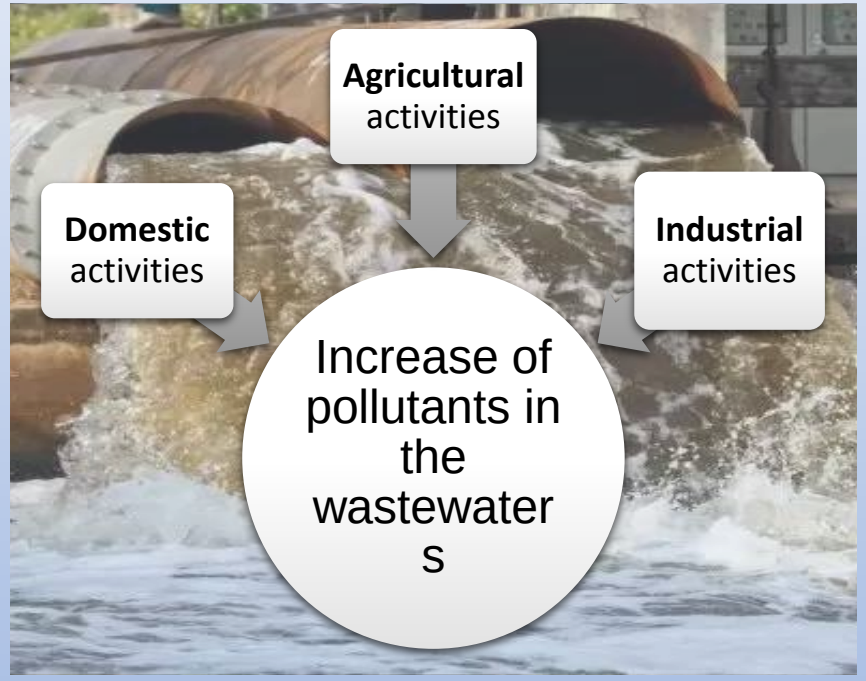
The wastewaters



High concentrations of **nitrogen** and **phosphorus** in the wastewaters cause the ***eutrophication*** in the water bodies

<u>Treatment is needed to reduce the nutrients that cause eutrophication</u>

Wastewater Treatment Plant → removal of organic and inorganic compounds from wastewaters

Wastewater treatment plant of HERA-Ferrara

Satellite image of the central wastewater treatment plant of Hera S.p.A. Via Gramicia, 95, Ferrara ©Google 2020

Urban line

Wastewaters from urban settlements

1.Primary treatments

2.Nitrification/ Denitrification

3.Phosphorus removal Disinfection

Po di Volano (water body)

Sludge

Sludge treatment line

1.Thickening

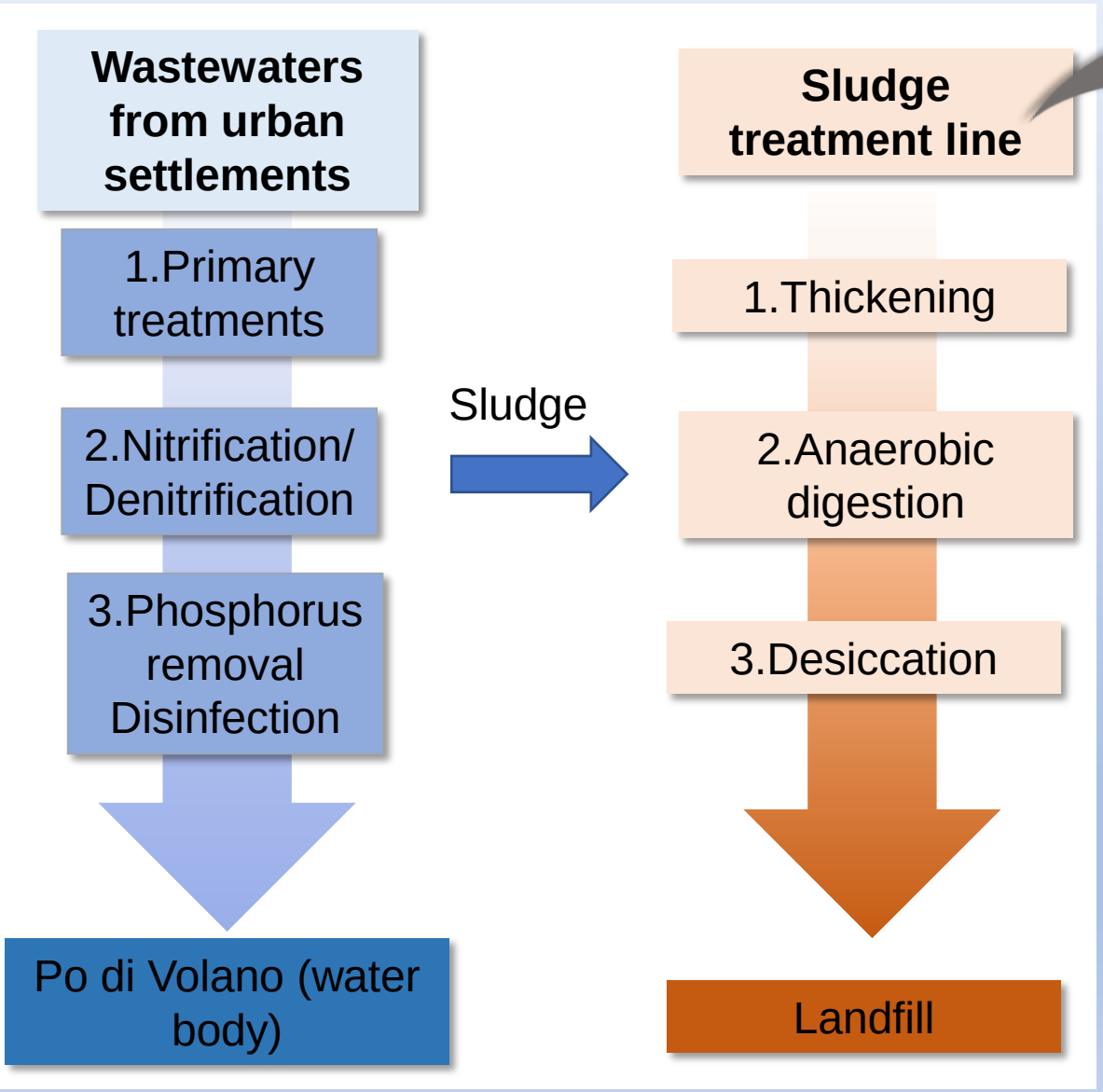
2.Anaerobic digestion

3.Desiccation

Landfill

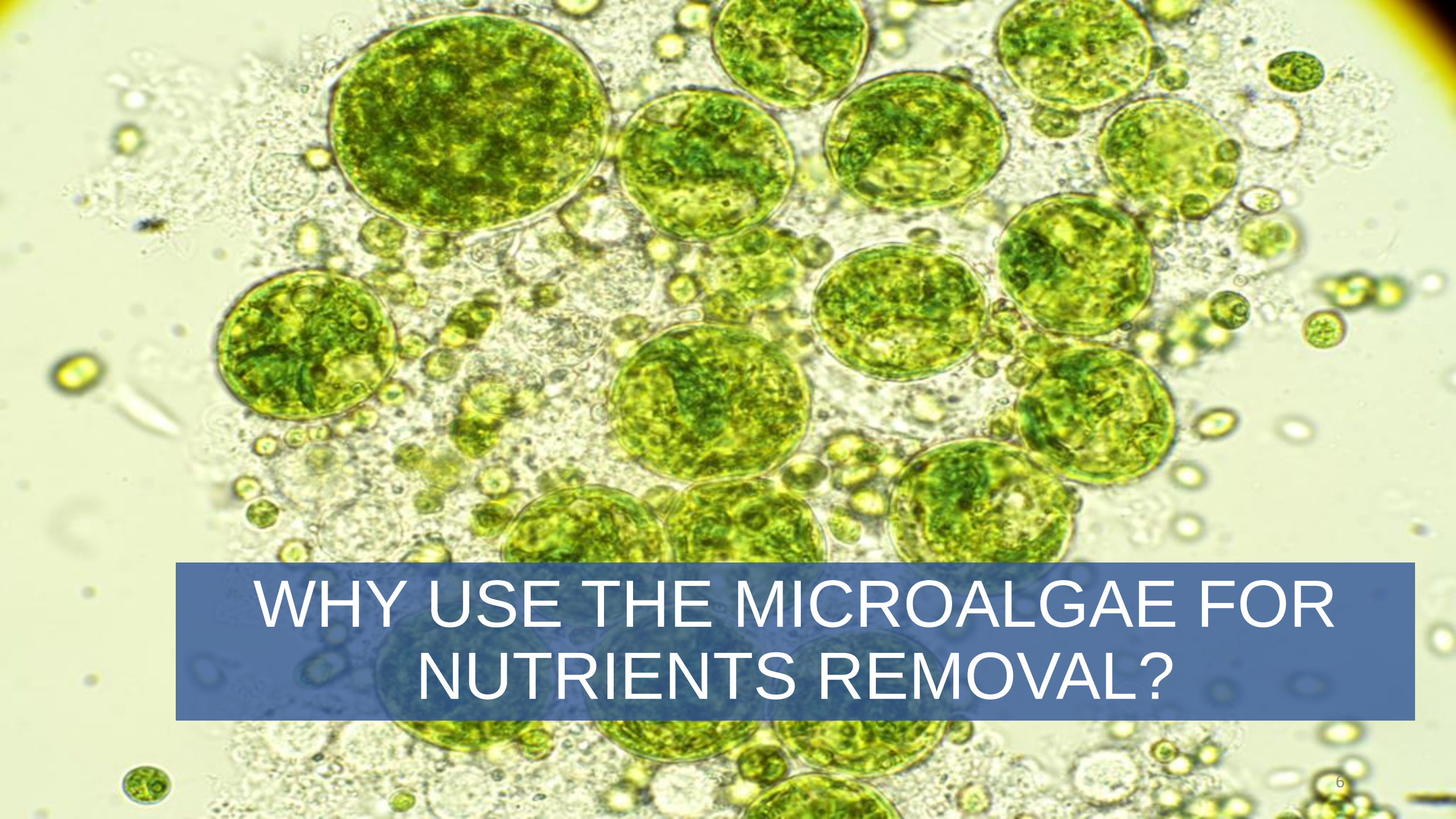
Satellite image of the central wastewater treatment plant of Via Gramicia, 95, Ferrara ©Google 2020

Urban line



The sludge is still rich in nutrients, such as **ammonium (NH_4^+)** and **phosphates (PO_4^{3-})**

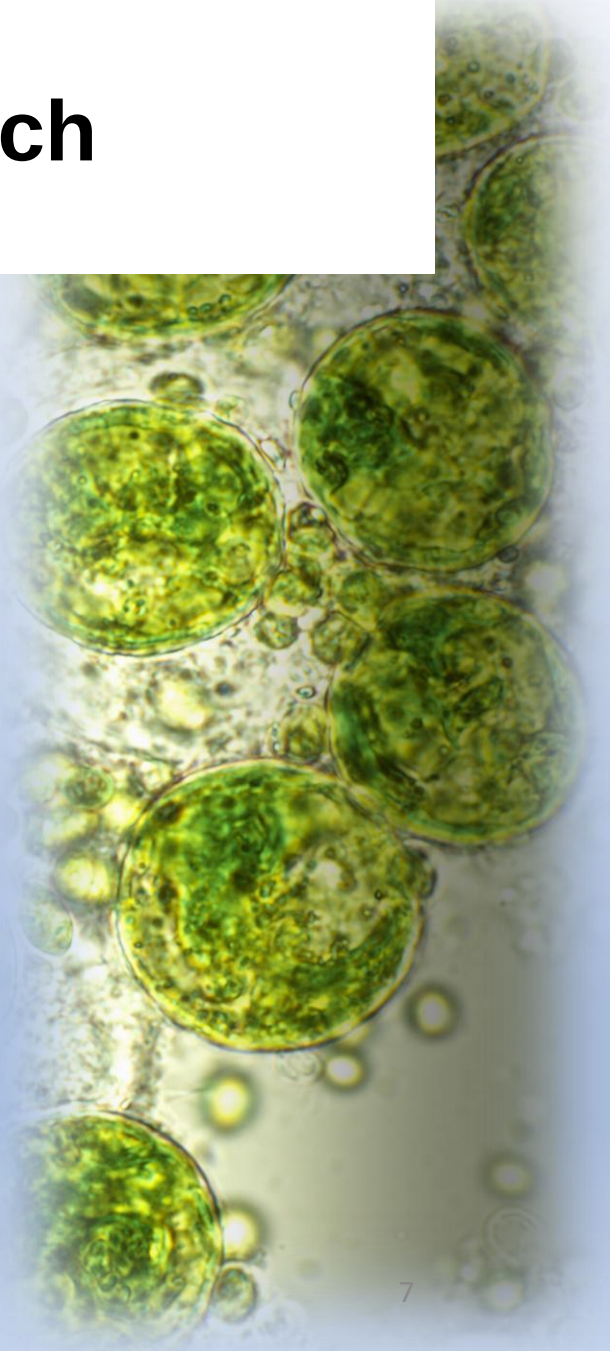
<u>Sustainable approaches are necessary for nutrients removal</u>



WHY USE THE MICROALGAE FOR NUTRIENTS REMOVAL?

Microalgae as a suistanable approach

- Eukaryotic unicellular and photosynthetic organisms
- High growth rate and biomass productivity
- Ability to nutrients removal
- Adaptive capabilities to environmental conditions



RENEWABLE ENERGY SOURCE

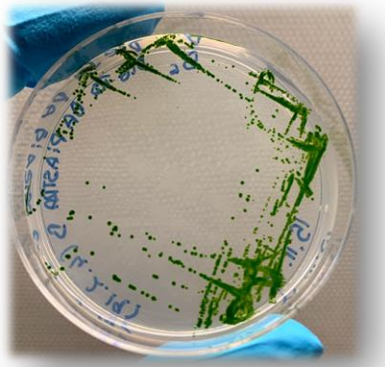
Harvested microalgae biomass can be converted to value-added products useful for **energy**, **agricultural** or **feed** sectors

Aims of the work

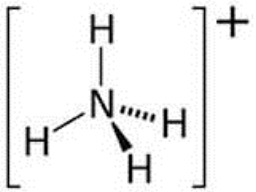
1. ISOLATION
of autochthonous microalgal strains from wastes of

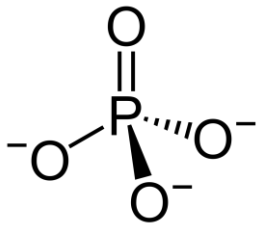
- Thickening
- Anaerobic digestion
- Desiccation

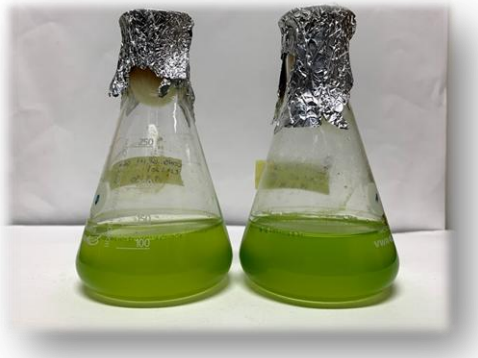
Sludge depuration steps



2. NITROGEN (AMMONIUM) AND PHOSPHORUS (PHOSPHATE) REMOVAL TEST
on sludge surnatant by microalgae isolated







1. What microalgae have been isolated from sludge surnatants?

2. Do isolated microalgae grow well in wastewater?

3. Can microalgae remove ammonium and phosphates from wastewater?

4. Is it possible to cultivate the microalgae on large scale?

Experimental plan and analysis

Step 1: isolation

Sludge depuration steps

- Thickening → Microalgal strain
- Anaerobic digestion
- Desiccation → Microalgal strain

Step 2: cultivation tests

Microalgal strains

- **Modified synthetic medium** (control cultures)
- **Sludge surnatants** (treated cultures)

Step 3: PBR cultivation

Microalgal strain ***from desiccation step*** → cultivation tests in open 20L-photobioreactor

N and P removal tests

&

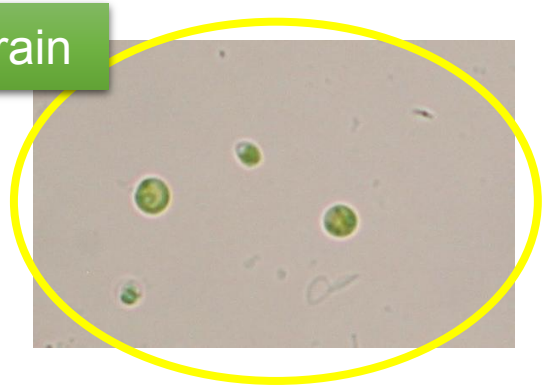
- ✓ Growth aspects
- ✓ Photosynthetic aspects
- ✓ Cell morphology

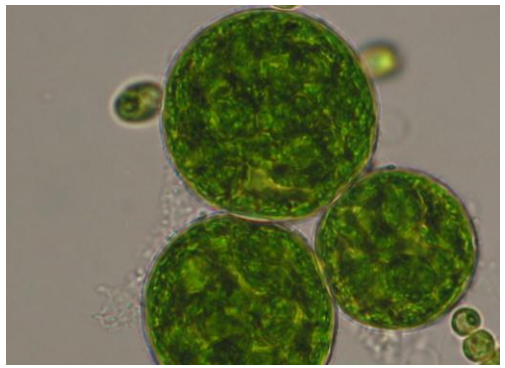
1. What microalgae have been isolated from wastewaters?

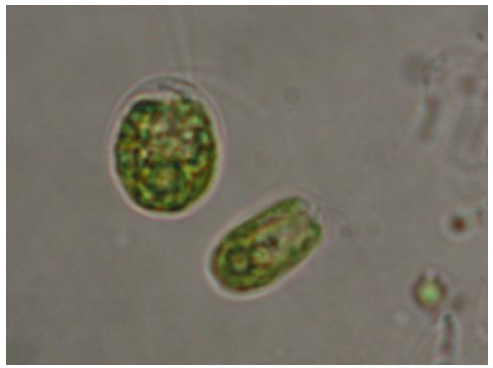
Step 1: isolation

… from ***thickening*** step

"T" strain



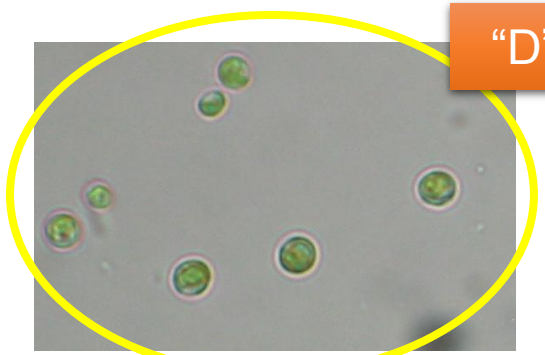


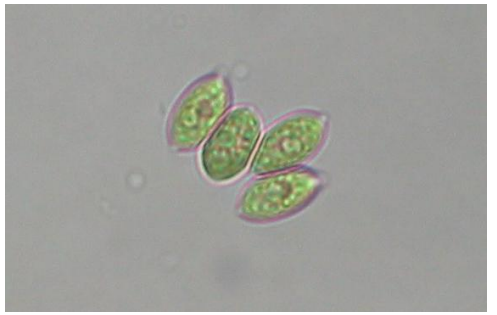


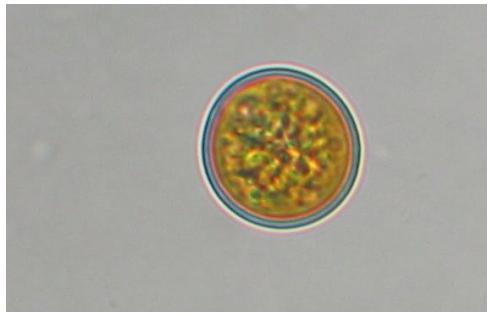
Chlorella-like

… from ***desiccation*** step

"D" strain



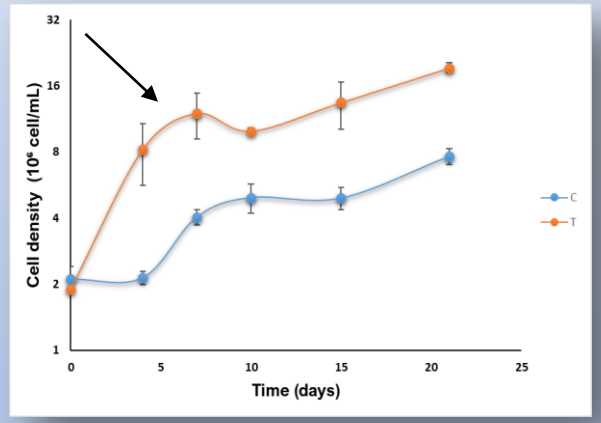


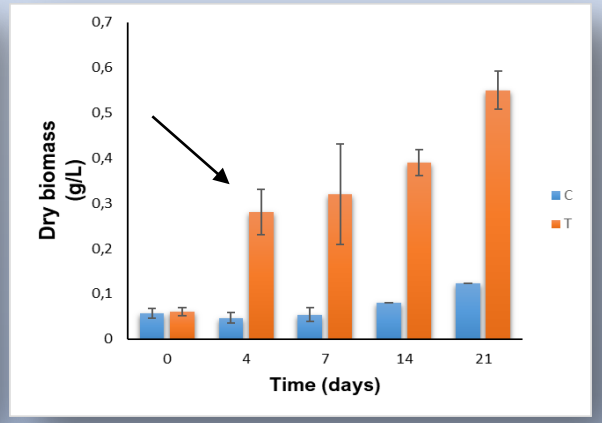


2. Do isolated microalgae grow well in wastewaters?

Step 2: cultivation tests

T STRAIN

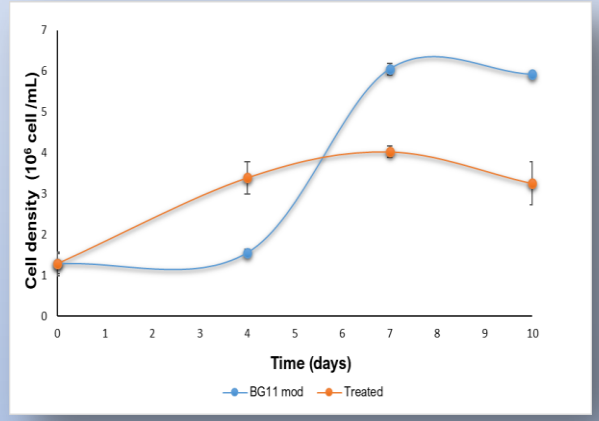




Thickener surnatant
Vs
Modified synthetic medium

The microalgae growth was promoted in wastewater

D STRAIN



Centrate surnatant
Vs
Modified synthetic medium

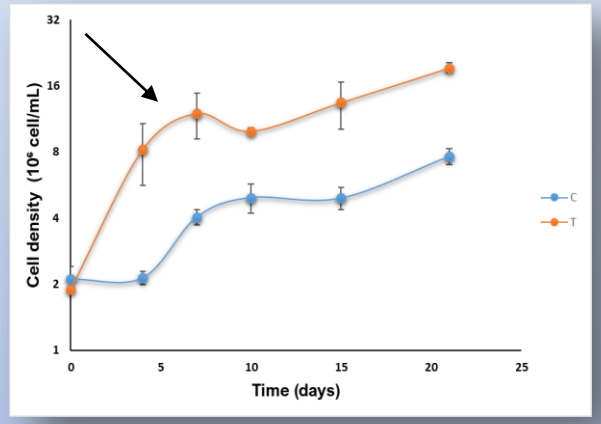
Growth inhibition in pure wastewater

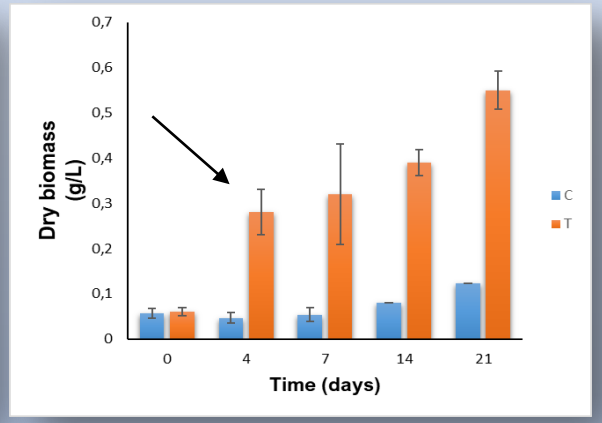
Dilution of sludge surnatant was necessary

2. Do isolated microalgae grow well in wastewaters?

Step 2: cultivation tests

STRAIN T

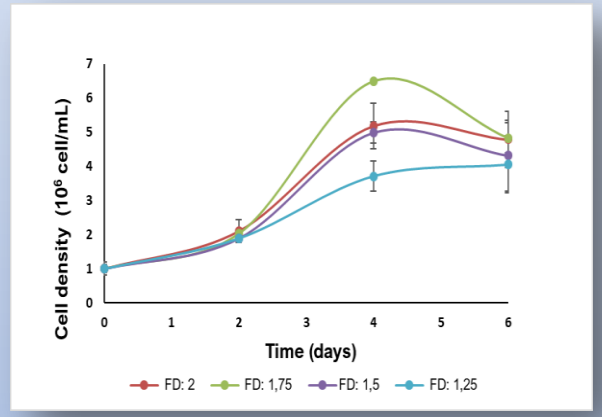


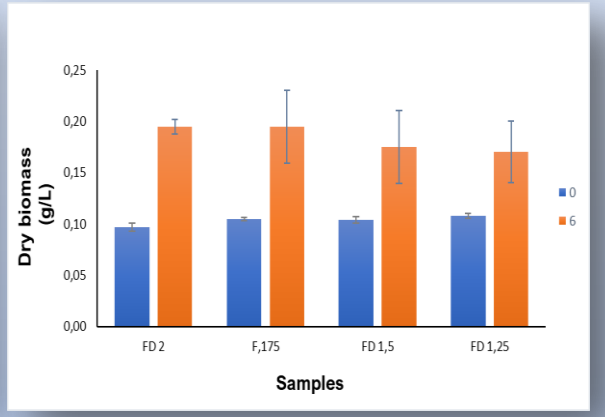


Thickener surnatant
Vs
Modified synthetic medium

The microalgae growth was promoted in wastewater

STRAIN D





Diluted Centrate surnatant with tap water

Dilution factors:

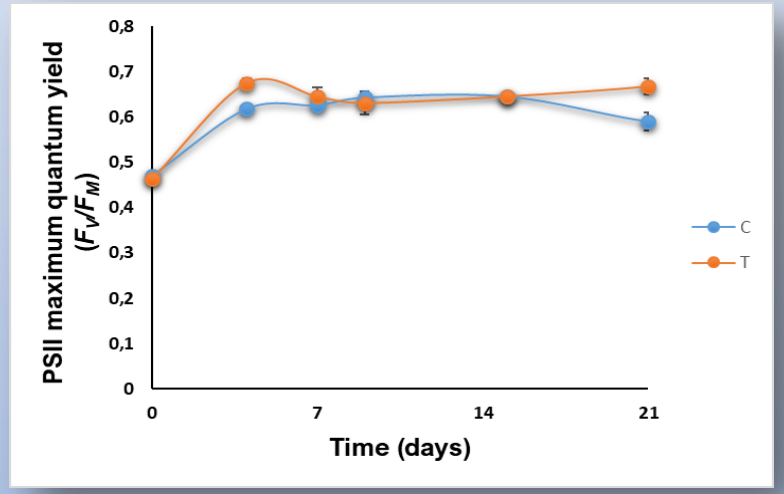
- **1.25**
- **1.5**
- **1.75**
- **2**

Microalgae grew better in more diluted substrates

2. Do isolated microalgae grow well in wastewaters?

Step 2: cultivation tests

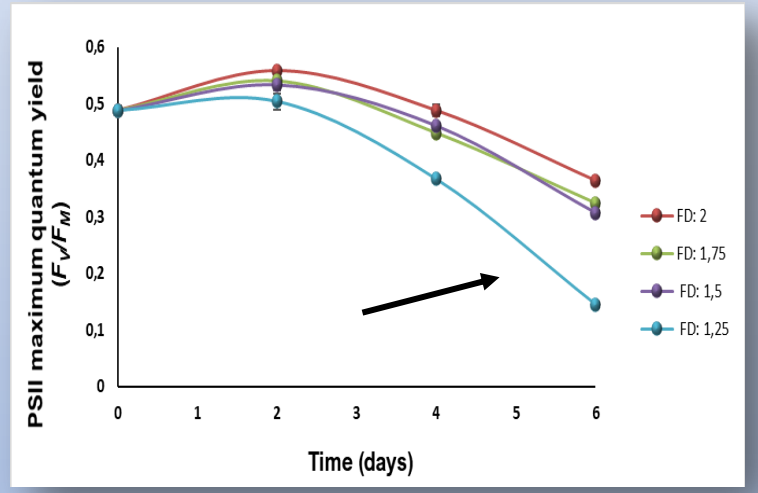
T STRAIN



Good state of health = good photosynthetic efficiency

for both growth substrates

D STRAIN



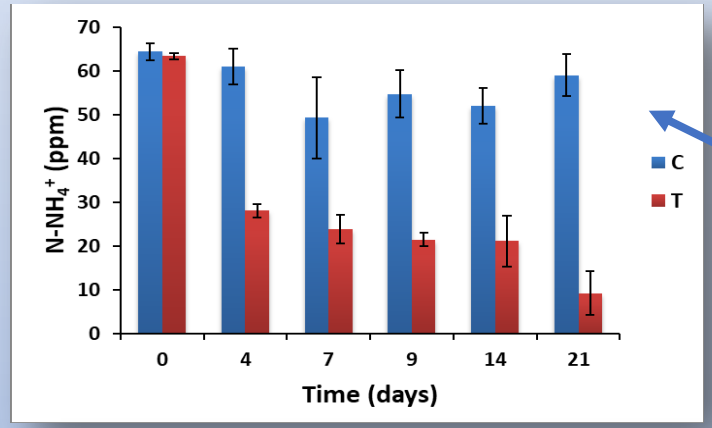
Good state of health in first 2 days

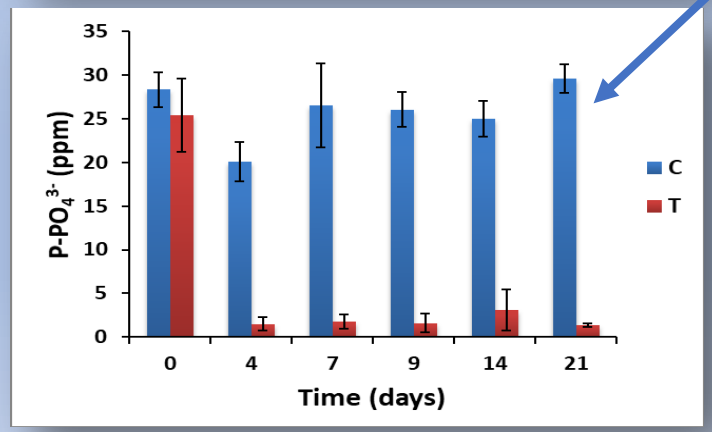
Then, the photosynthetic efficiency decreased to sub-optimal values

3. Can microalgae remove ammonium and phosphates from wastewaters?

Step 2: cultivation tests

T STRAIN





No **N-NH_4^+** and **P-PO_4^{3-}** removal in modified synthetic medium

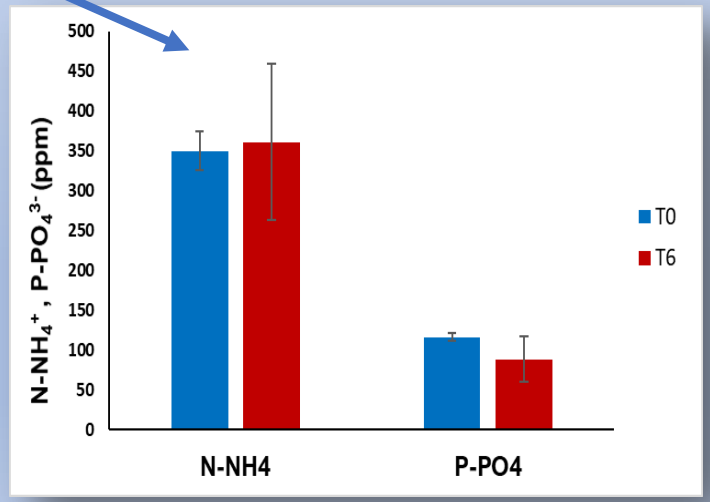
C = modified synthetic medium

T = Sludge surnatant

D STRAIN

T0

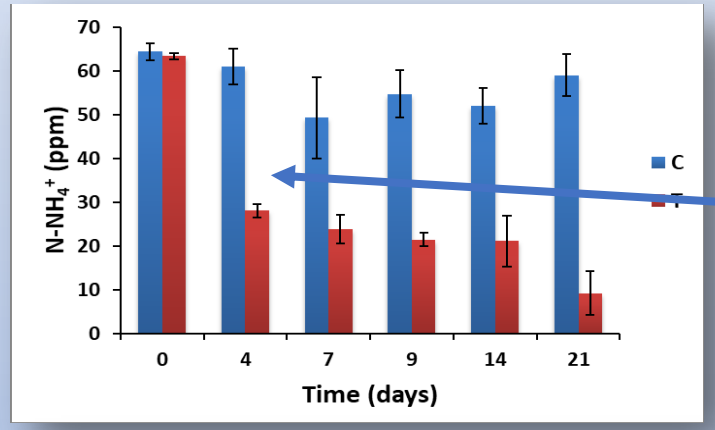
T6

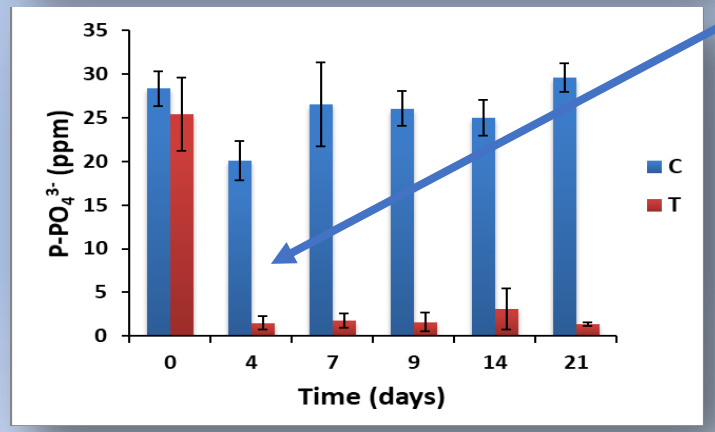


3. Can microalgae remove ammonium and phosphates from wastewaters?

Step 2: cultivation tests

T STRAIN





Thickener surnatant treatment

- 55% of **N-NH_4^+**
- 94% of **P-PO_4^{3-}**

in 4 days of cultivation

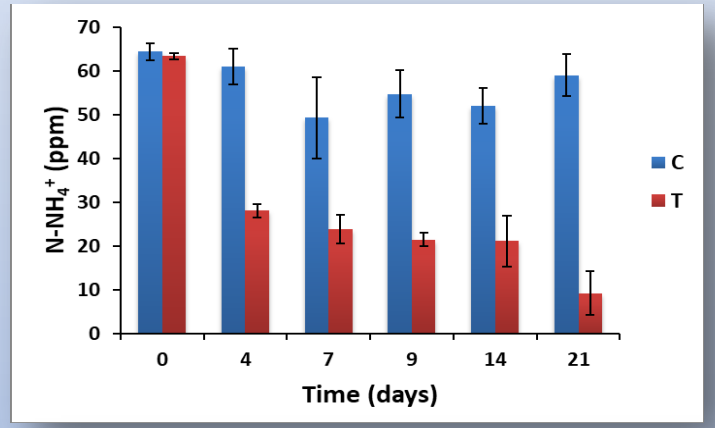
C = modified synthetic medium

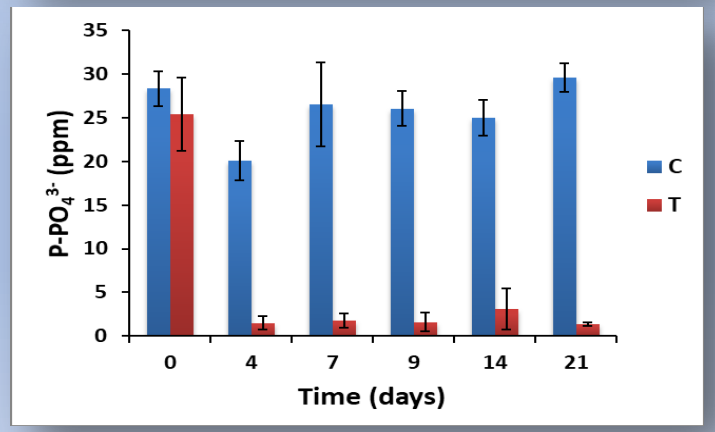
T = Sludge surnatant

3. Can microalgae remove ammonium and phosphates from wastewaters?

Step 2: cultivation tests

T STRAIN





Diluted centrate surnatant treatment

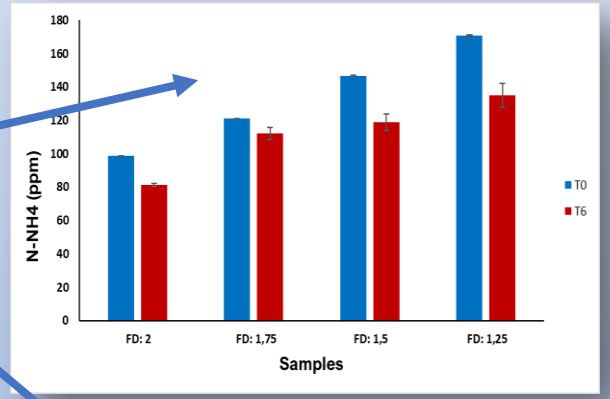
- 18-21% of **N-NH_4^+**
- 72-76 % of **P-PO_4^{3-}**

Higher N and P removal in samples with lower dilution factor

C = modified synthetic medium

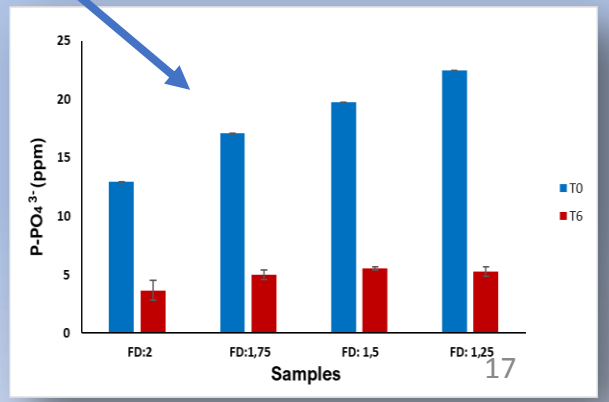
T = Sludge surnatant

D STRAIN



T0

T6

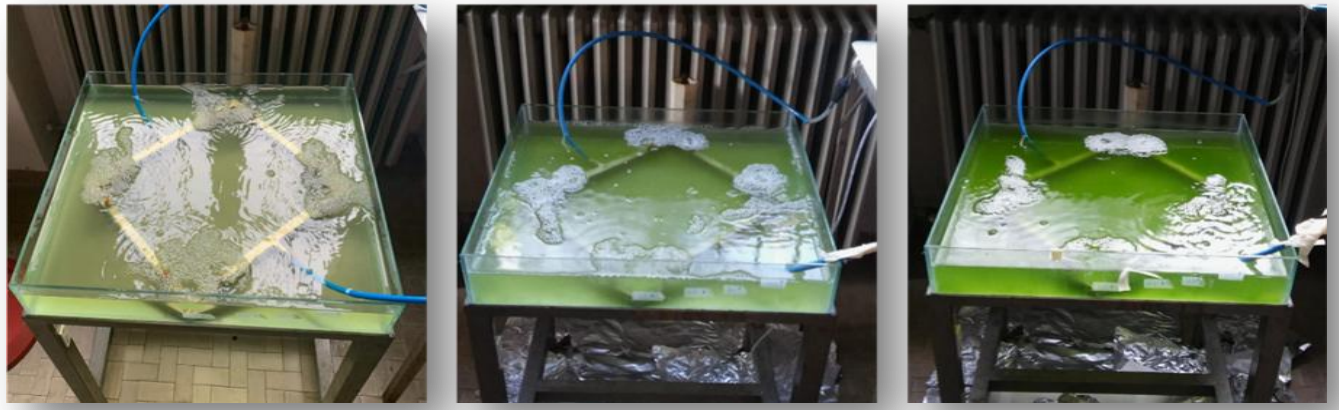


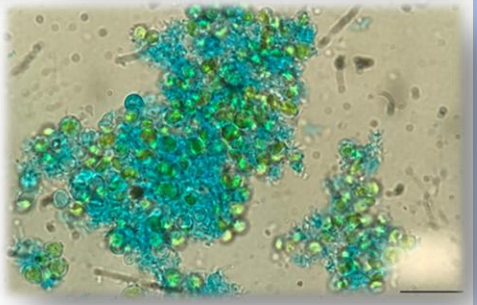
4. Is it possible to cultivate microalgae on large scale ?

Step 3: PBR cultivation

STRAIN D cultivated in open 20L- photobioreactor in <u>not-diluted</u> sludge surnatant

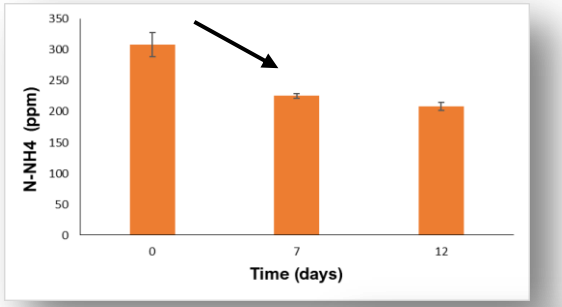
Day 0 **Day 7** **Day 20**

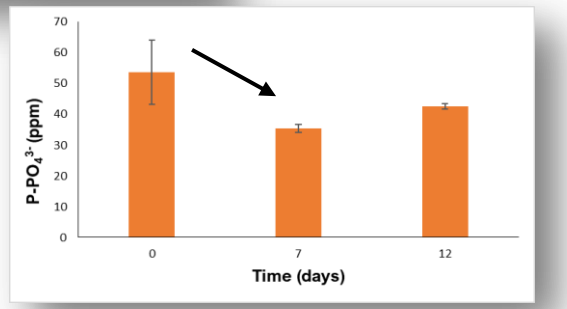




- Cell aggregates → the growth was not estimate
- Microalgae were healthy

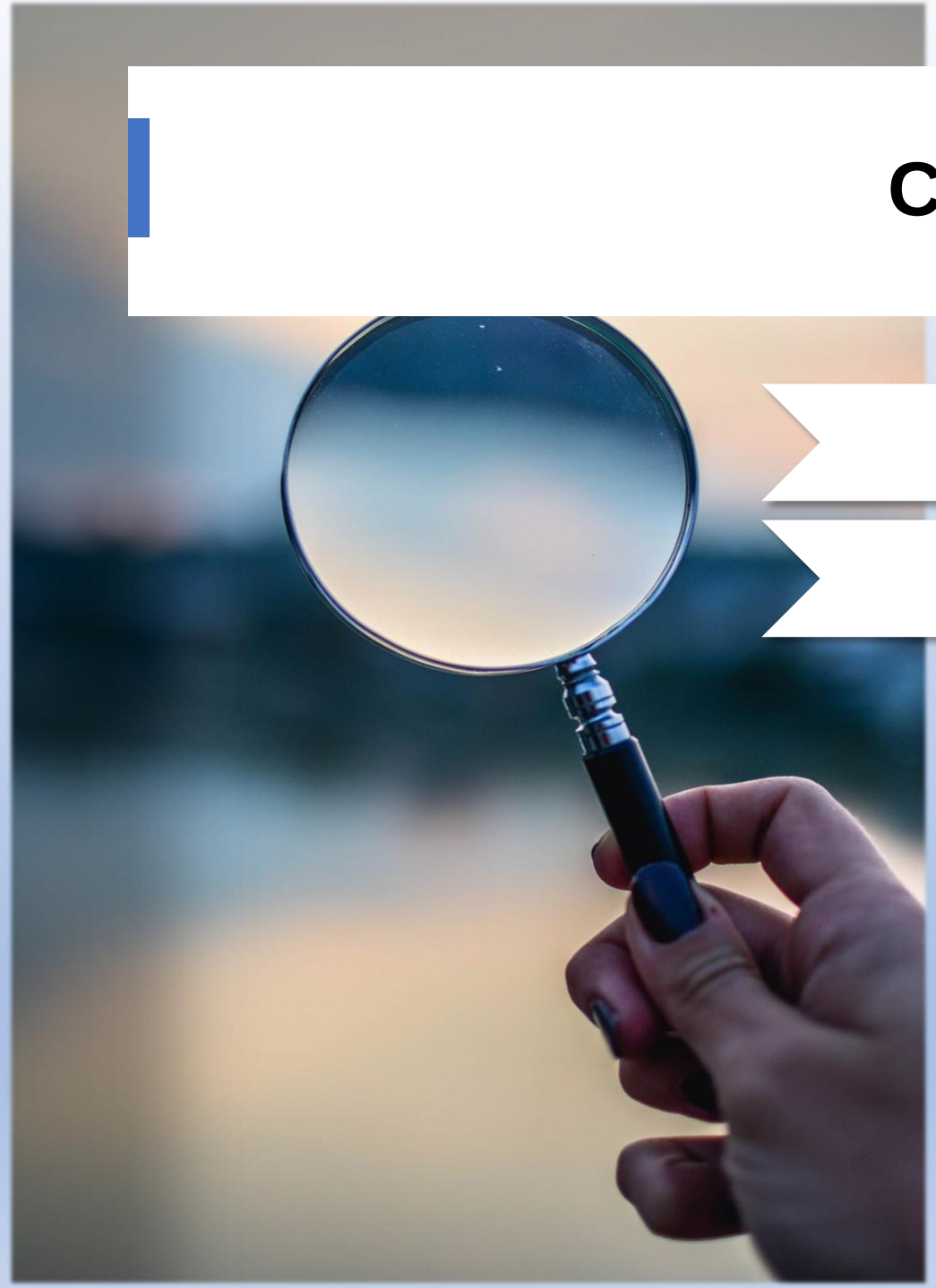
N and P removal tests





→ 20% removal of $N\text{-}NH_4^+$ and $P\text{-}PO_4^{3-}$ in 7 days

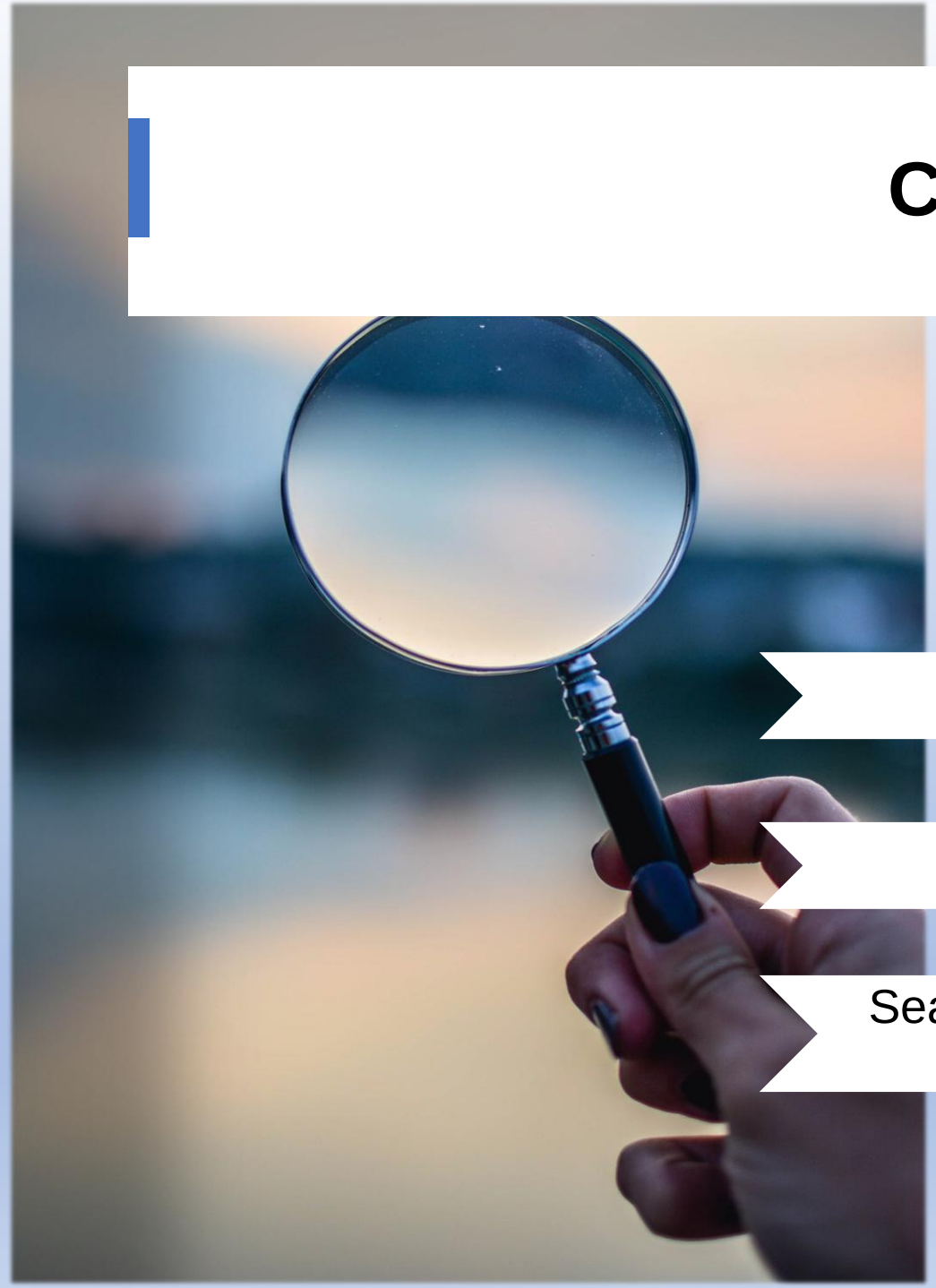
Conclusions



Good adaptability in sludge effluents

High nutrient removal ability

These microalgae are good candidates for large-scale cultivation as a tertiary treatment in HERA-Ferrara wastewater treatment plants.



Conclusions

Next perspectives…

- Study microalgae-bacteria interactions
- Cultivation tests on other isolated microalgae
- Search for the best growing conditions for large-scale cultivation

This work was supported by

POR FERS 2014-2020 (VALUE CE-IN project)

granted by Emilia-Romagna region

«*VALorizzazione di acque reflUE e fanghi in ottica di economia circolarE e simbiosi INdustriale*»

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THANKS FOR THE ATTENTION

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