HOKKAIDO UNIVERSITY

Greywater treatment and resources recovery using high rate algal pond

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Outline

Background

Objectives

Materials and methods

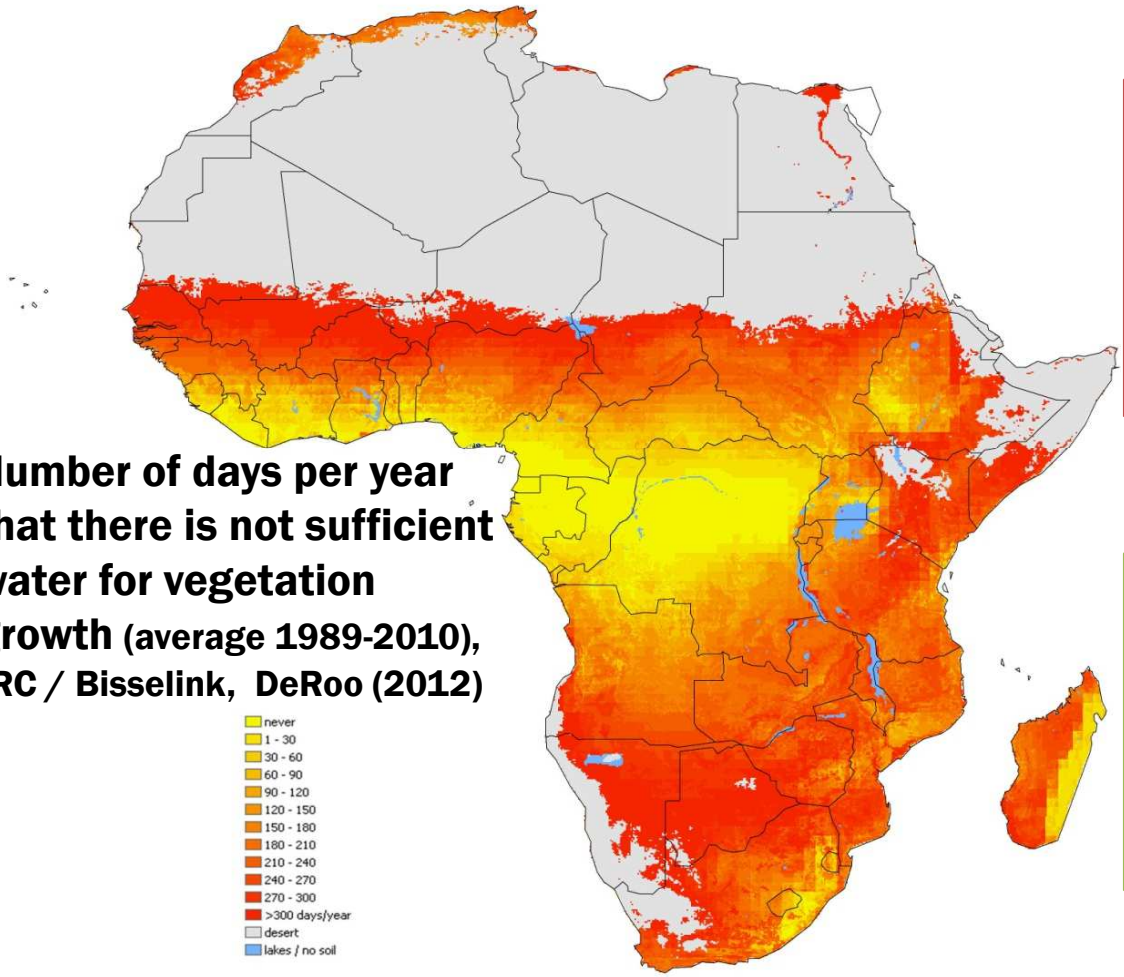
- Sequencing batch reactors (SBRs)
- Continuous flow reactors (CFRs)
- High rate algal pond

Results and discussion

- Algal Productivity and nutrients balance under batch and continuous operations
- Effects of the solid retention time and the algae recirculation on algal productivity and nutrients removal

Conclusion

Water availability in arid and semi - arid areas of Africa



Number of days per year that there is not sufficient water for vegetation growth (average 1989-2010), JRC / Bisselink, DeRoo (2012)

Fresh water generation

- **<200 mm/year**

Soil moisture stress

- **>200 days/ year**

Water and other resources for vegetation growth

Opportunity to recover treated water, nitrogen and phosphorus from the greywater for the growth and survival of the plants

Wastewater treatment using high rate algal pond (HRAP)

Retain the advantages of conventional activated sludge systems

- **Simplicity and economy**

Low energy requirement

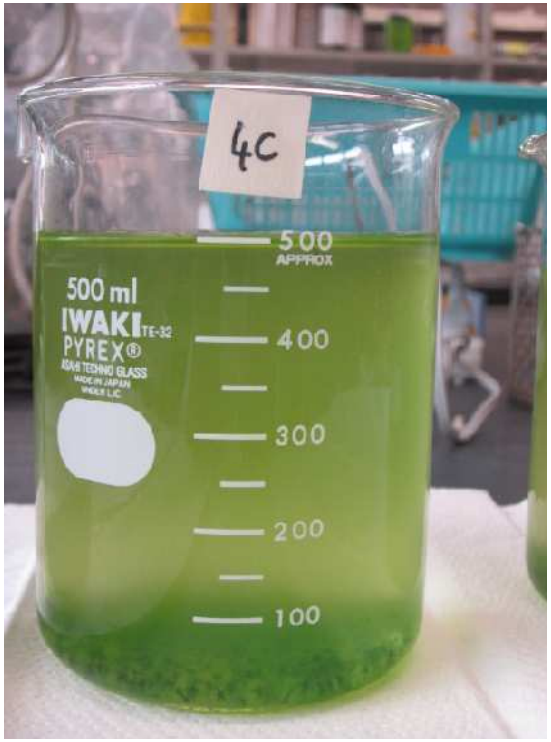
Resources recovery from the wastewater

- **Biomass and energy recovery for beneficial use**

Problems to be solved

Algae proliferation

High suspended solids in the treated effluent



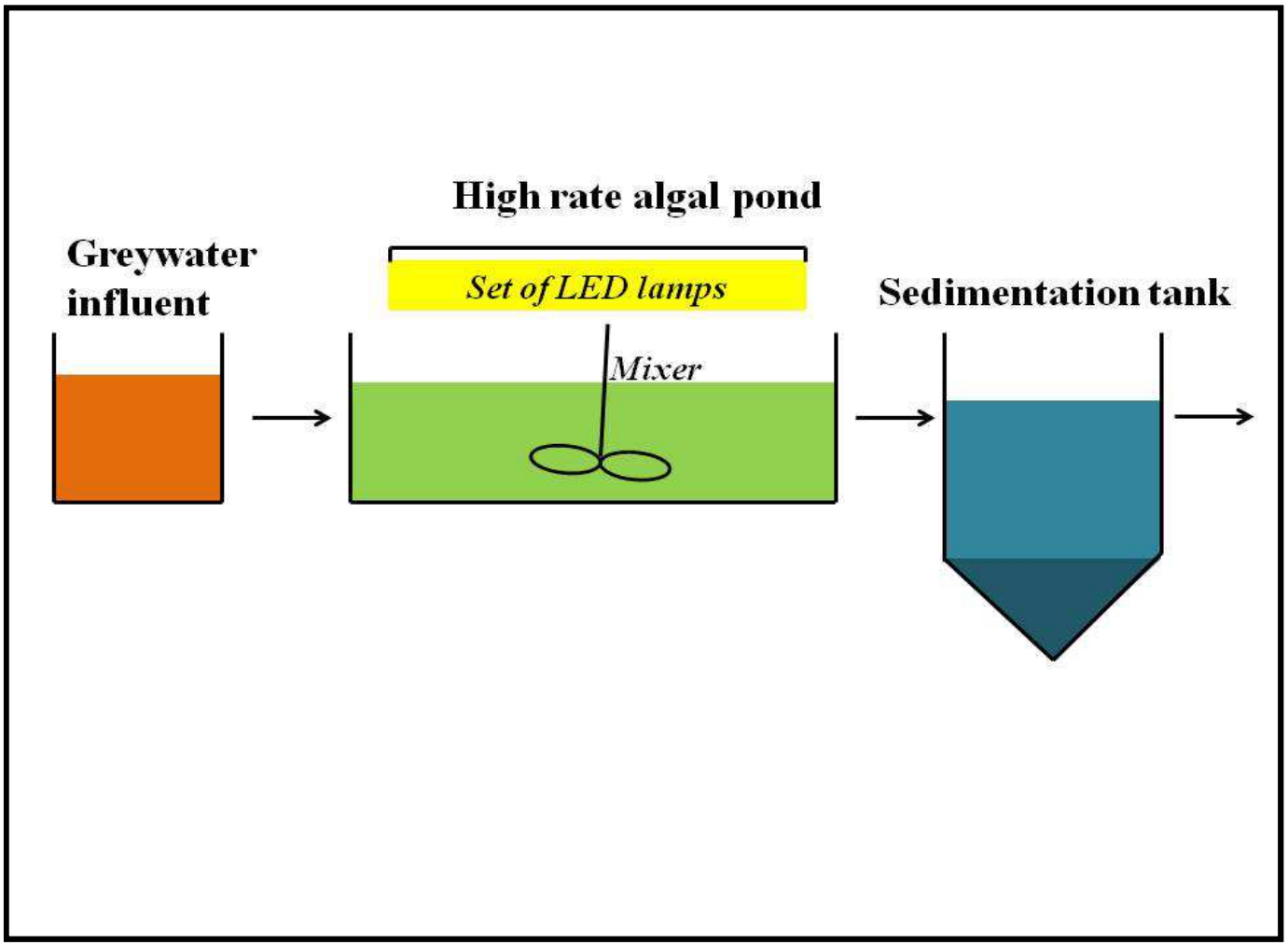
After 1h sedimentation

Objectives

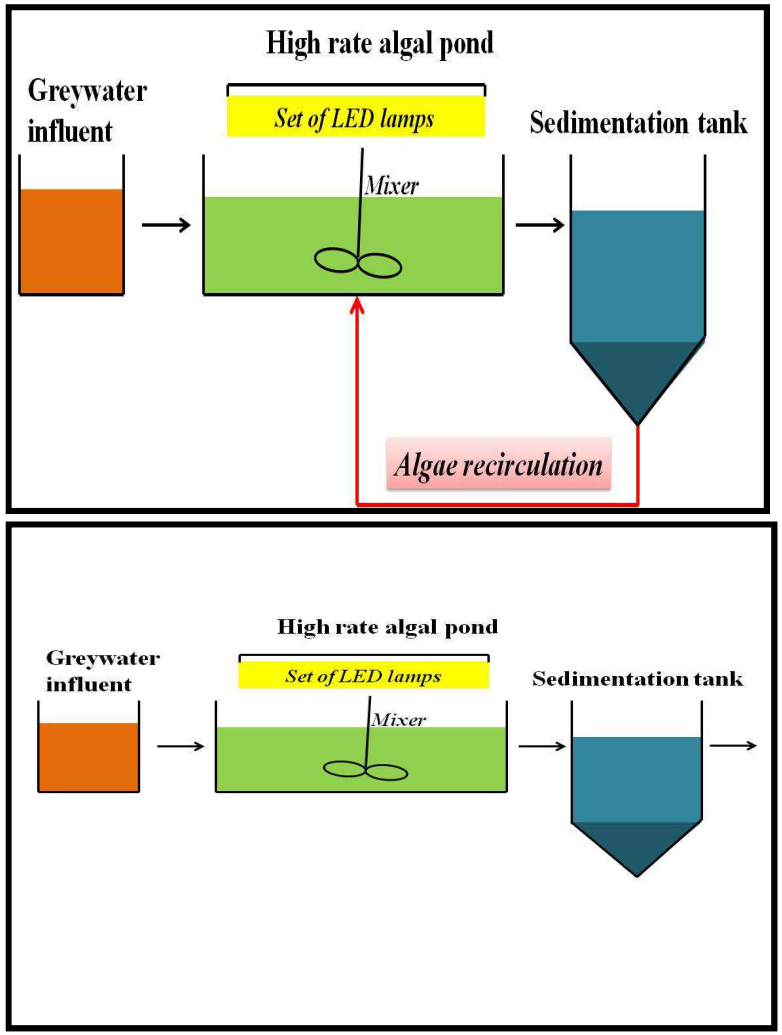
Enhance the selection of settleable algae

Assess the effects of the SRT on the algal production and the nutrient removal

The high rate algal pond system



Material and methods –SBRs and CFRs



3 replications of sequencing batch reactors (SBR)

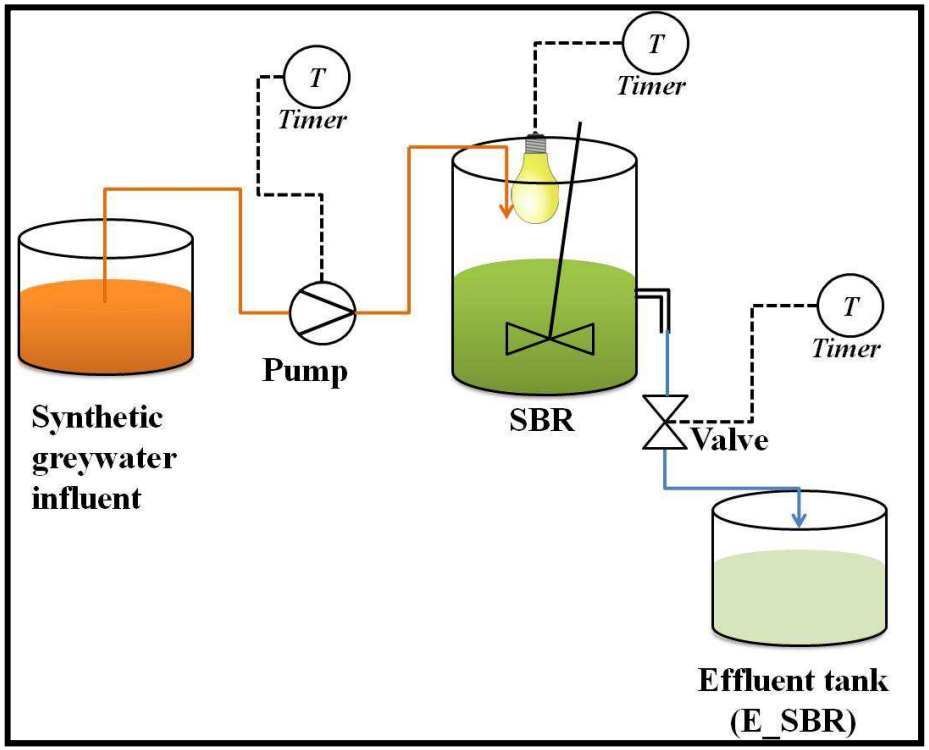
- Simulated the HRAP with algal recirculation

3 replications of continuous flow reactors (CFR)

- Simulated conventional HRAP without algal recirculation

To make sure of the selection of flocculated algae

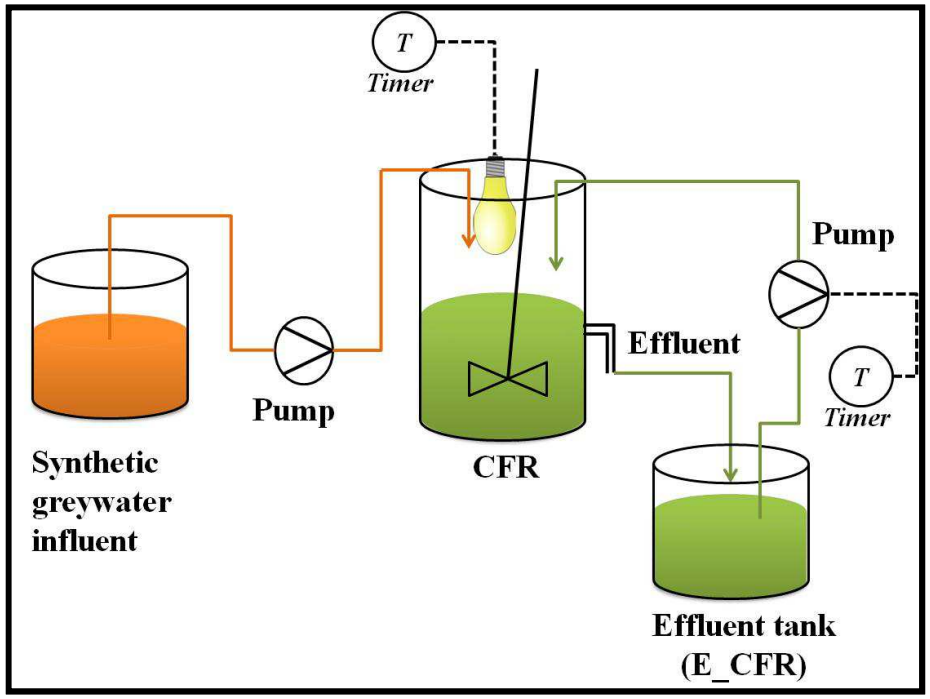
Material and methods – SBRs operation



Sequencing batch reactor (SBR)

Reaction (feeding, mixing)	17 h 30 min
Sedimentation	6 h
Discharge and idle	30 min
SRT	20 days
HRT	10 days
Temperature	30°C

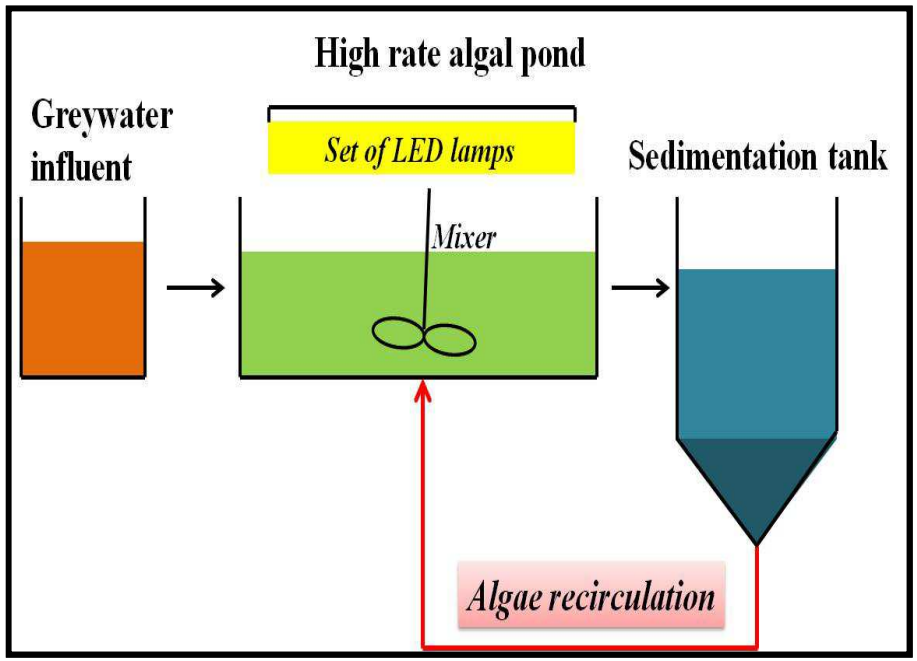
Material and methods – CFRs operation



Continuous flow reactor (CFR)

Continuous flow	
SRT	20 days
HRT	20 days
Temperature	30°C

Material and methods – HRAP operation



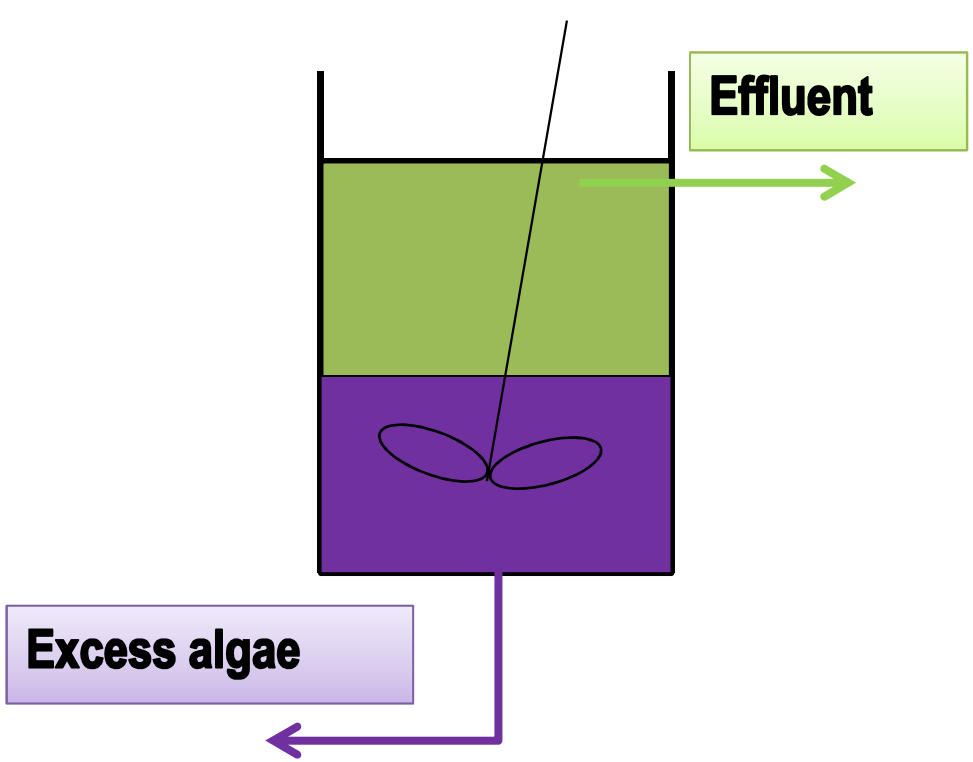
High rate algal pond system

High rate algal pond	
Volume	26 L
Temperature	30°C
HRT	8 days
SRT	10, 15 and 20 days

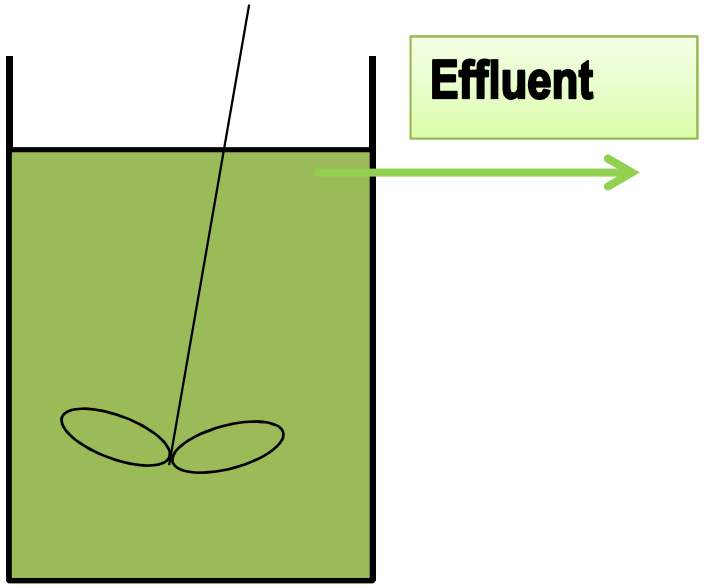
Sedimentation tank	
Volume	15 L
Algae recirculation ratio	0.5

RESULTS AND DISCUSSION – SBR AND CFR

Algal productivity under batch and continuous operations

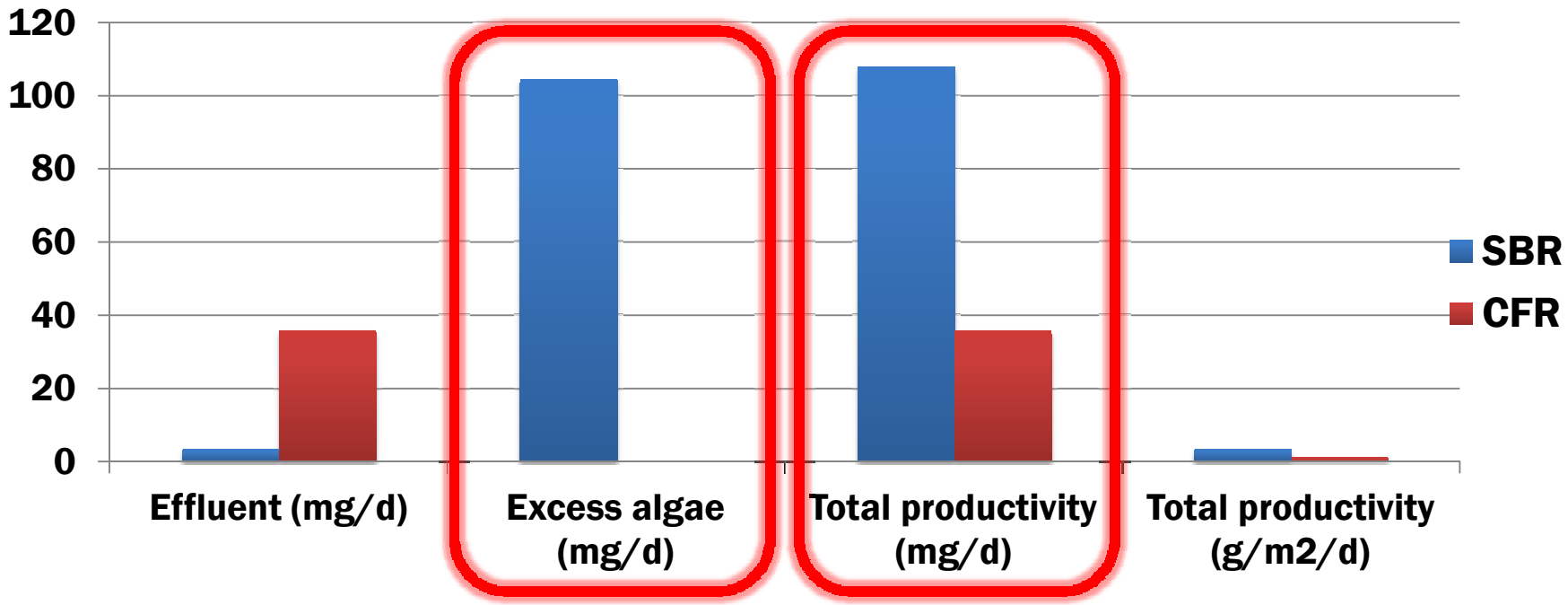


Sequencing batch reactors



Continuous flow reactors

Algal productivity in SBRs and CFRs

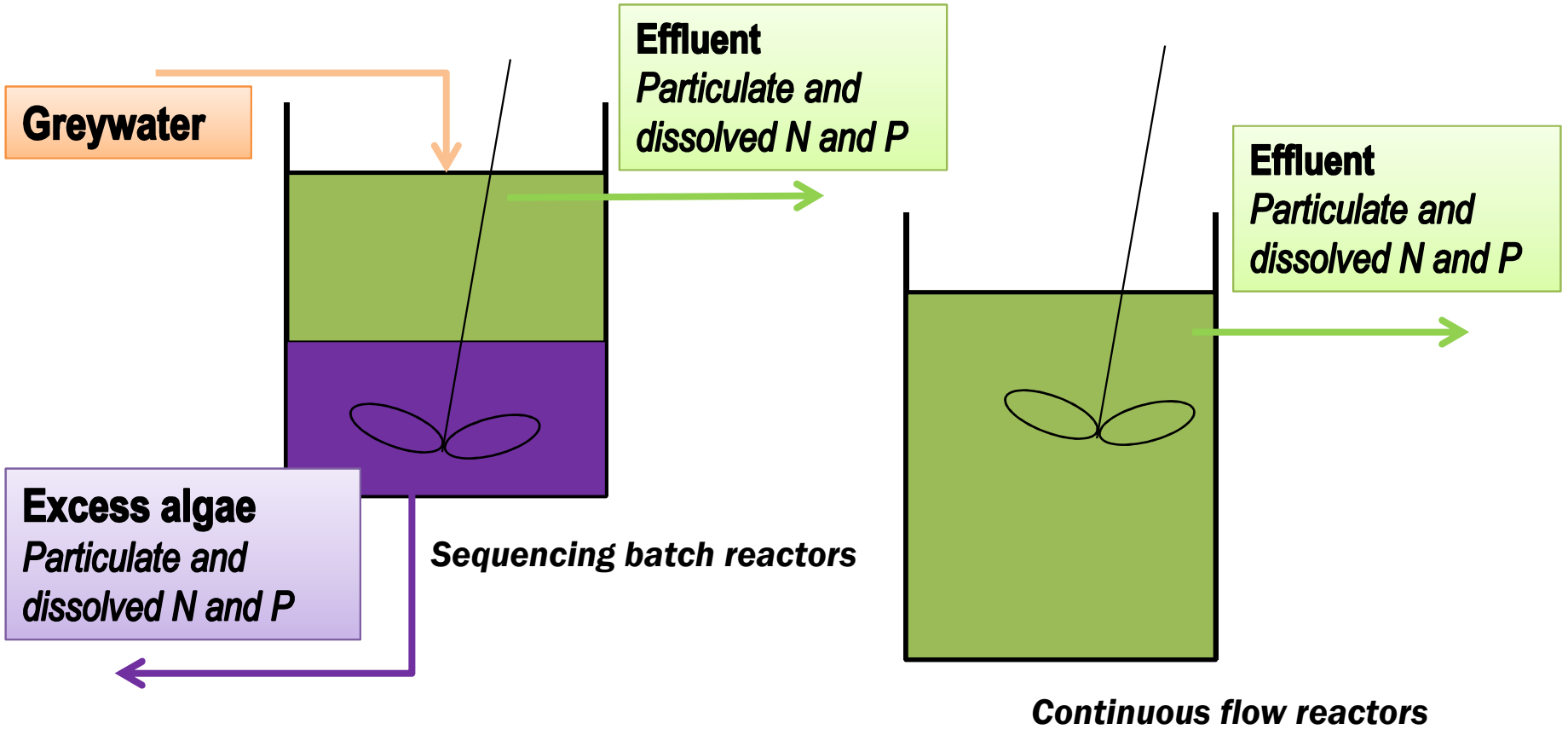


Higher algal productivity in SBRs than in CFRs

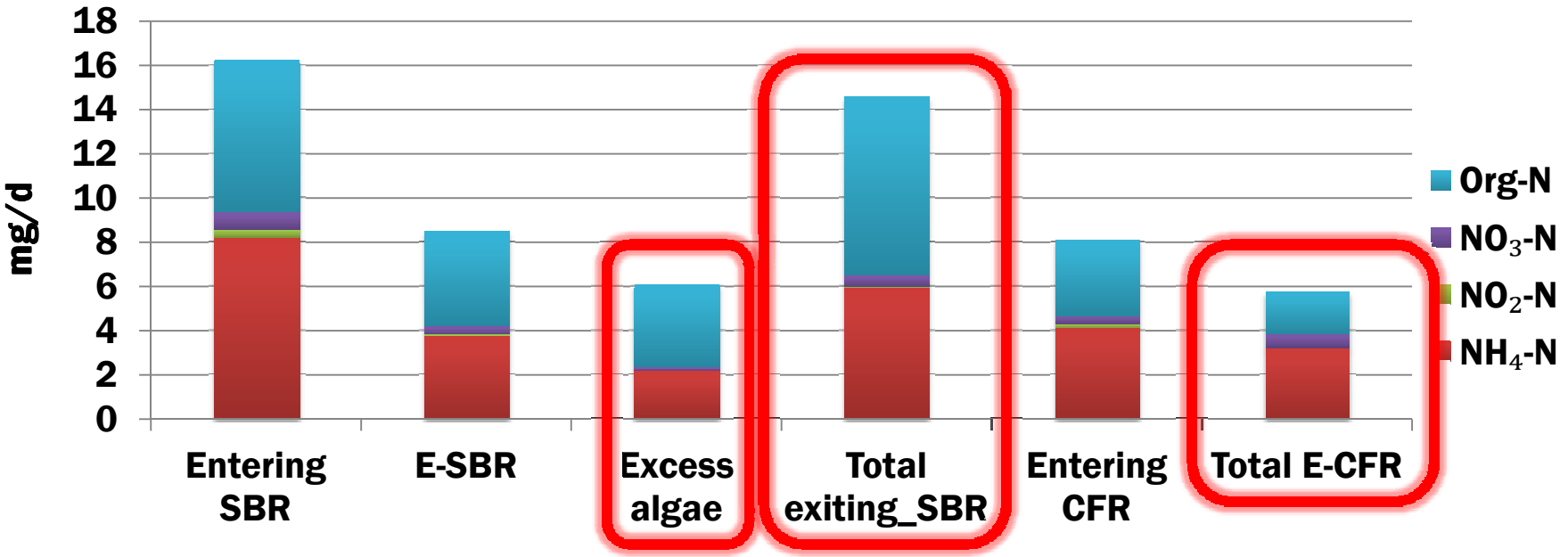
- **Short HRT and contribution of excess algae in the SBRs**

RESULTS AND DISCUSSION – SBR AND CFR

Nutrients balance under batch and continuous operations



Results & discussion– Nitrogen balance in SBRs and CFRs

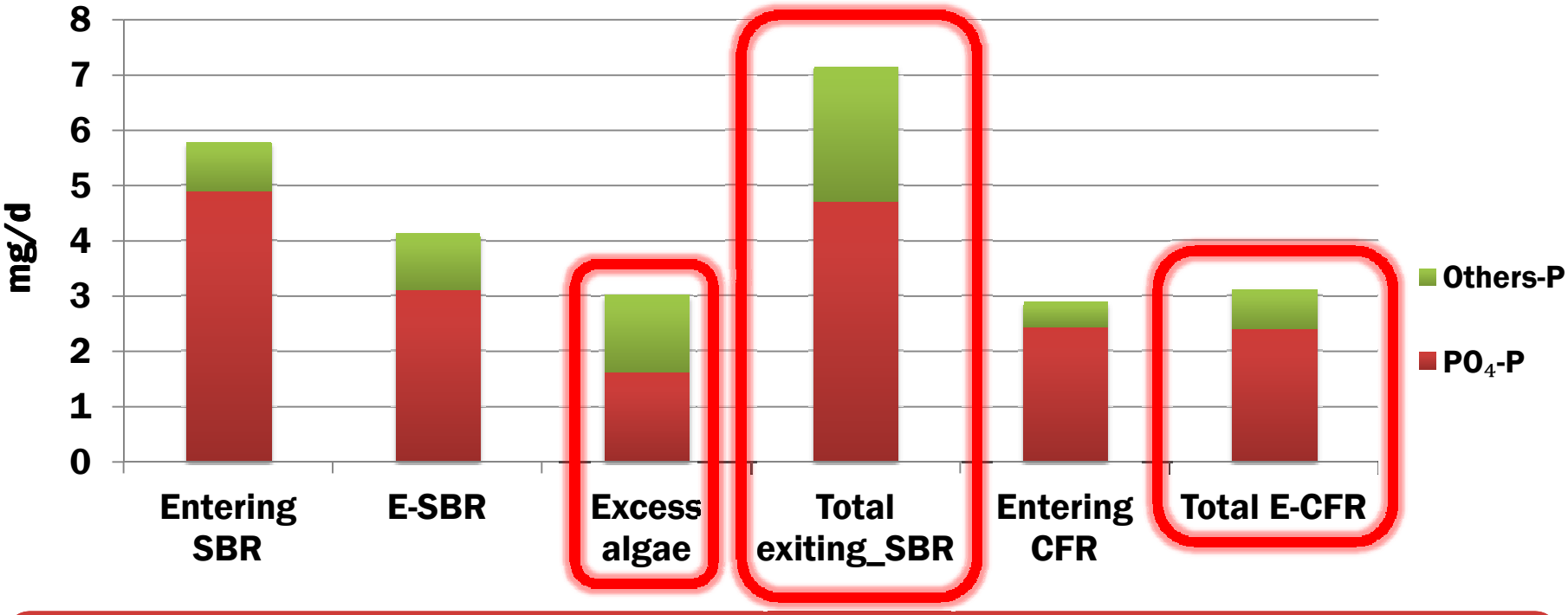


For both reactors the main nitrogen species exiting the systems were ammonium and organic nitrogen

The excess algae withdrawn from the SBRs has lead to the increase of the nitrogen removal efficiency

- **T-N removal efficiency of 63% from the excess algae and 48 % from the effluent**

Results & discussion– Phosphorus balance in SBRs and CFRs



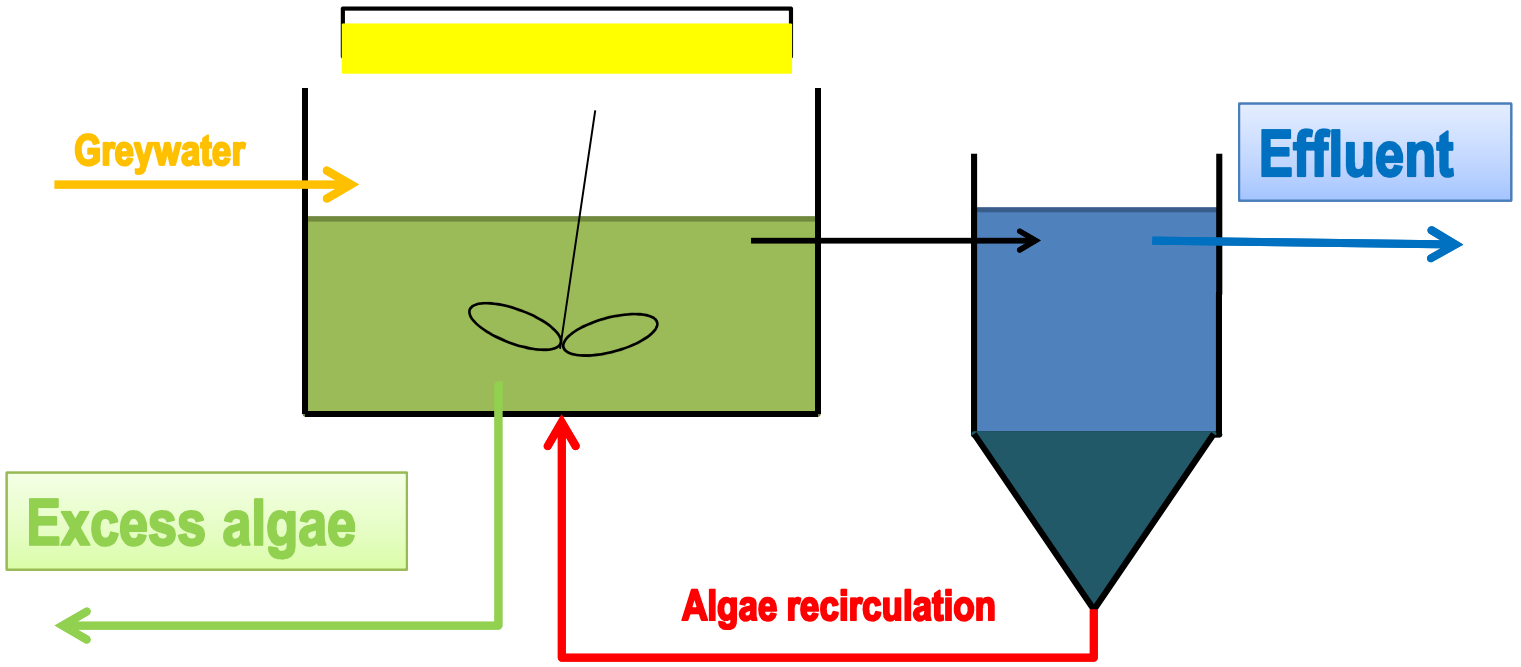
The removal of the phosphorus was enhanced by withdrawing the excess algae

- % T-P removal of 48 % from the excess algae and 28 % from the effluent

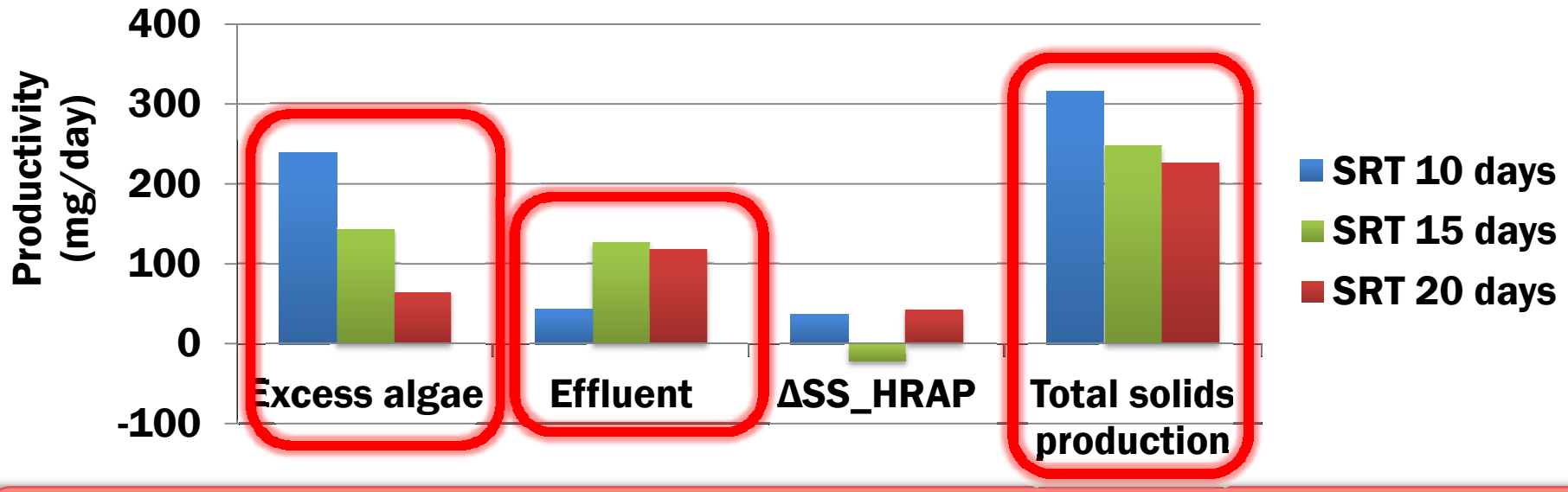
Results and Discussion - HRAP

Effects of the algal recirculation and SRT control

Algal productivity and nutrients balance



Effects of the SRT control and algae recirculation on the algal productivity

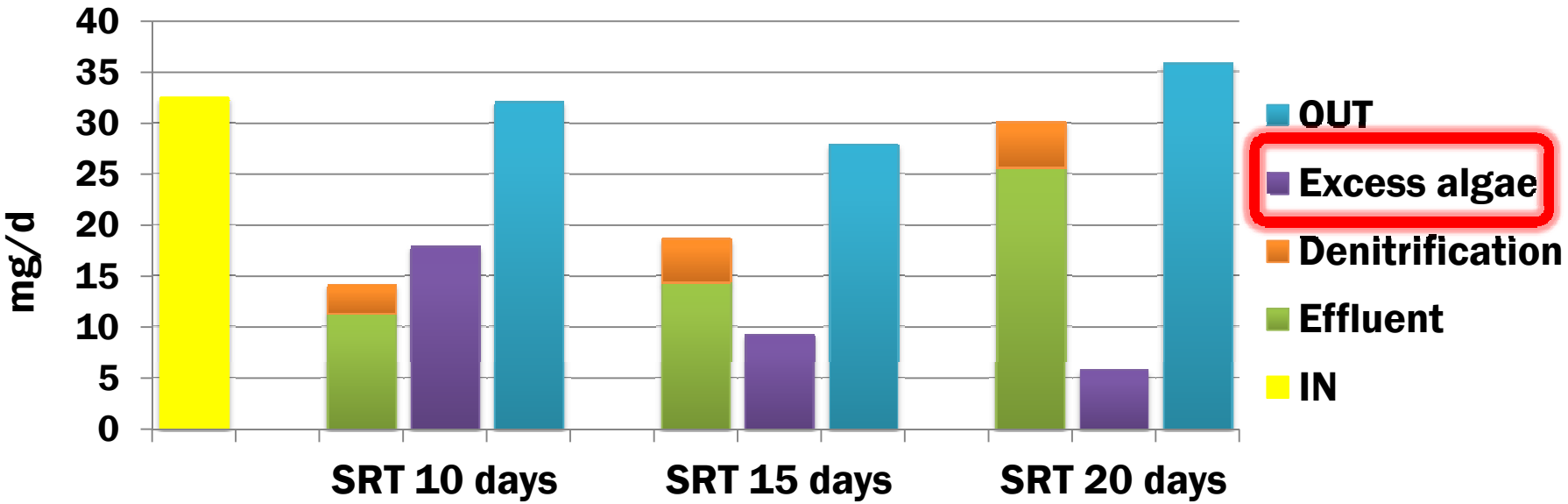


Significant increase in total solids production during short SRT control

- Greater removed excess solids during short SRT control
- Algae recycling process enabled the algae to grow larger

Algae removal enhanced by controlling short SRT

Total nitrogen balance with SRT control

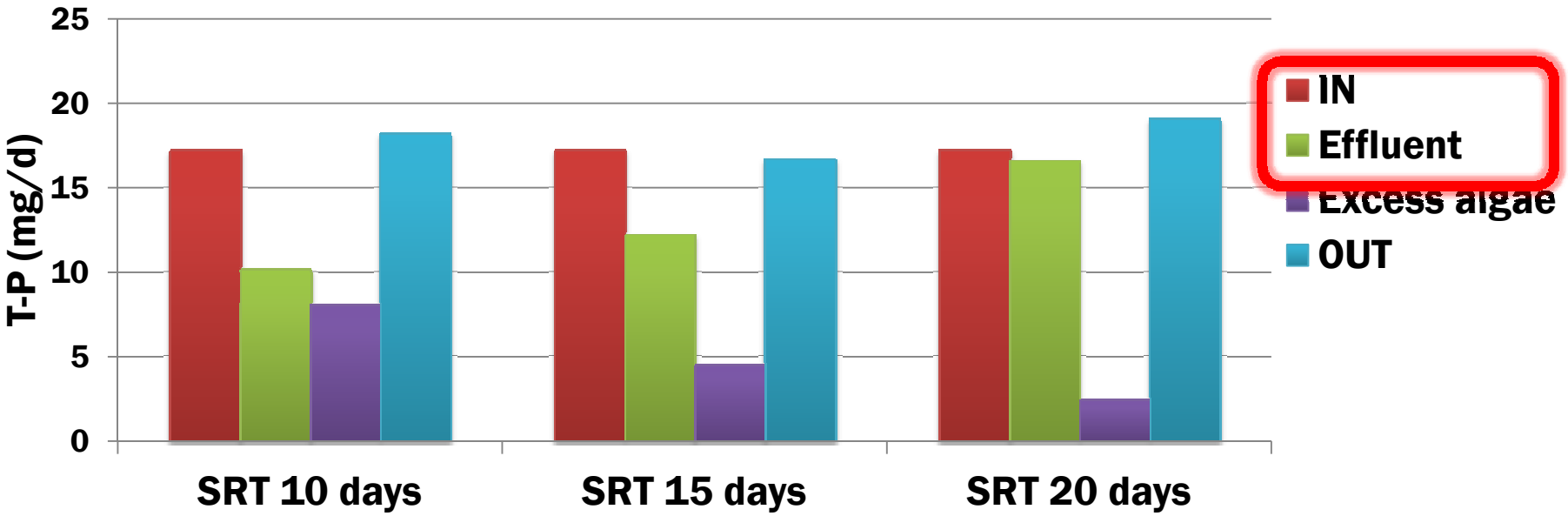


Short SRT enhanced T-N removal

- High T-N amount in the excess sludge during short SRT control

Nitrogen removal was performed by removing the algae

Total phosphorus balance with SRT control



Weak elimination of phosphorus in the effluent comparing to the N removal

- **Difference in the N:P ration of the algae and the wastewater**

High amount of T-P was found in the excess sludge when short SRT was controlled

Conclusions

The algal production and the fraction of N and P removed were increased due to:

- **The contribution of the daily withdrawal of the excess algae**
- **And the operation of algae recirculation**

By controlling the SRT, the HRAP was able to produce:

- **High algal biomass and high N and P removal efficiency during short SRT control**
- **Low algal biomass and low N and P removal efficiency during long SRT control**

Pilot scale plant in 2iE campus, Ouagadougou

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Thank you for your attention