Contributing to the transition from linear to circular urban water management

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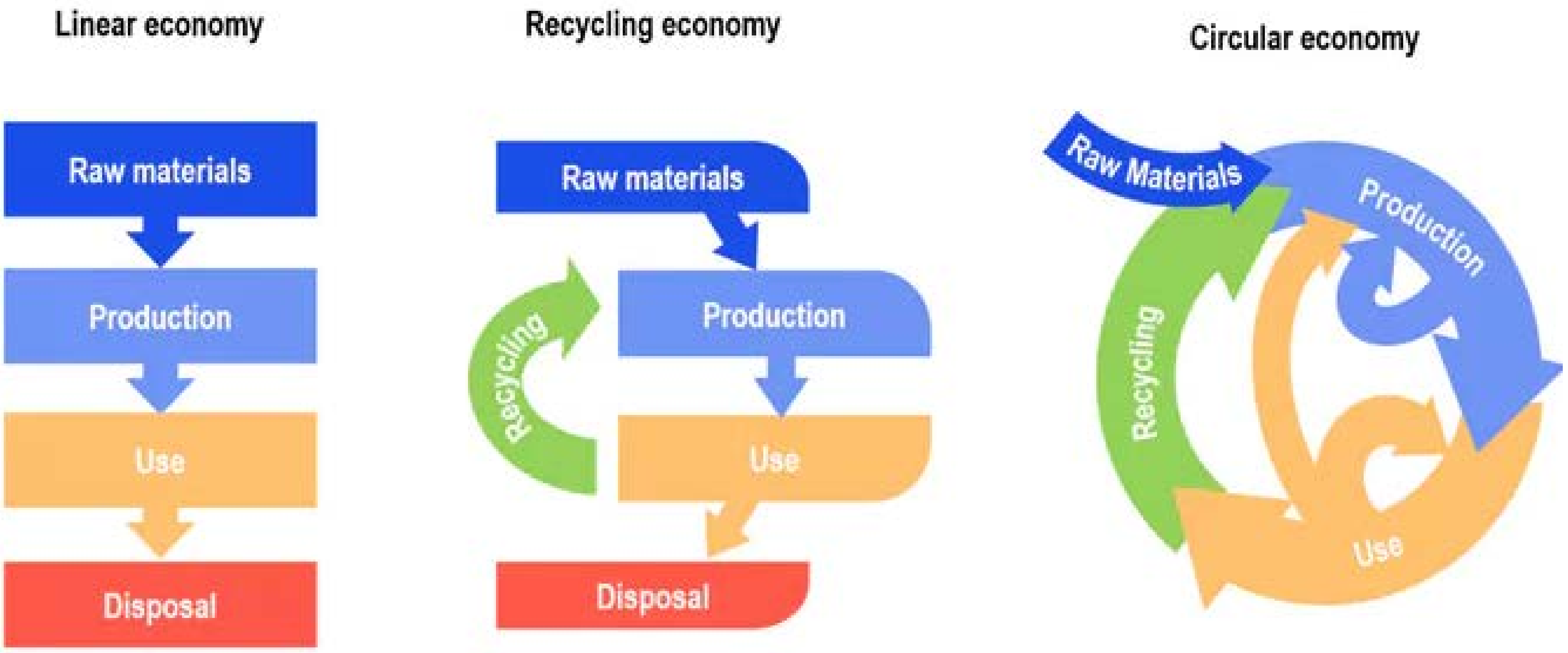
A quick recap of the Circular economy concept



Source: http://theconversation.com/the-planned-national-waste-policy-wont-deliver-a-truly-circular-economy-103908

From policies to practical implementation

Gathering sufficient knowledge on the functioning of the new circular systems to avoid unwanted consequences

Policies → Practical implementation

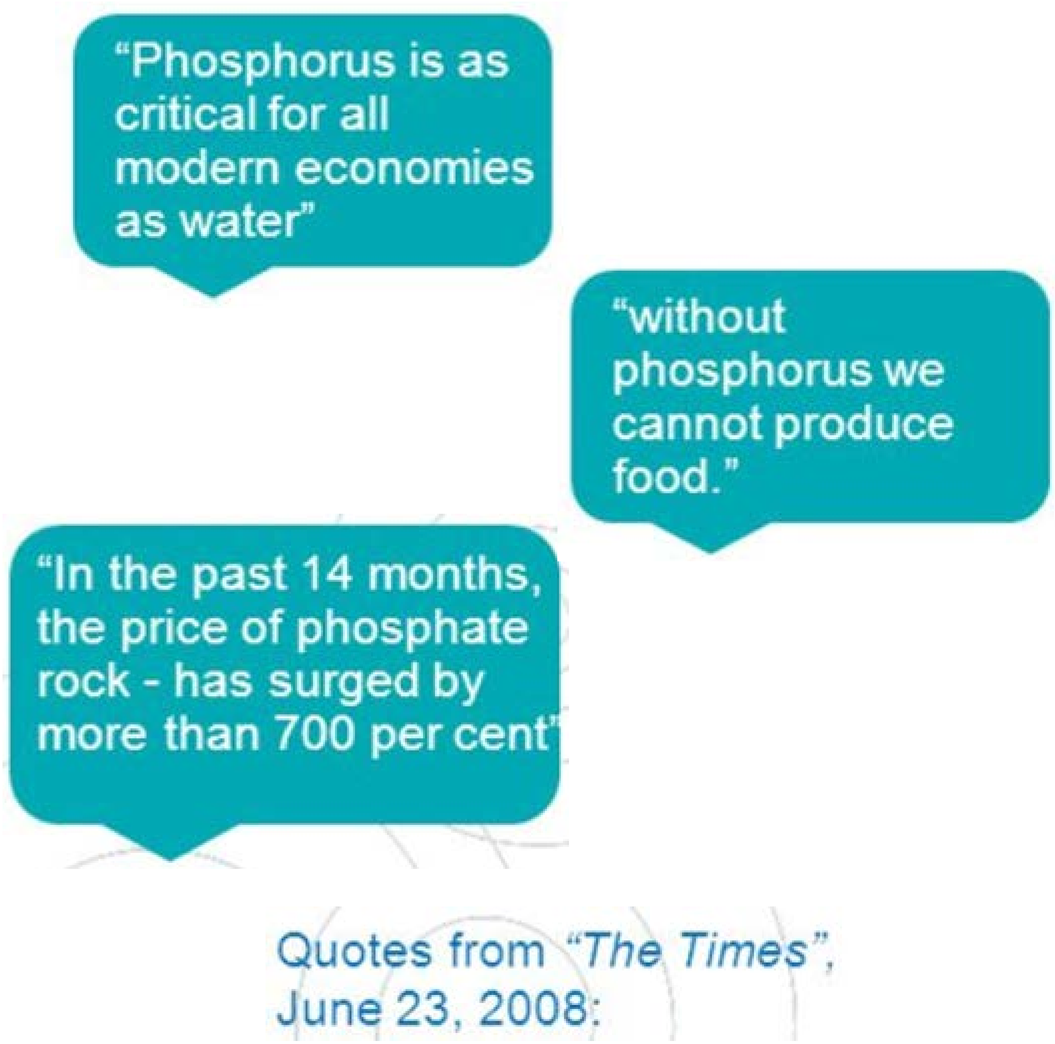
COM (2014) 0398. Towards a circular economy: a zero waste programme for Europe

COM (2015) 614. Closing the loop – An EU action plan for the circular economy

COM, 2014. On the review of the list of critical raw materials for the EU and the implementation of the Raw Materials Initiative

Example with phosphorus in the urban water management will be discussed in this presentation

Why phosphorus?



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In 2014 rock phosphate was added to the European Commission list of Critical Raw Materials, having a substitutability index estimated at 0.98.

This index is a measure of the difficulty in substituting the source, scored and weighted across all applications and has values between 0 and 1, with 1 being the least substitutable.

Phosphorus: linear pathway use

P-recovery appears a good idea

Mined phosphate
100%

Non-agricultural and industrial
5-10%

Agricultural application
90-95%

Human
20-25%

Soil erosion
4%

Run-off
no data found

Sewage treatment
8-9%

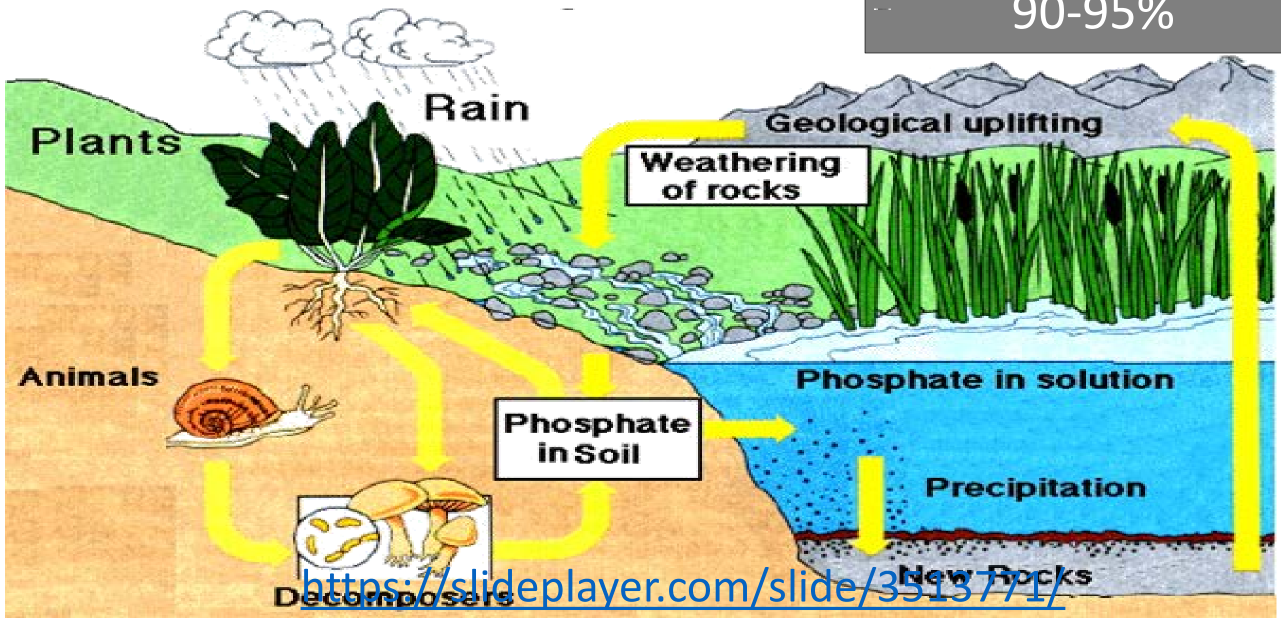
Effluent
1%

Sludge
7%

Natural water bodies
no data found

Dissipation

Dissipation



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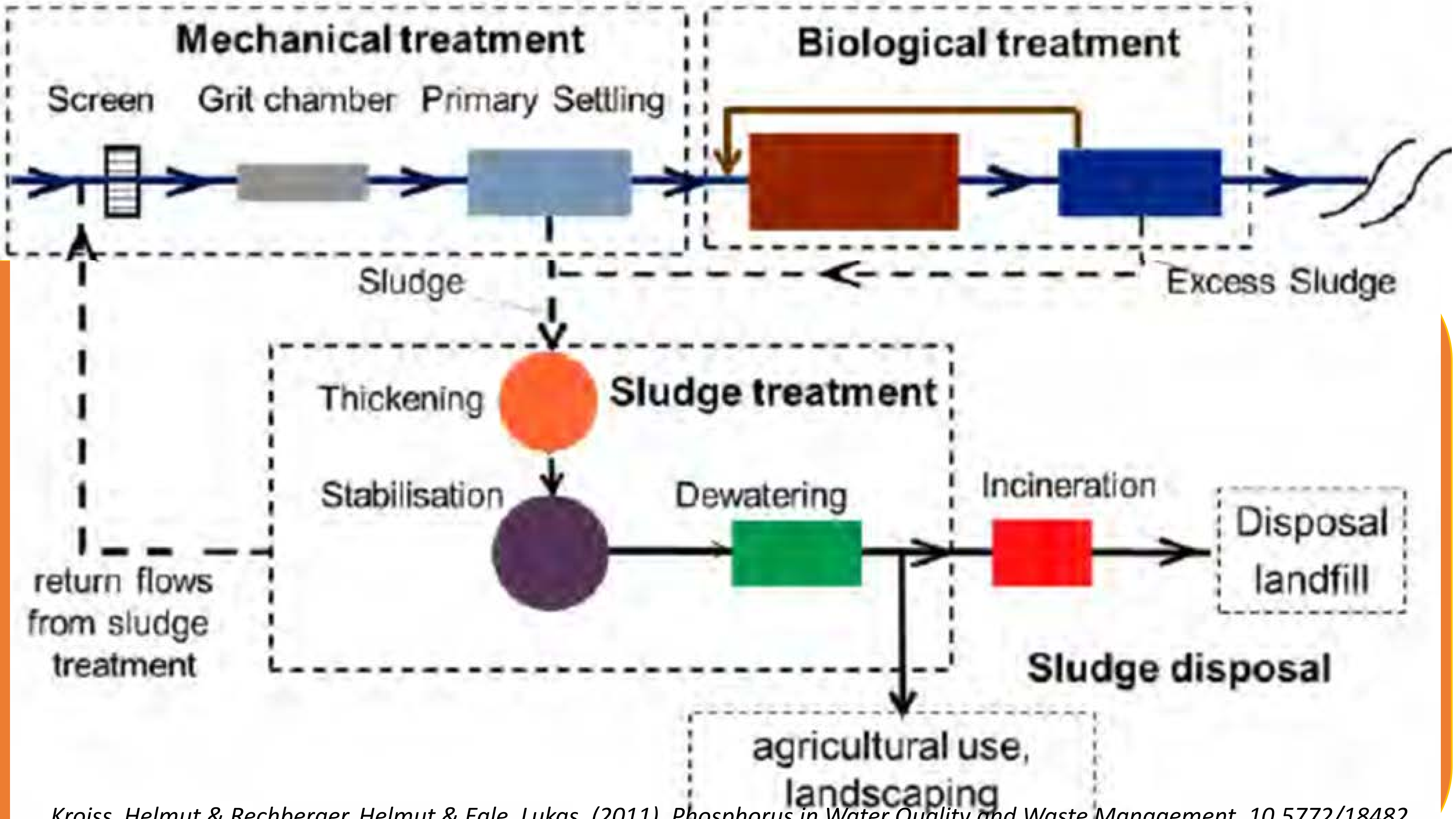
WWTP

Wastewater line

Sludge line



Kroiss, Helmut & Rechberger, Helmut & Egle, Lukas. (2011). Phosphorus in Water Quality and Waste Management. 10.5772/18482.

Phosphorus removal and recovery

1. Phosphorus is in the wastewater

Wastewater line

Metal Salt Addition

$Fe^{+3} + PO_4^{-3} \rightarrow FePO_4$

$Al_2(SO_4)_3 + 2PO_4^{-3} \rightarrow 2AlPO_4$

2. Phosphorus precipitates in the sludge

Chemical Additions

H_2SO_4

Na_2S

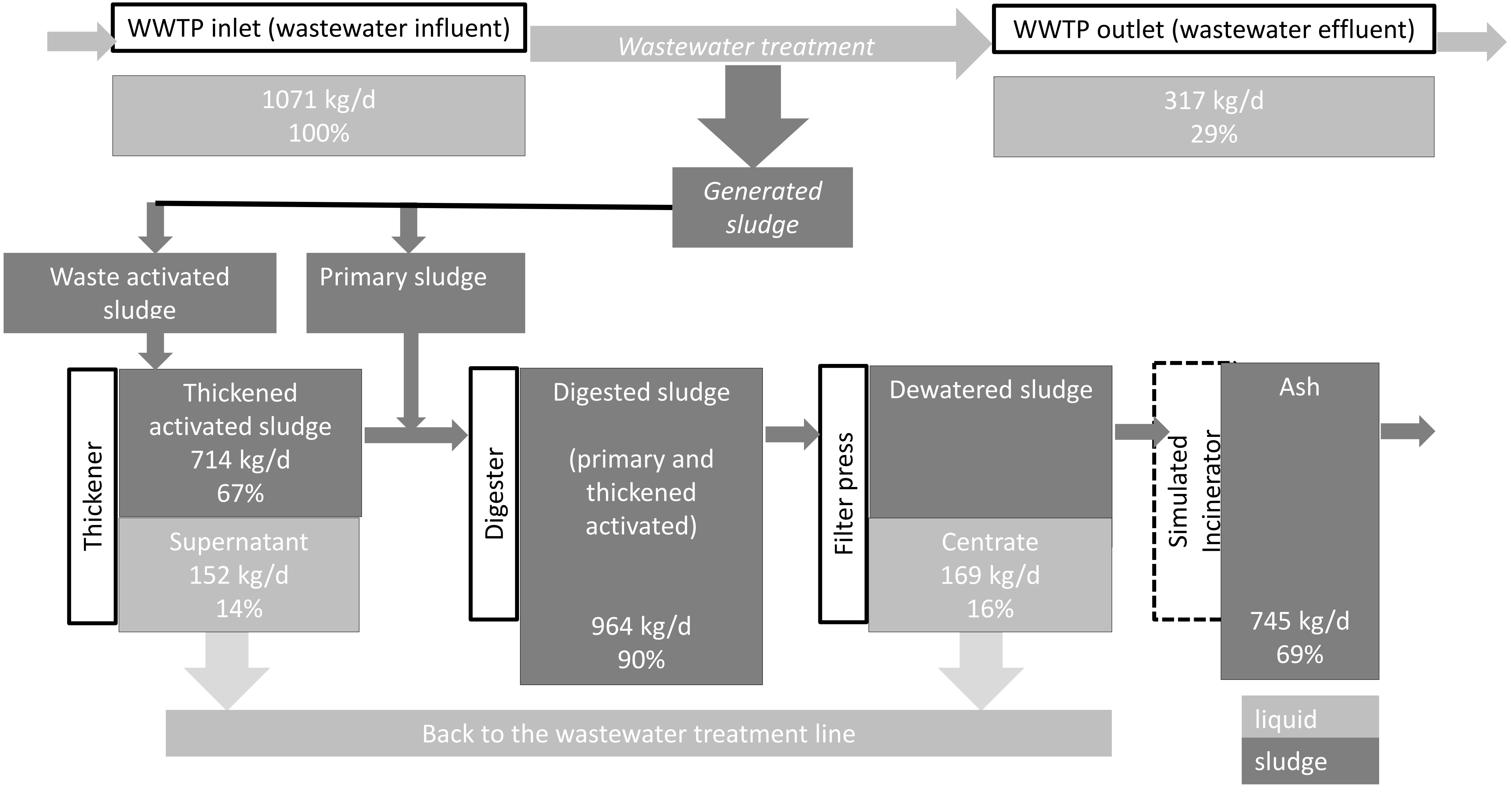
$NaOH$

$Mg(OH)_2$

Sludge line

3. Phosphorus is
rec
the

Total phosphorus budget for Sofia WWTP



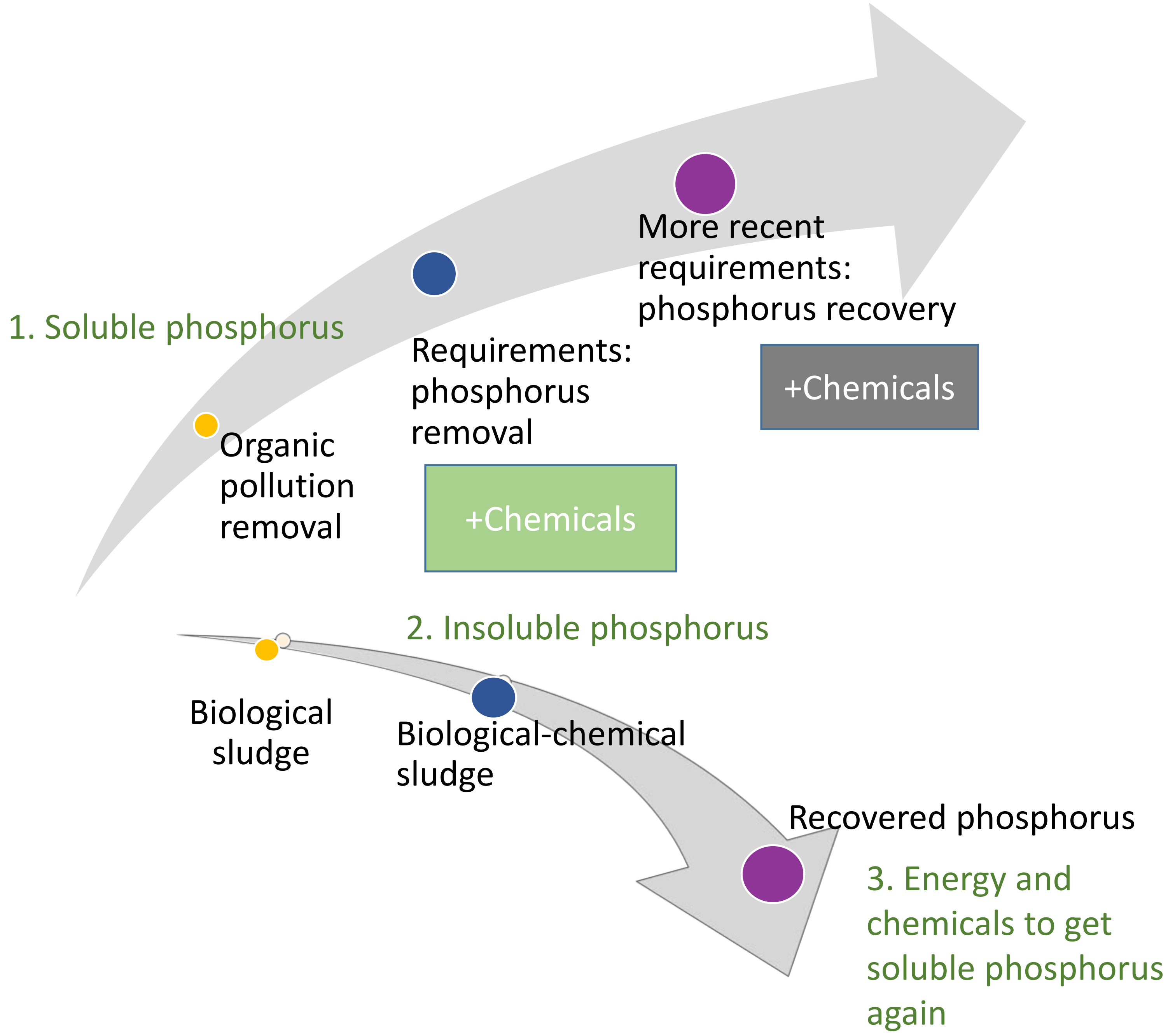
Phosphorus-recovery potential in Sofia WWTP

The available technologies for phosphorus recovery may be grouped as follows:

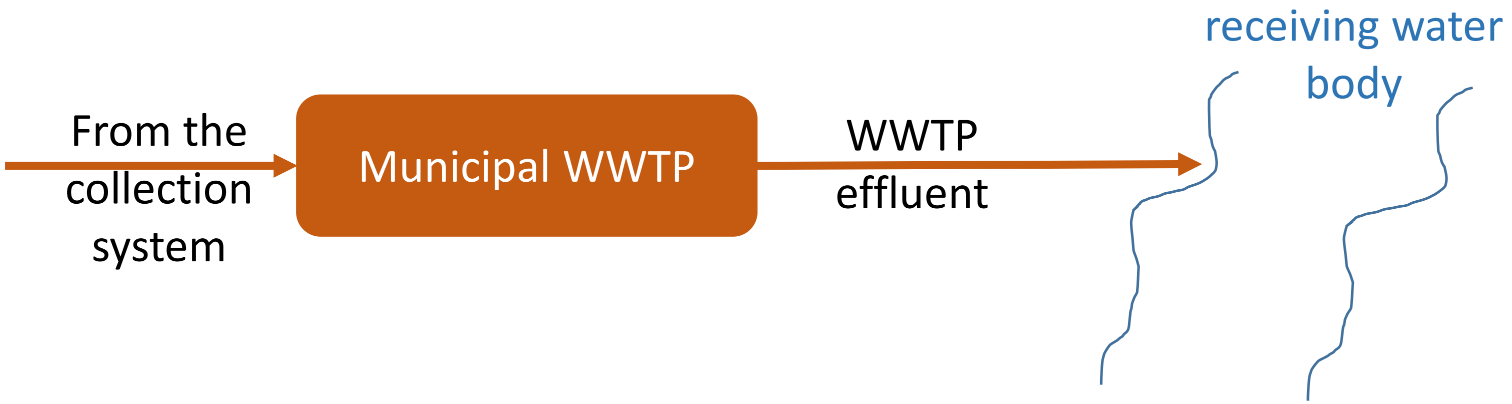
- Phosphorus recovery from the liquid phase;
- Phosphorus recovery from digested sludge or dewatered digested sludge;
- Phosphorus recovery from sewage sludge ash.

Sludge	Amount	Possible P recovery	Potentially recovered P
	kg/d	%	kg/d
Sludge after digestion	964	50	450-500
Ash after incineration	745	90	650-700

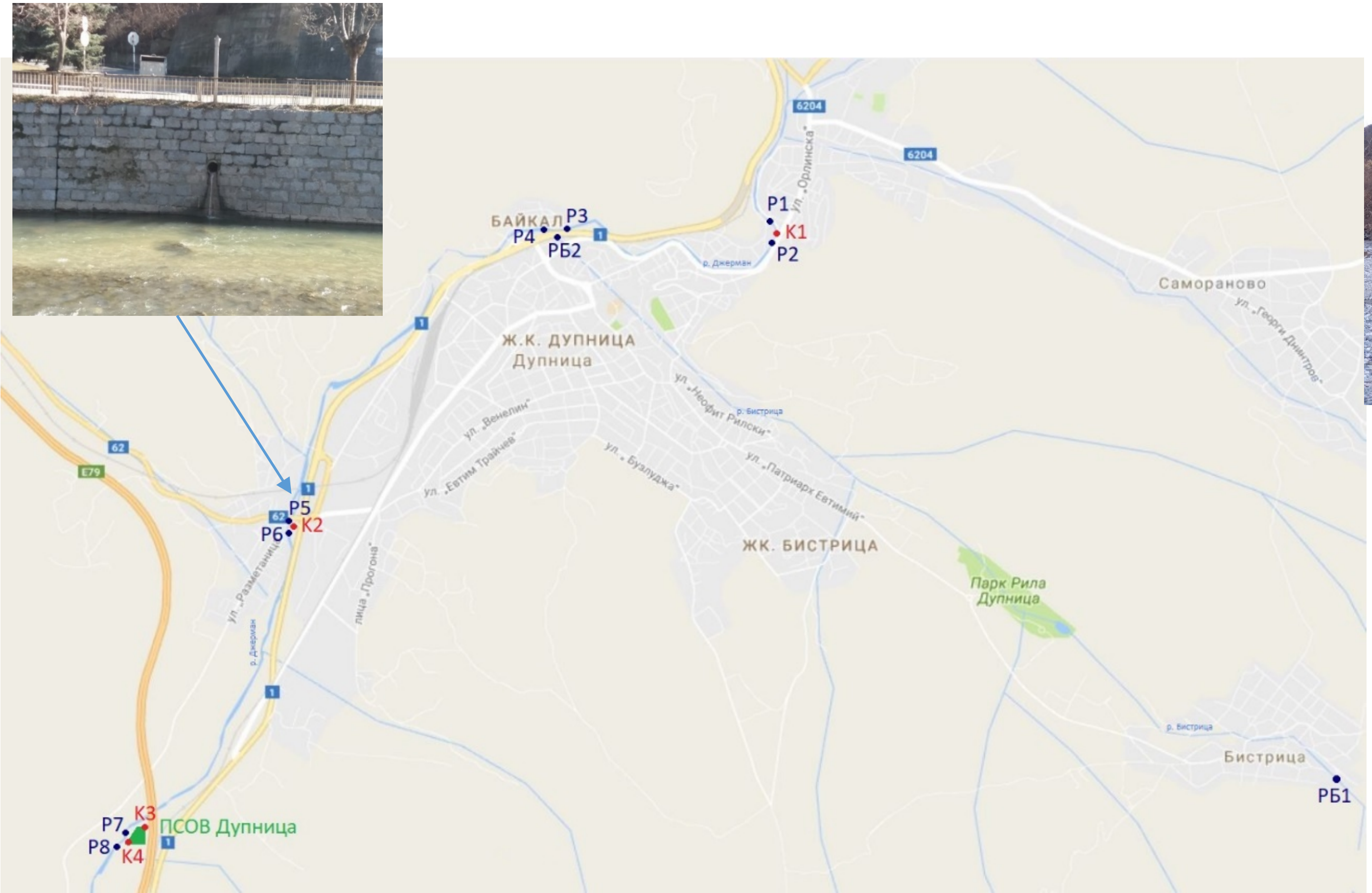
Phosphorus in the urban water management: Does it look sustainable?



Understanding the system better: How much phosphorus should be actually removed



Study river: Djerman



The approach: Grey Water footprint

The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards.

$$GWF = \frac{Q_e.(c_{e,p} - c_{\max,river})}{c_{\max,river} - c_{nat,p}}$$

The grey water footprint refers to the volume of water that is required to assimilate waste, quantified as the volume of water needed to dilute pollutants to such an extent that the quality of the ambient water remains above agreed water quality standards.

$$\frac{GWF}{Q_p} \leq 1$$

Hoekstra, A.Y., et al., 2011. The Water Footprint Assessment Manual: Setting theGlobal Standard. Earthscan, London, UK

Morera S., Corominas L., Poch M., Aldaya M., Comas J. “Water footprint assessment in wastewater treatment plants” Journal of Cleaner Production 112 (2016)

Results

Alternative technologies for phosphorus removal: Algae-based technologies

→ Screen → Grid chamber → Primary clarifier → Bioreactor → Secondary clarifier → Algae post-treatment → Discharge

https://www.wef.org/resources/topics/browse-topics-a-n/algae/

http://news.algaeworld.org/2017/08/new-wastewater-treatment-system-runs-on-algae/

https://www.us.schott.com/innovation/wastewater-treatment-latest-footwear-algae-solves-problems/

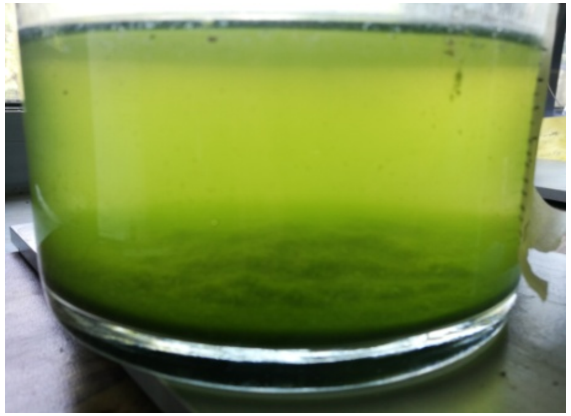
Main challenges and opportunities of algae technologies

- **Challenges**
  - Separation of the algae from the treated effluent
  - Contamination of the strains
  - Area requirements
  - Seasonal and daily irregularities - different treatment rate
- **Opportunities**
  - Biofuel
  - Capture of CO2 from air
  - Production of oxygen
  - Other use

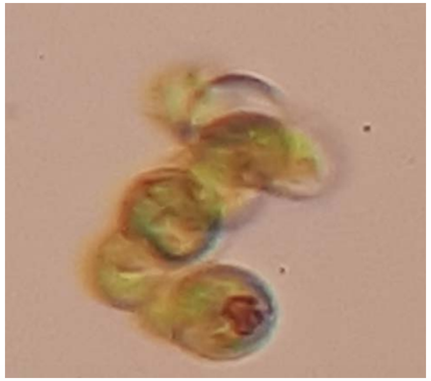
Our research results (1)

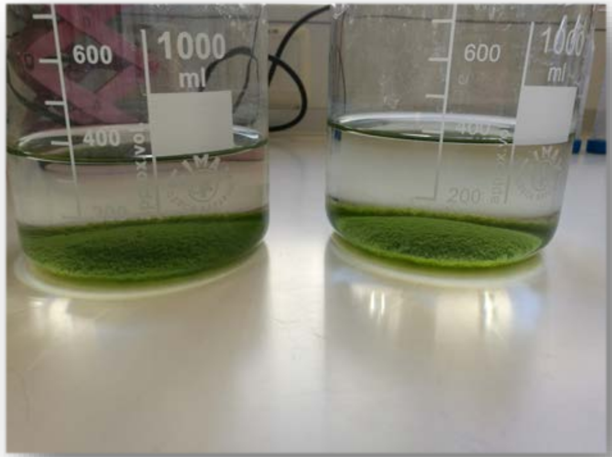
Selection of algae strains: settling properties

Desmodesmus



Visheria





Better settling

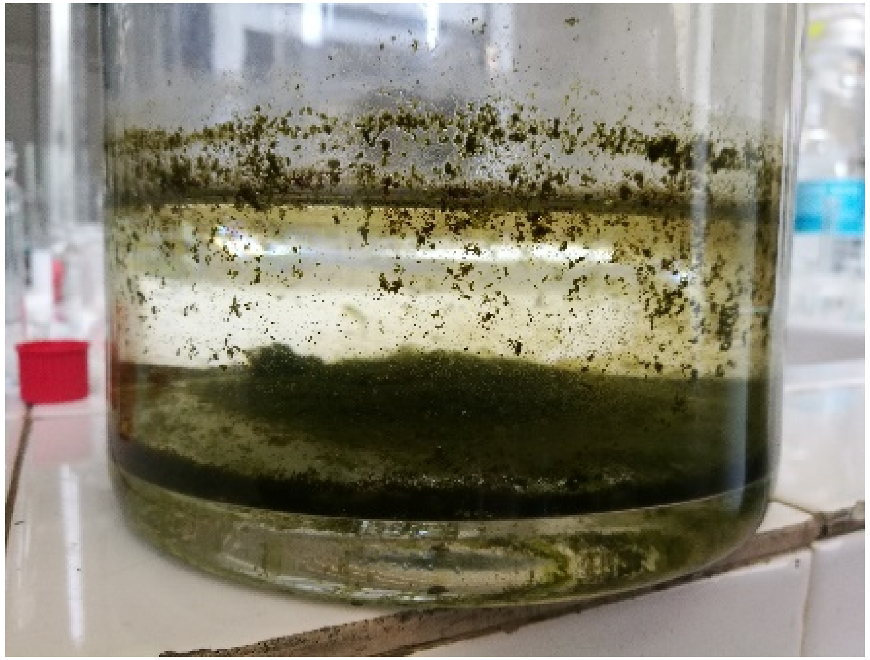
Our research results (2)

Daily treatment rate variations

Effluent phosphorus concentration

Our research results (3)

Contaminations



Phosphorus removal rate

Conclusions: Knowledge gathered

- This presentation illustrates the importance of gathering sufficient knowledge on the functioning of the new circular systems to avoid unwanted consequences
  - A valuable product (phosphorus) is recovered from a waste (sludge is WWTPs), which looks in line with the circular economy concept
  - However, the process of chemical phosphorus removal followed by chemical recovery consumes other resources (energy, chemicals). Therefore, it is not in line with the principles of the sustainable development.

- The importance of synchronization between two EU Directives (Urban WWTP and WFD) has been demonstrated; in particular is was shown that:
  - The wastewater treatment rate should be determined on a case by case basis considering its dependence on the ratio of the river run off to WWTP effluent
  - Seasonal variations should be considered
  - The ecological status of the river before discharge of wastewater should be considered

Policy recommendations

- Synchronization of the Urban WWTP 91/271, the WFD and the circular economy policies appears necessary in order to:
  - Determine correct P removal and recovery rates considering environmental constrains (good ecological status of the rivers), costs implications (avoiding unnecessary excessive costs) and the global threat of P depletion (recovery when cost/benefit ratio is favorable)

- Application of a systems approach to engineering efforts appears to be necessary:
  - Some good intentions could lead to unwanted consequences if the picture is not seen in its completeness
  - The upgrade of the available engineering infrastructure as well as any new construction is usually cost-effective. Considering system's dynamics, constrains and conditions before undertaking any actions will minimize financial, social and environmental costs.

Acknowledgments

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Source: http://chavdarchernev.com