

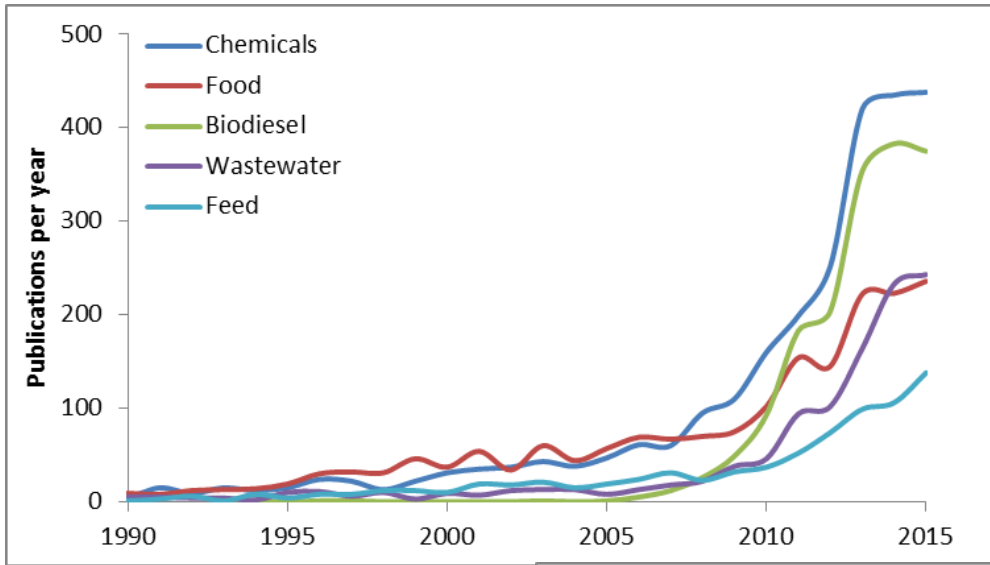


# Session 3: Residual streams

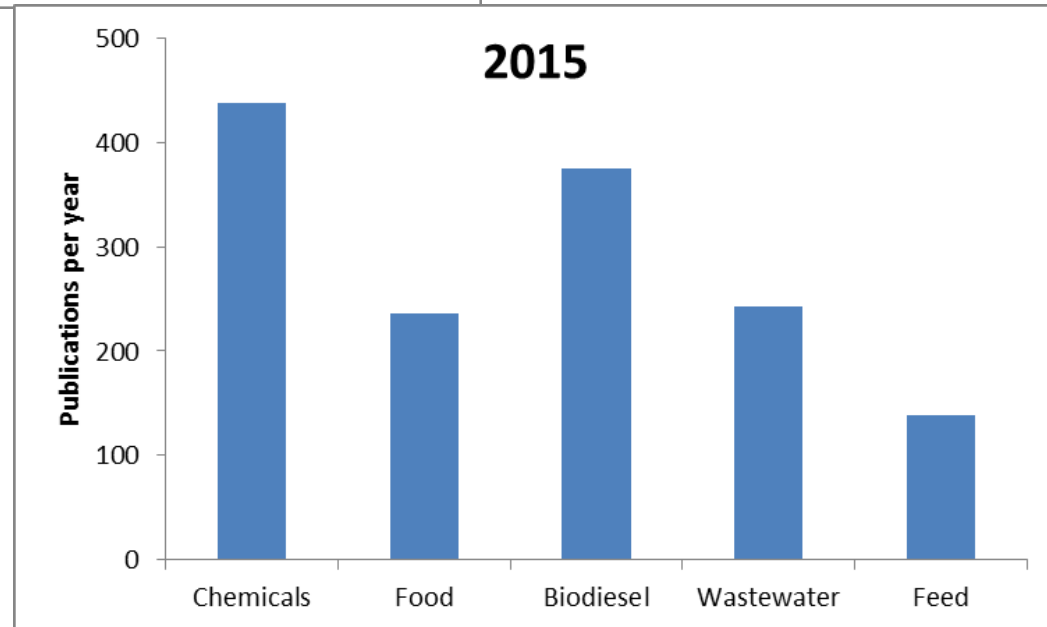


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# Residual streams- Scientific relevance



Source: Scopus 1990-2015  
Search criteria: "Microalga"+...



# Residual streams- Industrial relevance

Wastewater treatment imposes a high cost and energy consumption, nutrients being lost

Sewage: Aqualia (250 plants=500 Mm<sup>3</sup>/yr)

- Water treatment cost=0.2 €/m<sup>3</sup>
  - Energy consumption= 0.5 kWh/m<sup>3</sup>
  - **Nitrogen removal/losses=25.000 t/yr**
  - **Phosphorous removal/losses =5.000 t/yr**
- } “Microalgae=0.5 Mt/yr”

Manure plants: **more than 1.4 billions tons produced in Europe**

- Undigested manure is land spread with adverse environmental effects
- Nitrate Directive (1991) limit to 0.17 tonN/ha·year land uses
- Digestion to biogas produces digestate that is highly contaminant
- Treatment of digested manure imposes power consumption up to 1 kWh/m<sup>3</sup> and high cost up to 3 €/m<sup>3</sup>

Currently used treatments are designed to remove nutrients and not to produce biomass, employing a large amount of energy to do it

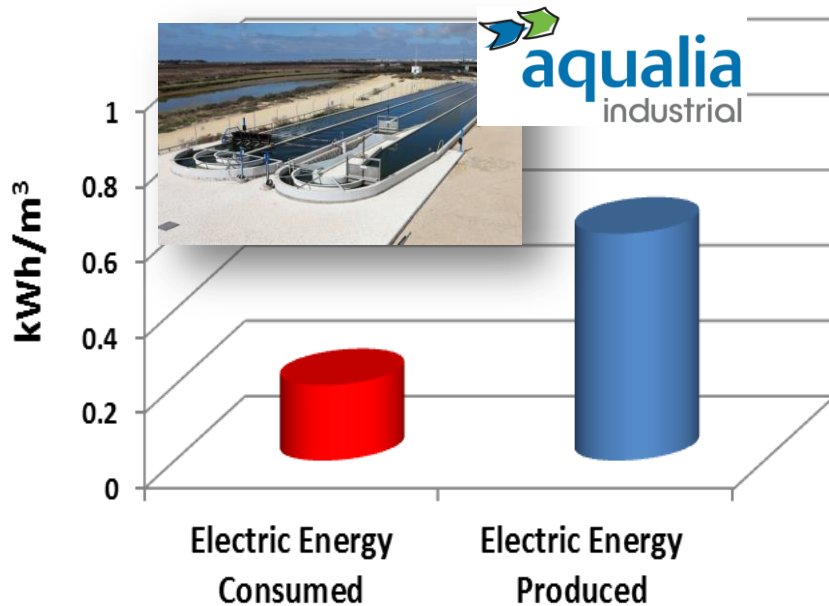
# Residual streams- Sustainability

Coupling the production of microalgae with wastewater treatment is the best option to achieve economic and environmental sustainability

## Energy balance

## Economic analysis

Microalgae Based Wastewater Treatment Plant



- CO<sub>2</sub> and fertilizers 1.25 €/kg
- Flue gases and wastewater 0.39€/kg

Acién et al., (2013) Economics of microalgae biomass production, *Biofuels from Algae*, Elsevier

- Benefit of wastewater treatment allows to produce “**free microalgae biomass**”

**ENERGETIC SELF-SUFFICIENCY=301%**

# Residual streams- Oral presentations

Robert Reinhardt. “Algae - Wastewater – Biogas”. Algen, algal technology centre, Slovenia (AlgaeBioGas, invited speaker)

I. de Godos Crespo. “Optimization of microalgae culture in High Rate Algae Ponds for simultaneous bioenergy production and wastewater treatment. Aqualia S.A. (ALLGAS)

Fabian Abiusi. “Microalgae cultivation on wastewater to enhance water quality and for sustainable production of biobased products”. Wageningen University (MAB2.0)

# Highlights/breakthroughs

1. Microalgae have demonstrated to be suitable for the treatment of different residual streams, as contaminated water but also gases
2. The efficiency/robustness of the processes has been improved in the last times approaching the technology to be competitive with conventional processes
3. Microalgae based technology can be incorporated into the portfolio of “options” for residual streams treatment, microalgae biomass being a by-product of the process
4. Large amounts of cheap biomass can be produced on this way it being necessary to clarify market and legal aspects about the utilization of this biomass

# Focus points for future research

1. Removal of contaminants is the objective of the process.  
Optimization of the design/operation conditions still can improve the yield of the technology maximizing the capacity of water treatment
2. Microalgae/bacteria consortia is the core of the process.  
It is necessary to characterize/study this consortia and to know how to manage it to “control” the performance of the system
3. Large amount of microalgae biomass can be produced.  
Up to 1 kg of dry microalgae biomass can be produced per m<sup>3</sup> of wastewater, then it is necessary to define/develop optimal “utilization” processes for this biomass

# Sewage treatment with microalgae

European Demonstration projects

Production of bioenergy and wastewater treatment



Demonstration projects are currently carried out on this field to improve the technology and demonstrate their efficiency at large scale (10 ha)

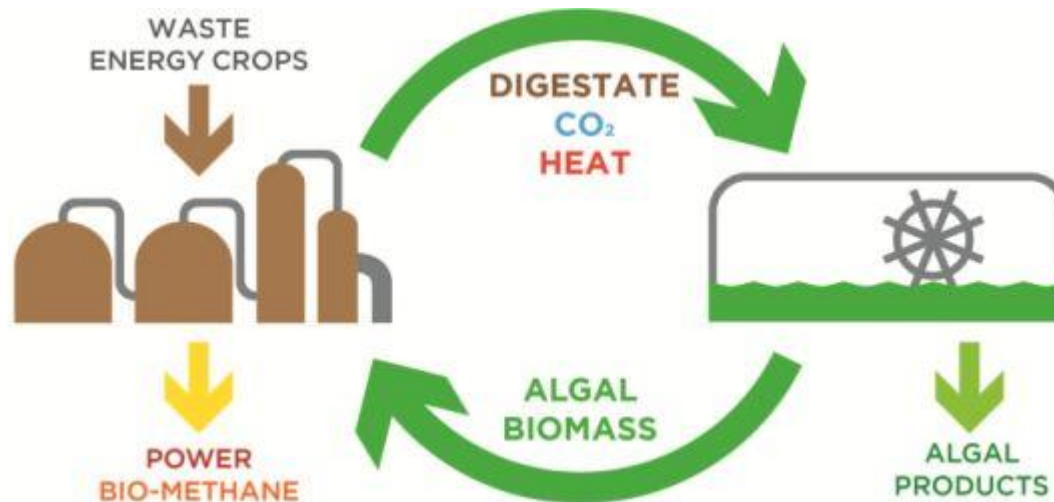


# Animal manure treatment with microalgae

## European Demonstration projects



AlgaeBioGas project is focused to market introduction of algal-bacterial treatment of biogas digestate and feedstock production, an innovative technology which has significant economic and environmental benefits to biogas operators.



There are several projects on this field, still the technology being under development due to different bottlenecks (N/P ratio, turbidity, etc..)