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Desing of a slurry treatment plant and biocombustible production

Part III: Module Tertiary Treatment and Biocombustible production

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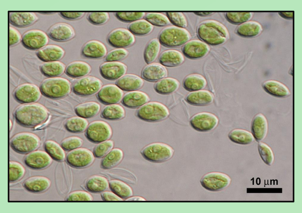
INTRODUCTION

The main purpose of the plant is to remove wastes resulting from the anaerobic digestión of pig manures.The effluents from this process are rich in nitrates and phosphates that, in excess, they becomes dangerous pollutants. In this paper it is proposed the use of microalgae as bioremediation organisms, since they are able to assimilate both components while consuming CO2 and produce a valuable biomass. Given the chemical composition of the biomass, It intend to carry out an ABE fermentation, with the consequent production of acetone, n-buthanol and ethanol, thus making profitable the plant costs.

- **Elimination N and P from water.**
- **Substitution EDAR tertiary treatment.**
- **Production n-butanol, acetone, ethanol.**
- **Renewable source energy.**
- **Greenhouse-gas reduction (CO2 consumption).**
- **Creation of sustainable production systems.**

MICROALGAE CULTURE

Scenedesmus obliquus



Characteristics:

- High growth rate.
- Rapid elimination of N and P.
- High tolerance to [N].
- High consumption CO2.
- Flocculation tendency.
- Proper chemical profile — 20-30% Lipids, 50% Carbohidrates, 15% Proteins

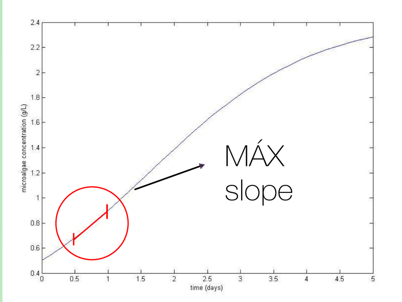
The pig manure effluent (2 m³/day) is mixed with water coming from the secondary treatment of EDAR plant at Prat de Lluçanes (29 m³/day).

Benefits:
- Energy savings: Replacing the classic tertiary treatment.
- Dilution of [N]: inhibition is minimized.
- The turbidity of pig manure decreases: better light penetration

CULTIVATION MODE

CCS:Chanels conected in serie

Growth simulation



$$\frac{dX}{dt} = \mu_{max} X\left(1 - \frac{X}{X_{max}}\right)$$

μmáx = 0.82 (d⁻¹)
Xmáx = 2.4 (g/l)

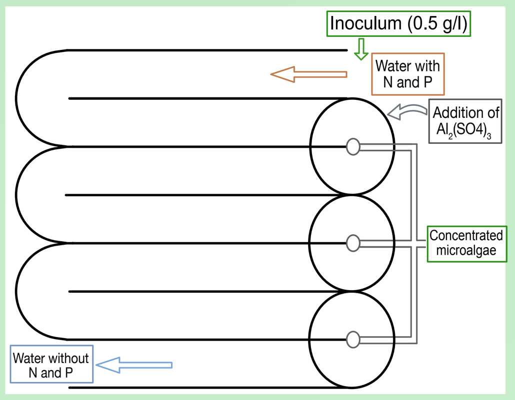
Ratio optimization N/P(15)

Optimizationof intervale growth (0.5-1 g)

Characteristics:

- Depth 25 cm
- Low cost system
- Robustness against temperature changes
- Analog flow to RCFP
- In each section are recovered $[X]_o$=0.5 g/l

Scheme CCS



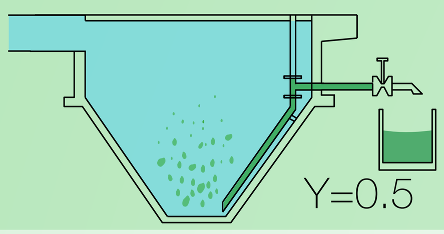
Advantages

- Inhibition is limited to the first section (230 ppm N)
- Last section are stressed by nutrient deficiency: lipids production is stimulated

MICROALGAE RECOVERY

Sedimentation

Flocculation favoured by the addition of $Al_2(SO4)_3$.



Disck centrifuge

Biomass concentration of 30 (g/l)

Flow = 10 m³/day

	Nitrogen total (mg/l)	Phosphorus total (mg/l)	Ratio N/P
Initial flow	230	32,6	15,65
F. Section 1	198	28,3	15,5
F. Section 2	167	24	15,4
F. Section 3	135	19,7	15,2
F. Section 4	104	15,4	15
F. Section 5	72	11	14,5
F. Section 6	41	6,8	13,4
Final flow	9,4	2	-

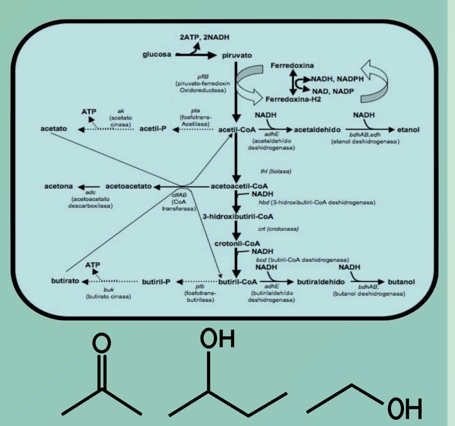
- 7 sections
- 3.6 hectares extension
- Productivity 3.65 g/l·day
- Production of 2715 kg/day

ABE FERMENTATION

Clostridium acetobutylicum

Characteristics

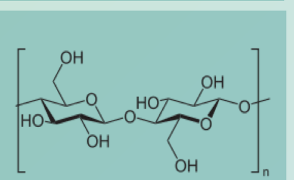
- Gramn positive
- Strict anaerobe
- Degradation of sugars, startch,protein and cellulose



TERMAL SACCHARIFICATION

Operating conditions

$V_{reactor}$ = 11 m³
5 cycles per day at 82% load
Y= 0.5 (g sugar/g algae)



- 60 g biomass/l
- 30 min
- 0.1 mM H_2SO_4
- 1.5 atm

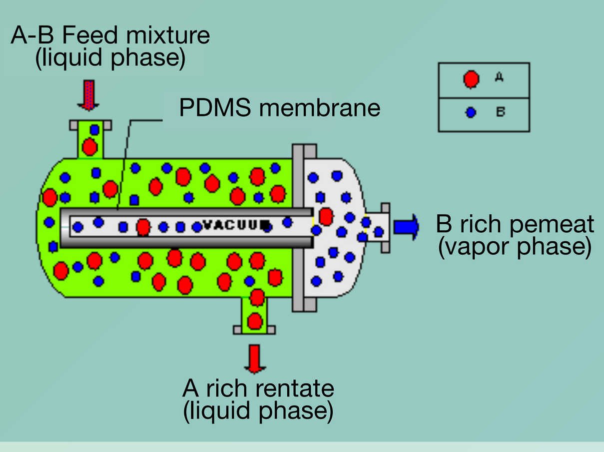
Obtaining solubles sugar

CULTIVATION MODE

- Air-lift operating in semi-continuous (140 m³)
- Inmmobilized cells in polyvinyl-cryogel support
- Pervaporation chamber in situ: Membrane PDMS

Homogeneous distribution of inhibitory compunds

Elimination of inhibitory compounds



Butanol = 424 T/year
Acetona = 69 T/year
Ethanol = 23 T/year

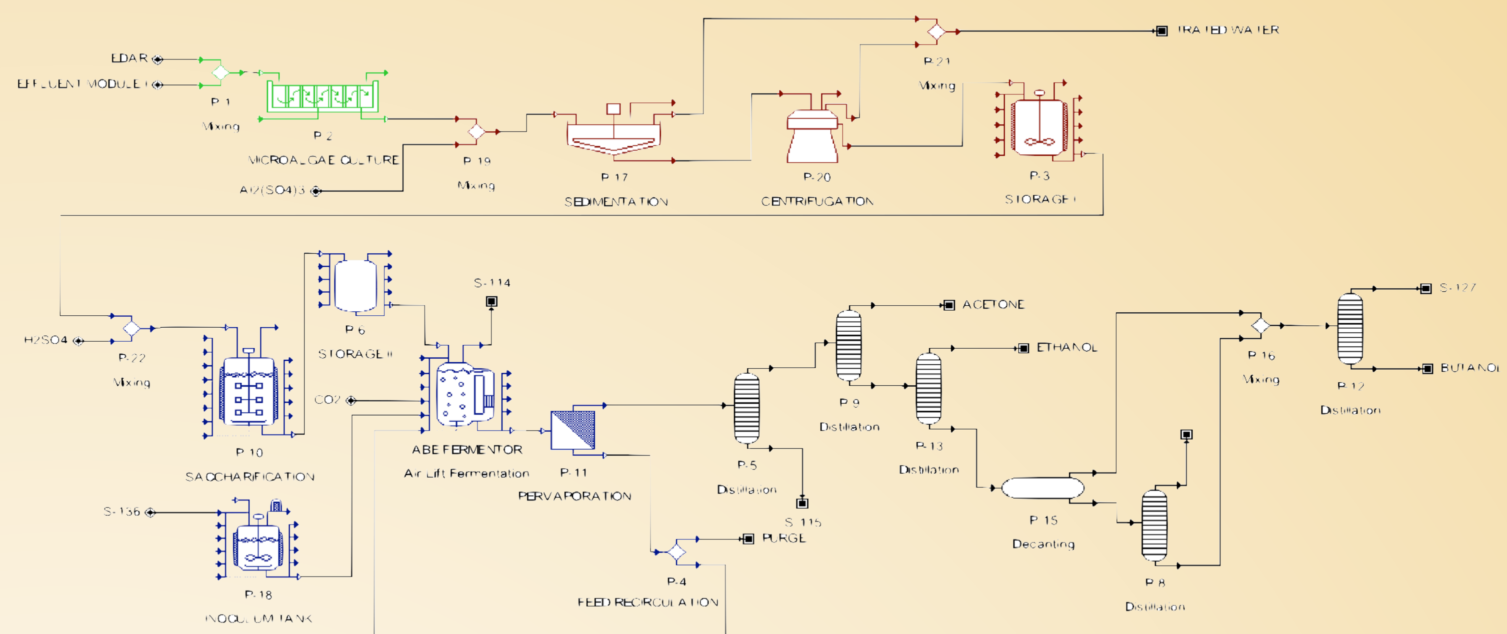
DOWNSTREAM

Distillation train

- Butanol 99.7%
- Acetona 99.5%
- Ethanol 96 %

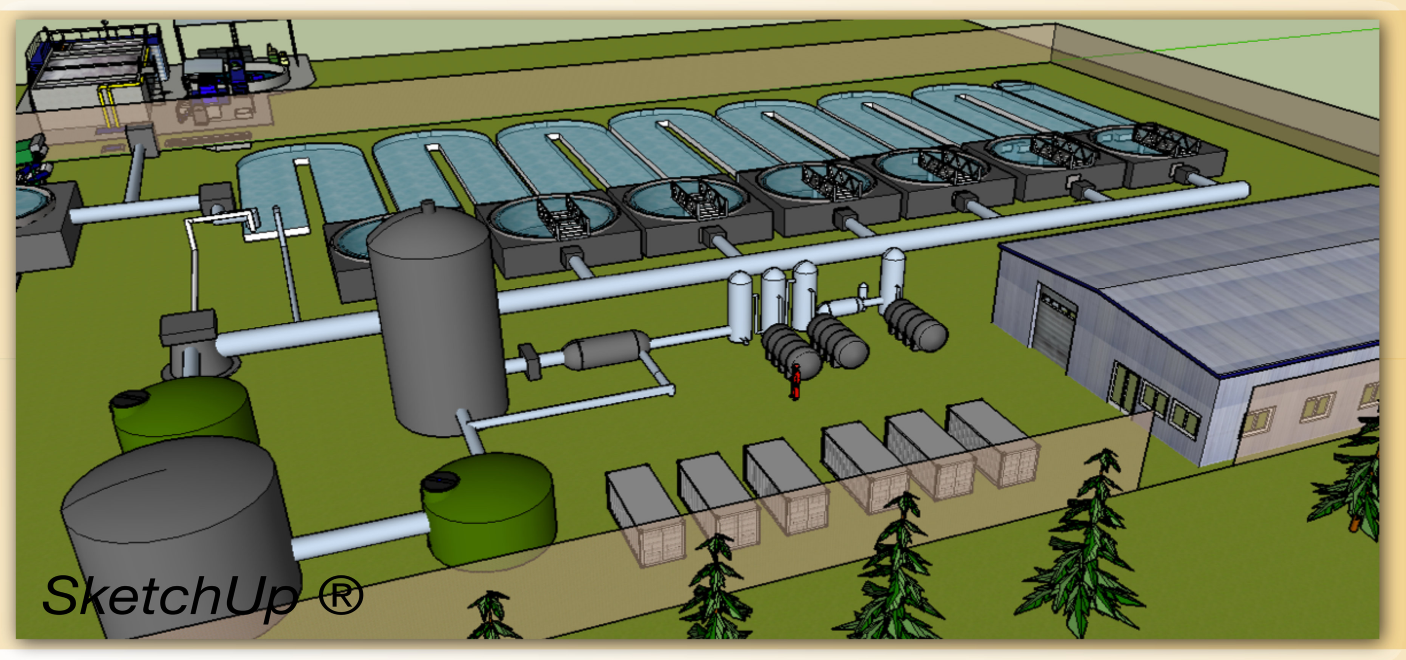
Reduction of 50% of total consumption compared to conventional technology

FLOW DIAGRAM



SuperPro Designer ®

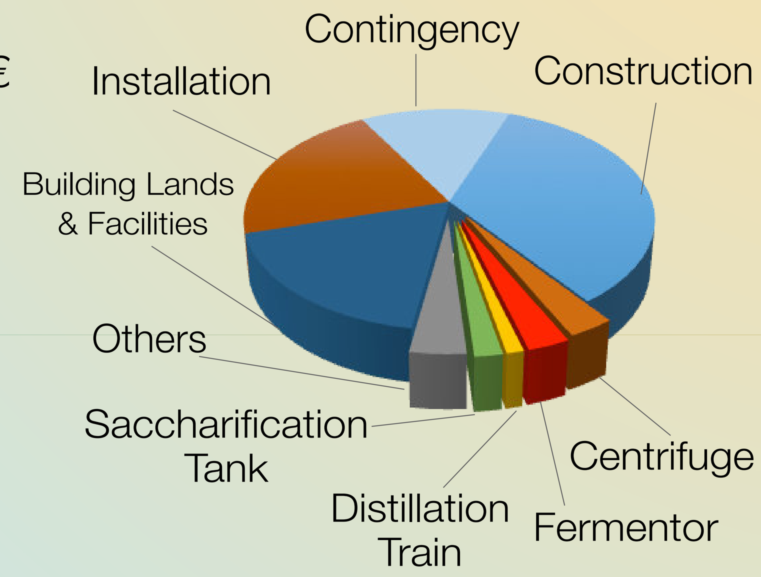
LAYOUT



ECONOMIC ANALYSIS

- TCI = 7.175 M €
- Anual operating cost= 0.43 M €
  - 6 Operators
- Revenues = 0.777 M €
- ROI = 4.9%

Total capital investement



Annual net profit of 390 000 €

ENVIRONMENTAL ANALYSIS

- Elimination of N and P: Neither eutrophication nor ground water leaching
- Bioremediation of pharmaceutical drugs in water
- Reducing emissions of greenhouse gases:1460 T CO2/year
- Sustainable Fertilizers Production
- Energy production from renewable sources

250 people

22.5 T/year

470 m³/year gasoline[equivalent]

Autonomy of the area is stimulated

CONCLUSIONS

A serious environmental problem is solved effectively and sustainably.
The use of microalgae as bioremediation system proves to be very effective and potentially applicable.
ABE fermentatios, as a strategy of biomass revaluation and production of biofuels, has many advantages but it must overcome some technical obstacles.

- **Avoid formation of biofilms: Use of closed systems cultivation.**
  - → **Reduction of land needed**
- **Butanol is high energy biofuel and it's not corrosive for engines.**
- **Use of engineering clostridium strains.**
- **Improvement of ABE products recovery systems.**

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