Valorizing nutrients from POME digestate

Upgrading and valorizing nutrients from Palm Oil Mill Effluent

Final presentation SMP 17018

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Aim and Activities

- Aim:
  - Analyse options for nutrient recovery from Palm Oil Mill Effluent (POME)
  - Assess the integration of potential technologies into an economically viable production chain

- Activities:
  - Desk study
  - Data analysis – input provided by all partners
  - Field visit to Indonesia by WFBR

Partner contribution

- Project implementation:
  - Wageningen Food and Biobased Research
- Partner contribution:
  - Biomass Research – Project coordination; economics of nutrient replacement
  - Indonesian Institutes – Practices, regulations and environmental impact
  - Enki Energy – Technical advice
  - AgriQuest – Crop nutrient requirements

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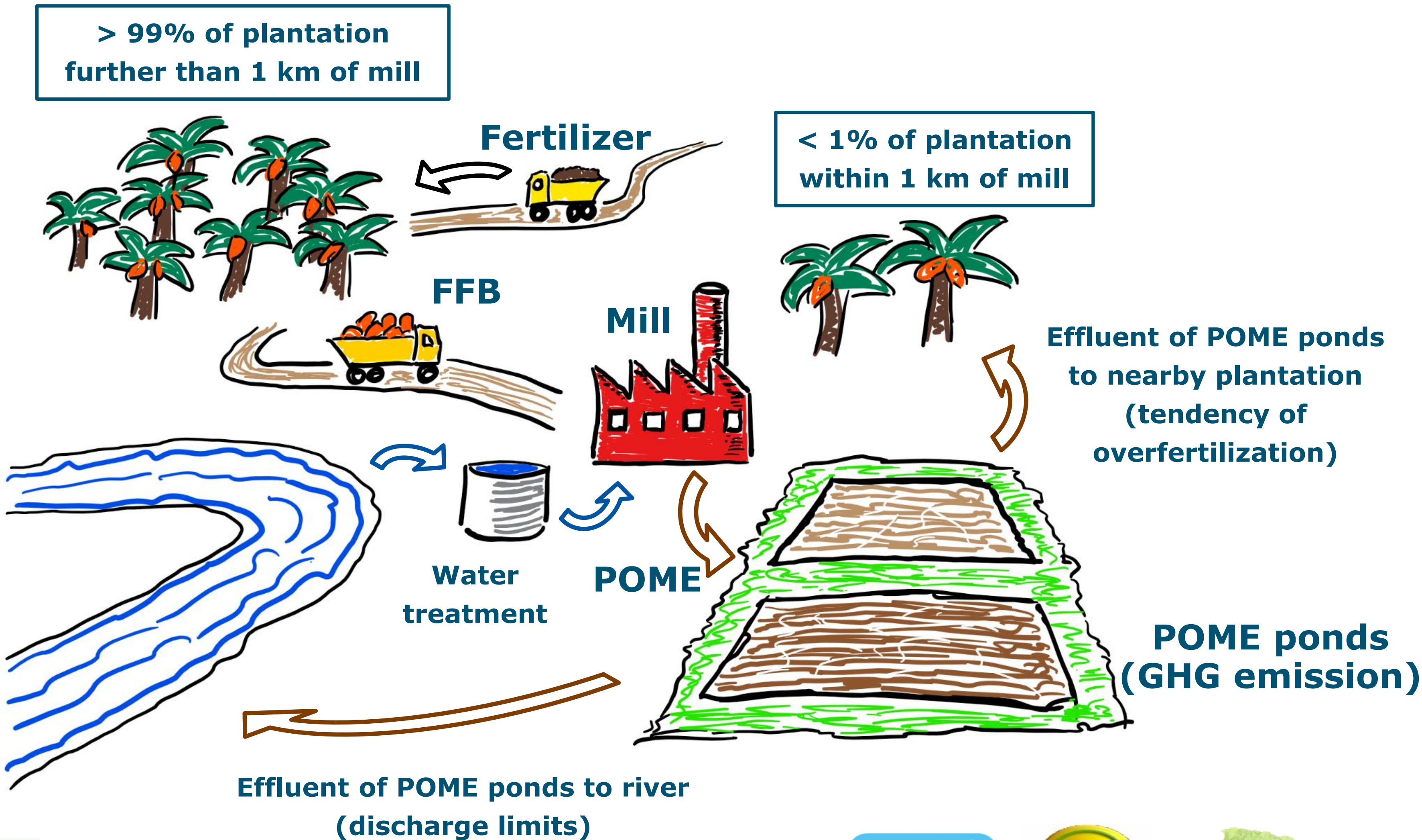
Introduction

Palm Oil Mill Effluent (POME): a problematic waste

- Source of spontaneous GHG emissions
- Use as fertilizer only near the mill because of high transport costs
    - Tendency of overfertilization
- Source of water pollution
    - Organic material (BOD)
    - Nutrients (eutrophication)

Current situation



Anaerobic digestion

POME is well suited for treatment in digestion tanks

- Anaerobic digestion reduces methane emissions and reduces BOD pollution
- Using minerals from POME digestate significantly increases the economic viability of digestion systems, while reducing environmental impacts of the mill
- However, the cost of the distribution of POME digestate generally is too high

Concentrating POME digestate

Screening options:

- Potassium struvite precipitation
- Bioaccumulation
- Concentration of minerals with membrane technology

Case definition

Production	365	d/y
	20	h/d
	7300	h/y

Plant capacity	FFB	CPO	POME	
	60	12,6	49,1	ton/h
	438	92	358	kton/y

Eff plantation area	20467	ha
Steam	31	ton/h
Steam/FFB	0,51	
POME/FFB	0,82	
POME/CPO	3,89	

		Fresh W	DW	N	K	Mg	P
		ton/ha.yr		kg/ha.yr			
Fresh fruit bunch	FFB	21,4	9,2	57,0	71,7	14,7	8,3
	Steam	10,9					
Crude palm oil	CPO	4,5	4,5				
	Raw POME	17,5	1,0	11,4	32,7	5,0	2,1
	Digested POME	16,8	0,2	6,5	28,9	5,5	1,0
			%	g/l			
	FFB		43,0%	2,66	3,35	0,69	0,39
	Raw POME		5,5%	0,65	1,87	0,29	0,12
	Digested POME		1,3%	0,39	1,72	0,33	0,06

Ref: Elbersen et al., Valorization of palm oil (mill) residues, 2013

Loh et al., Renewable and Sustainable Energy Reviews 74 (2017)

(raw and digested POME composition)

Potassium struvite precipitation

- Product: Potassium struvite $KMgPO_4$
- Equipment: Precipitation tank & separation

☒ High pH (9 – 11) required: Addition of base required
☒ Addition of salts required (Mg and PO_4): Adding relative high valuable salts to obtain relative low valuable fertilizer
☒ Fertilizer with fixed ratio, too much PO_4 for plantation
☒ Mineral yield: For high K yield, low (<75%) Mg and PO_4 yield and visa versa
☒ Rest stream: Demineralized POME digestate

Ref: Parasad et al., Environmental Materials and Waste, 1st Ed, 2016
Xu et al., Chemosphere 84 (2011)
Xu et al., Water Research 80 (2015)

Bioaccumulation

- Product: Duckweed (= animal/fish feed)
- ✖ Equipment: Raceway ponds
  - FFB: ~ 9,2 ton DW/(ha·yr)
  - Duckweed in raceway pond: ~ 20 ton DW/(ha·yr)
    - ~ Same K conetent per ton DW in FFB and duckweed (~ 1%)
    - ~ 40% of K in FFB in POME digestate
    - **~ 20% of plantation area required for bioaccumulation**
- ✖ Mineral yield: < 75%
- ✖ Rest stream: demineralized POME digestate

Ref: Leng, Duckweed: A tiny aquatic plant with enormous potential for agriculture and environment, 1999

Online: http://www.fao.org/ag/againfo/resources/documents/DW/Dw2.htm

Concentration of minerals with membrane technology

- Product:
  - Mineral concentrate 5% w/w
    - Concentration factor of 10
  - Boiler feed water
- Equipment:
  - Pretreatment -> Anaerobic digestion and aerobic treatment reduces BOD, COD, TS => **Required for membrane processes!**
  - Ultrafiltration (UF)
  - Reversed Osmosis (RO)

❌ Requires skilled operators (for cleaning, maintenance)

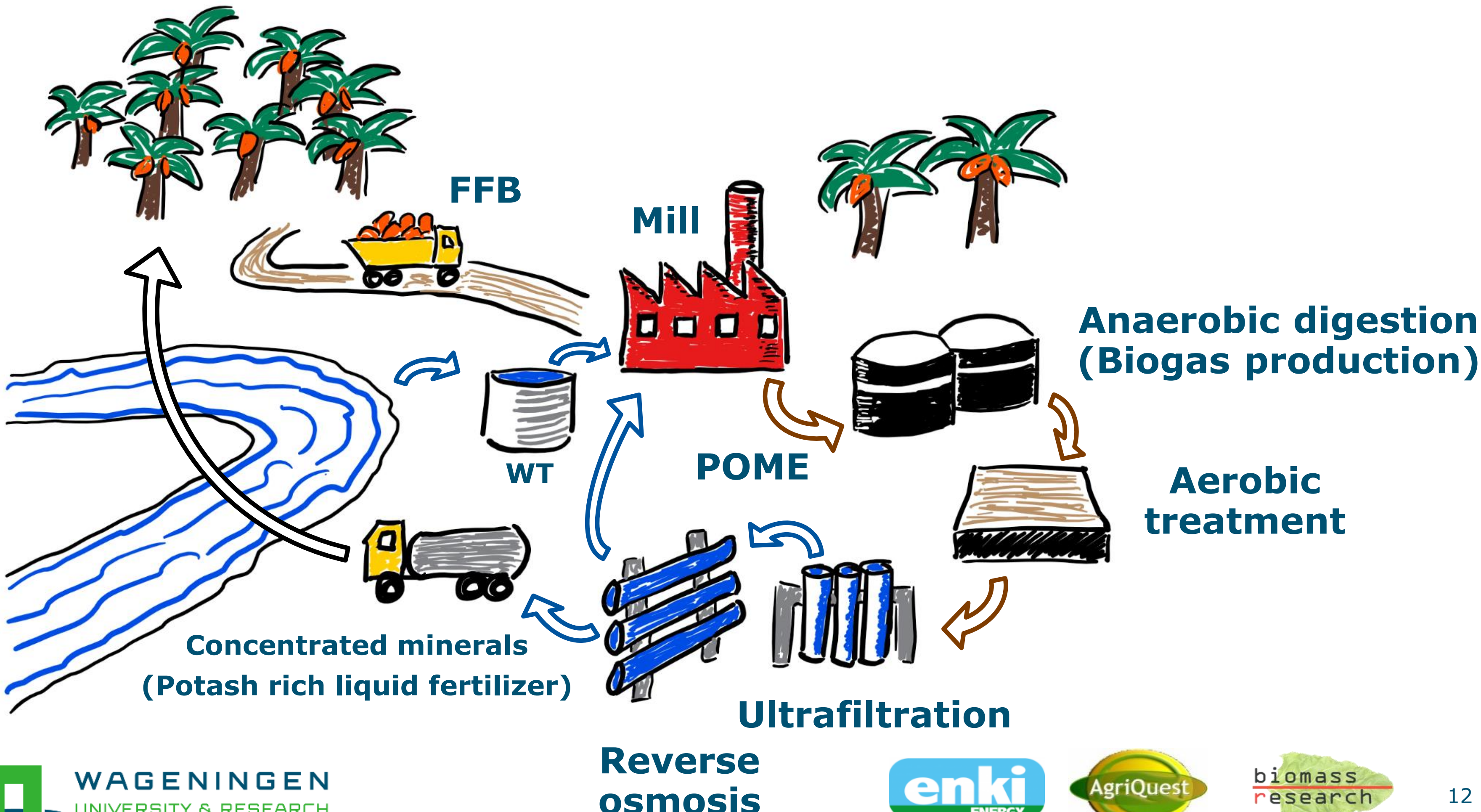
✅ Mineral yield: 100%

✅ Rest stream: None

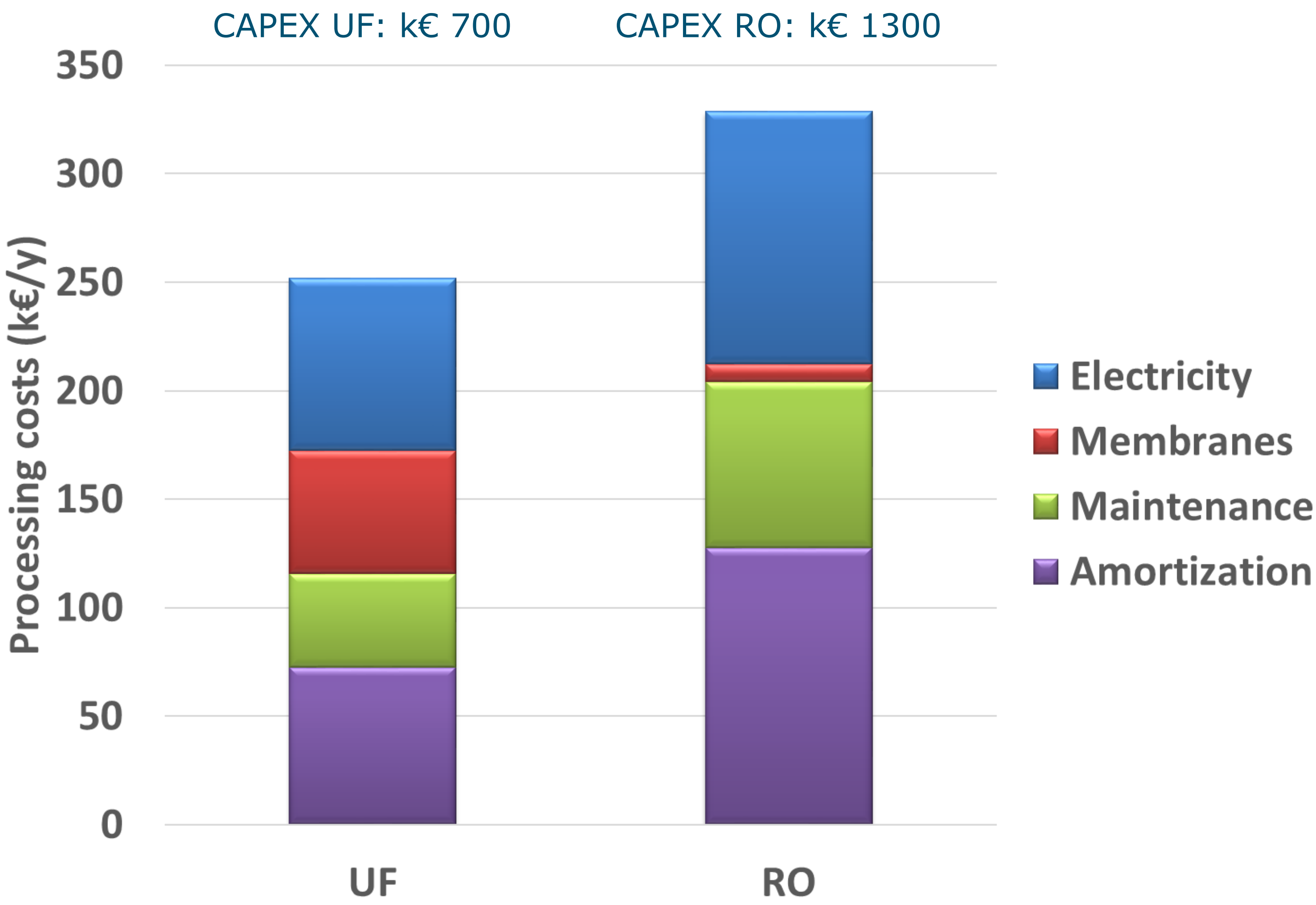
Evaluated in more detail

(techno-economic evaluation)

POME to biogas and valorizing nutrients and water from POME digestate



Results: Processing costs



Conclusion

- Despite a concentration factor of 10, application costs of the mineral concentrate remain too high
- Reducing application costs of the concentrate, savings can exceed costs under scenarios of high fertilizer prices
- Improvement of membrane technology and/or reduction of membrane technology costs significantly increase profitability
  - Membrane technology should be evaluated experimentally

SMP output and follow-up

- The membrane technology is the most suitable technology for nutrient recovery
- The consortium intends to explore opportunities for
  - Experimental evaluation of membrane technology
  - Explore options for further cost reduction of ultrafiltration and reversed osmosis
  - Potential application of nutrient concentration technologies for residues generated in other biomass refinery processes

SMP output and follow-up

- The outcomes of the SMP study have been submitted to The European Biomass Conference & Exhibition (EUBCE) to be presented at the 2018 Conference in Copenhagen