PALM OIL EDUCATIONAL OUTREACH WEBINAR

Water and wastewater management in the Palm oil industry, Malaysia

Prof. Shamsul Rahman Mohamed Kutty

CUReS, CEE, UTP

@Prof Shark

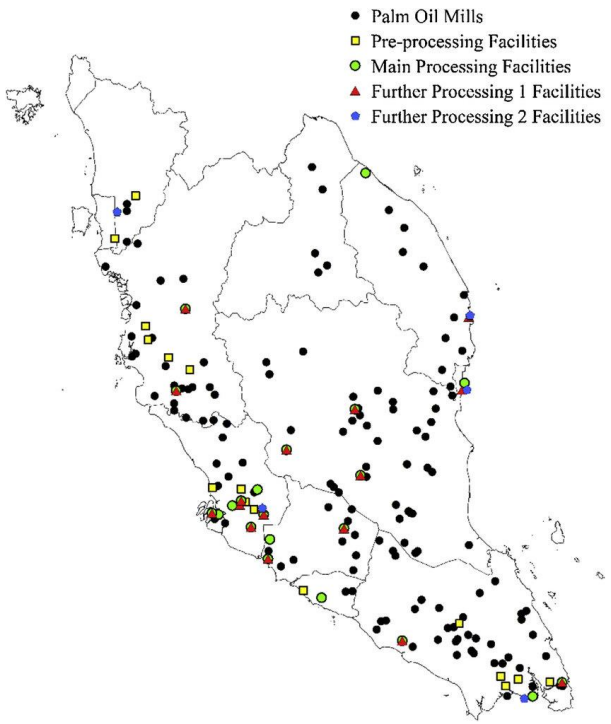
25/05/21

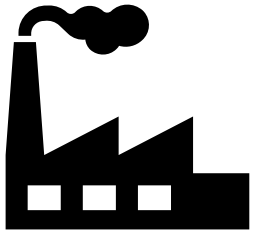
History of Malaysian POME industry

Agriculture based Industry.
Contributor to Malaysian's GDP
~ 6%

- Vegetable oil

- Production of foods such as cake, chocolate, biscuits, margarine and frying fats.
- Cosmetics, soap, shampoo, cleaning products
- Biofuel - production of biodiesel (palm oil methylester or palm oil diesel)





Palm oil production globally 2020/21 (USDA, 2020)

Production	2020/21 (Aug)
Indonesia	43,500
Malaysia	19,700
Thailand	3100
Colombia	1670
Nigeria	1015
Other	6013
Total	74,998

2011 Data:

A – Number of palm oil processing mills in operation;

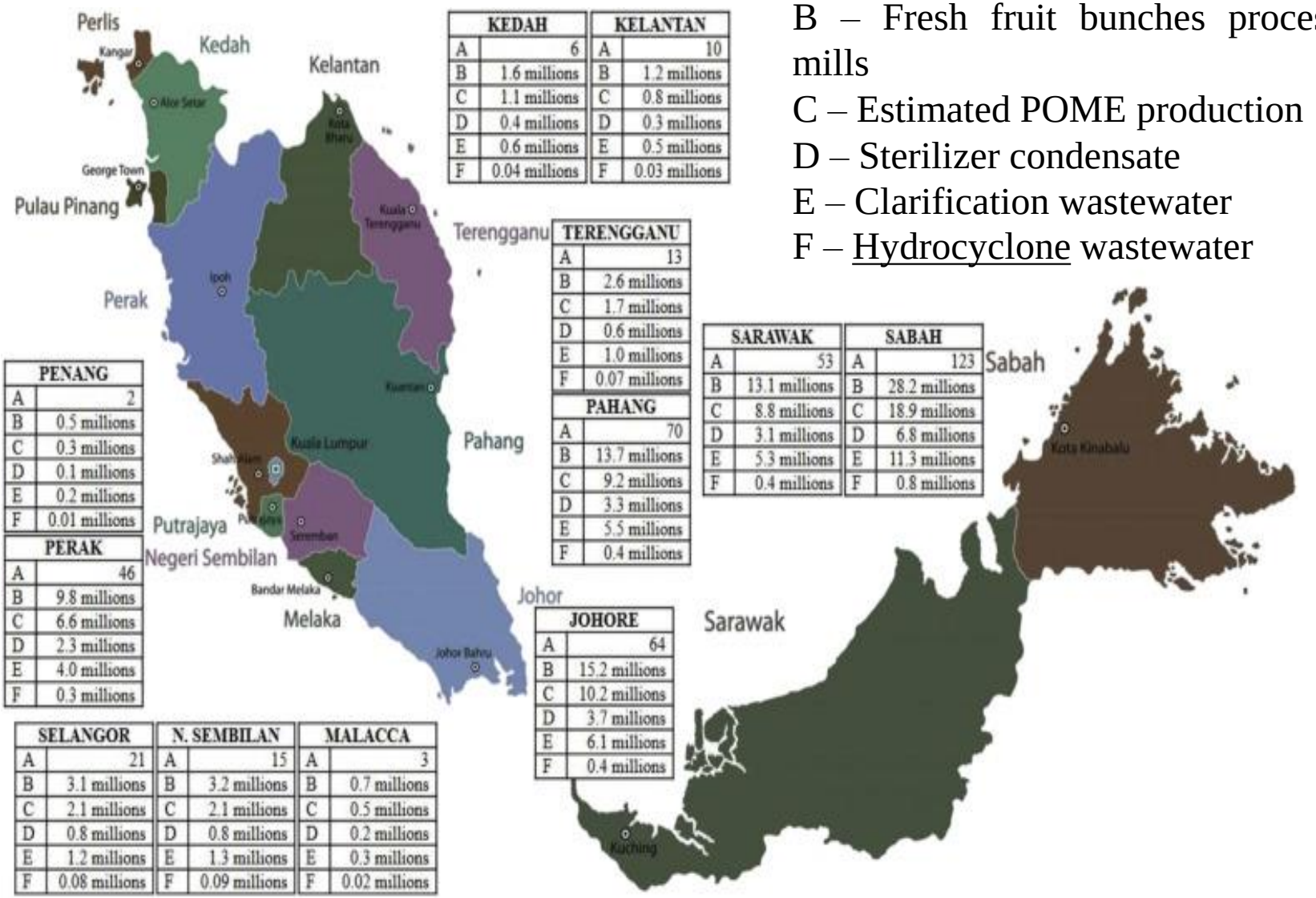
B – Fresh fruit bunches processed by mills

C – Estimated POME production

D – Sterilizer condensate

E – Clarification wastewater

F – Hydrocyclone wastewater



KEDAH	
A	6
B	1.6 millions
C	1.1 millions
D	0.4 millions
E	0.6 millions
F	0.04 millions

KELANTAN	
A	10
B	1.2 millions
C	0.8 millions
D	0.3 millions
E	0.5 millions
F	0.03 millions

TERENGGANU	
A	13
B	2.6 millions
C	1.7 millions
D	0.6 millions
E	1.0 millions
F	0.07 millions

PAHANG	
A	70
B	13.7 millions
C	9.2 millions
D	3.3 millions
E	5.5 millions
F	0.4 millions

SARAWAK	
A	53
B	13.1 millions
C	8.8 millions
D	3.1 millions
E	5.3 millions
F	0.4 millions

SABAH	
A	123
B	28.2 millions
C	18.9 millions
D	6.8 millions
E	11.3 millions
F	0.8 millions

PENANG	
A	2
B	0.5 millions
C	0.3 millions
D	0.1 millions
E	0.2 millions
F	0.01 millions

PERAK	
A	46
B	9.8 millions
C	6.6 millions
D	2.3 millions
E	4.0 millions
F	0.3 millions

JOHORE	
A	64
B	15.2 millions
C	10.2 millions
D	3.7 millions
E	6.1 millions
F	0.4 millions

SELANGOR	
A	21
B	3.1 millions
C	2.1 millions
D	0.8 millions
E	1.2 millions
F	0.08 millions

N. SEMBILAN	
A	15
B	3.2 millions
C	2.1 millions
D	0.8 millions
E	1.3 millions
F	0.09 millions

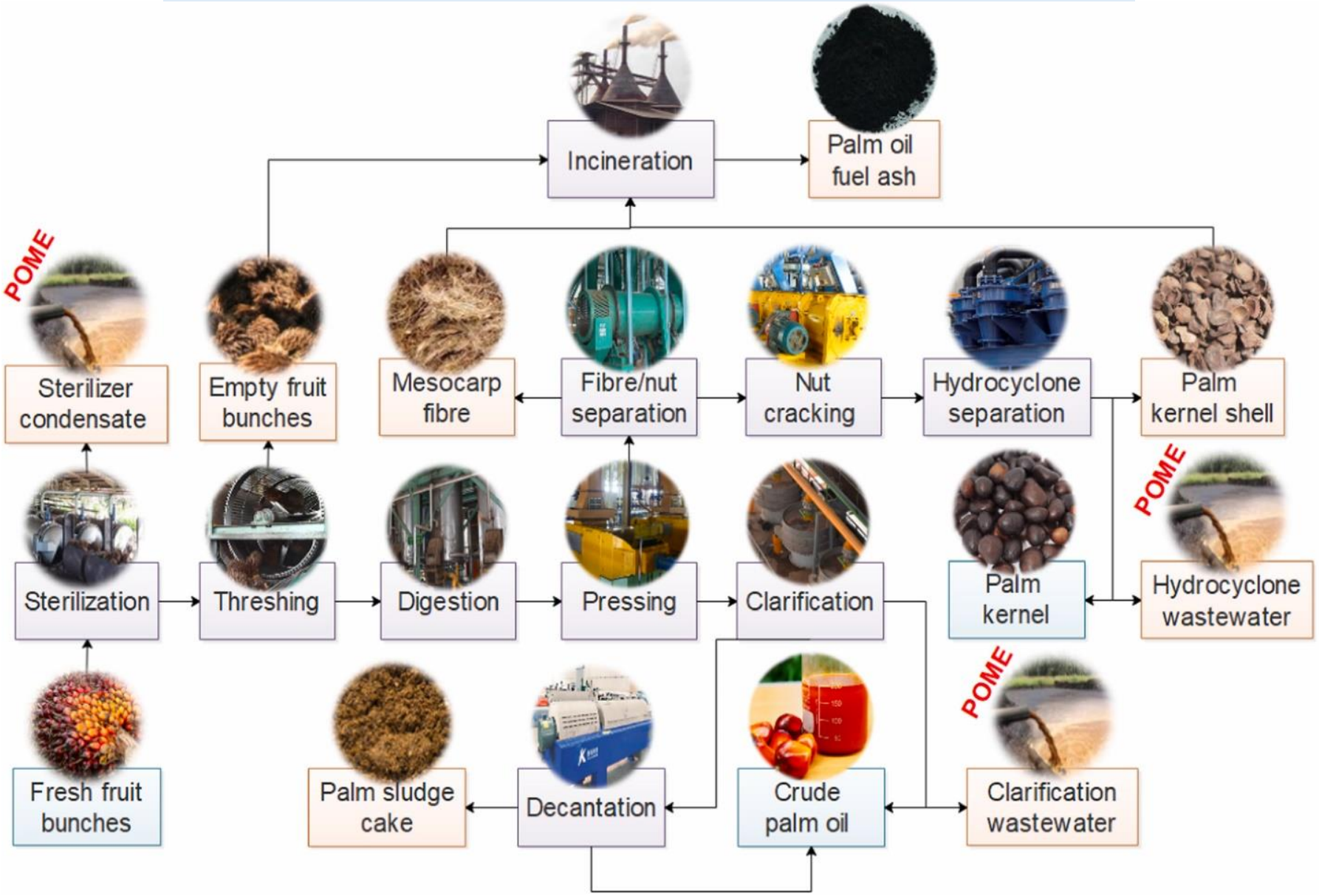
MALACCA	
A	3
B	0.7 millions
C	0.5 millions
D	0.2 millions
E	0.3 millions
F	0.02 millions

- **livelihood to rural families in government land schemes and private small holders**
- **employment opportunities to agricultural workers in estate.**

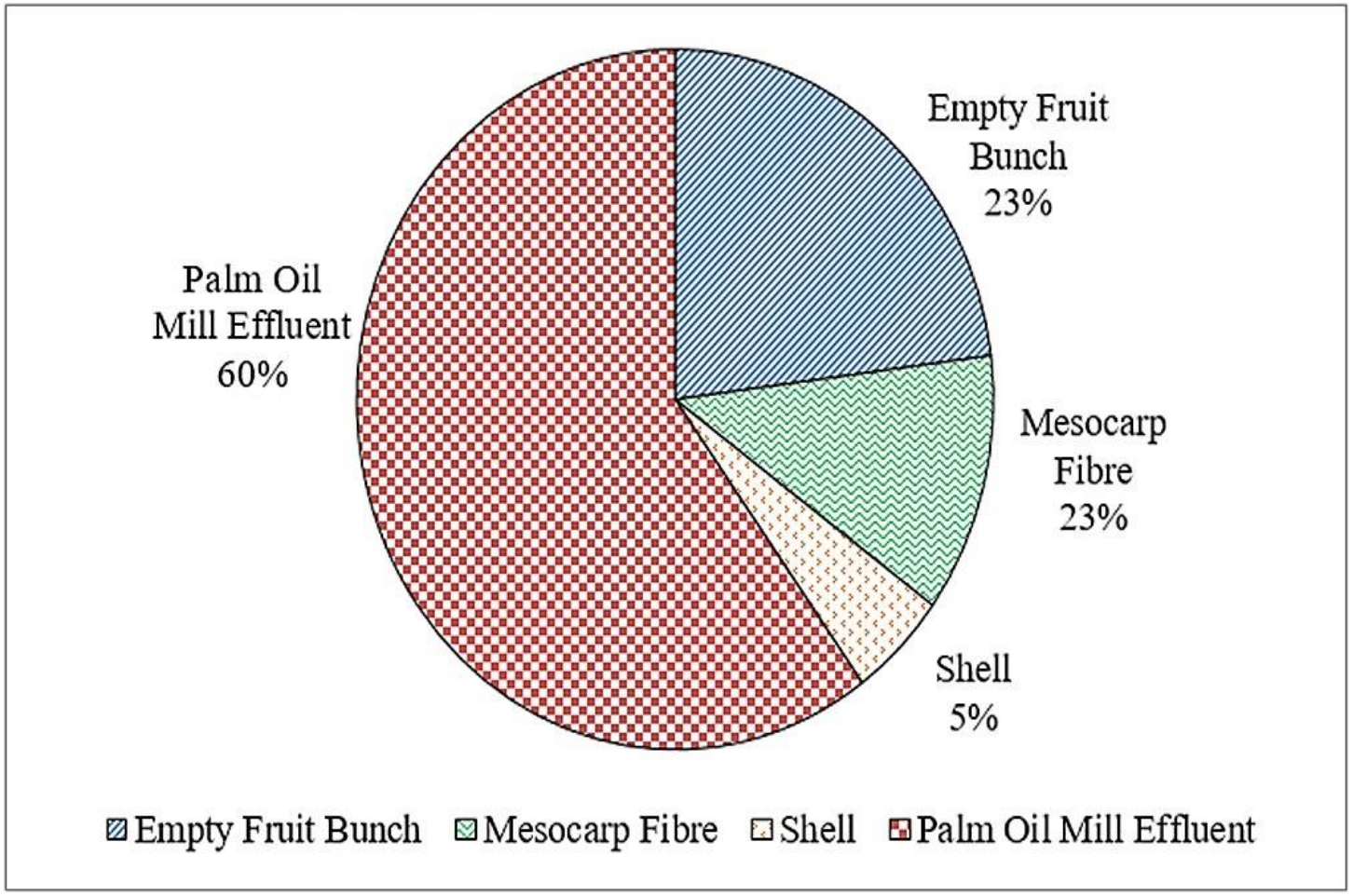
Palm Oil Mill Effluent POME

Largest Pollution Load in Rivers!

Generation of POME from wet palm oil milling process



Waste from the palm oil industry



Palm Oill Mill Effluent (POME)

- **0.5-0.75 tons of POME is generated for every tonne of fresh fruit bunch processed.**
- **Thick brownish colloidal mixture of water, oil and fine suspended solids**
- **Sterilizer condensate, separator sludge and hydrocyclone wastewater in a ratio of (9:15:1)**
- **Properties:**
  - **80-90^{o}C**
  - **non-toxic**
  - **high BOD_3, COD and acidic pH due to presence of organic acids in complex form.**
  - **95–96% water**
  - **4–5% total solids**
  - **0.6–0.7% oil.**

Laws and legislations governing the Palm oil industry

- POME has been identified as one of the major sources of industrial pollutants in Malaysia.
- Regulations applied to palm oil industries' waste management practices are:
  - Environmental Quality (Crude Palm Oil) Regulations, 1977
  - Environmental Quality (Clean Air) Regulations, 1978
  - Environmental Quality (Scheduled Waste) Regulations, 2005
- Specifically, the Environmental Quality Regulations enacted in the year of 1978 detailed out the thresholds for POME discharge.

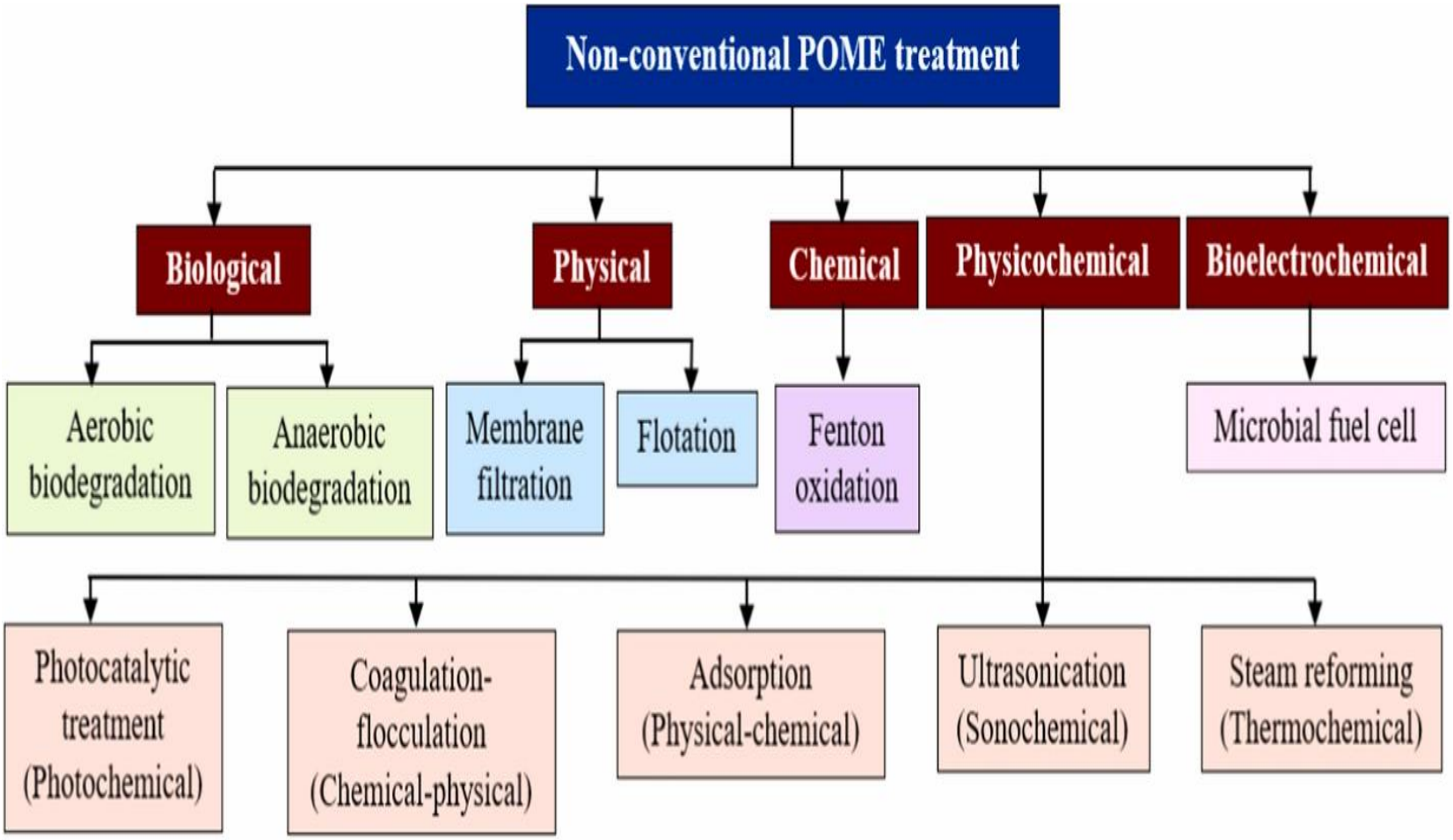
Characteristics of POME and its respective standard discharge limits set by Malaysian Department of Environment

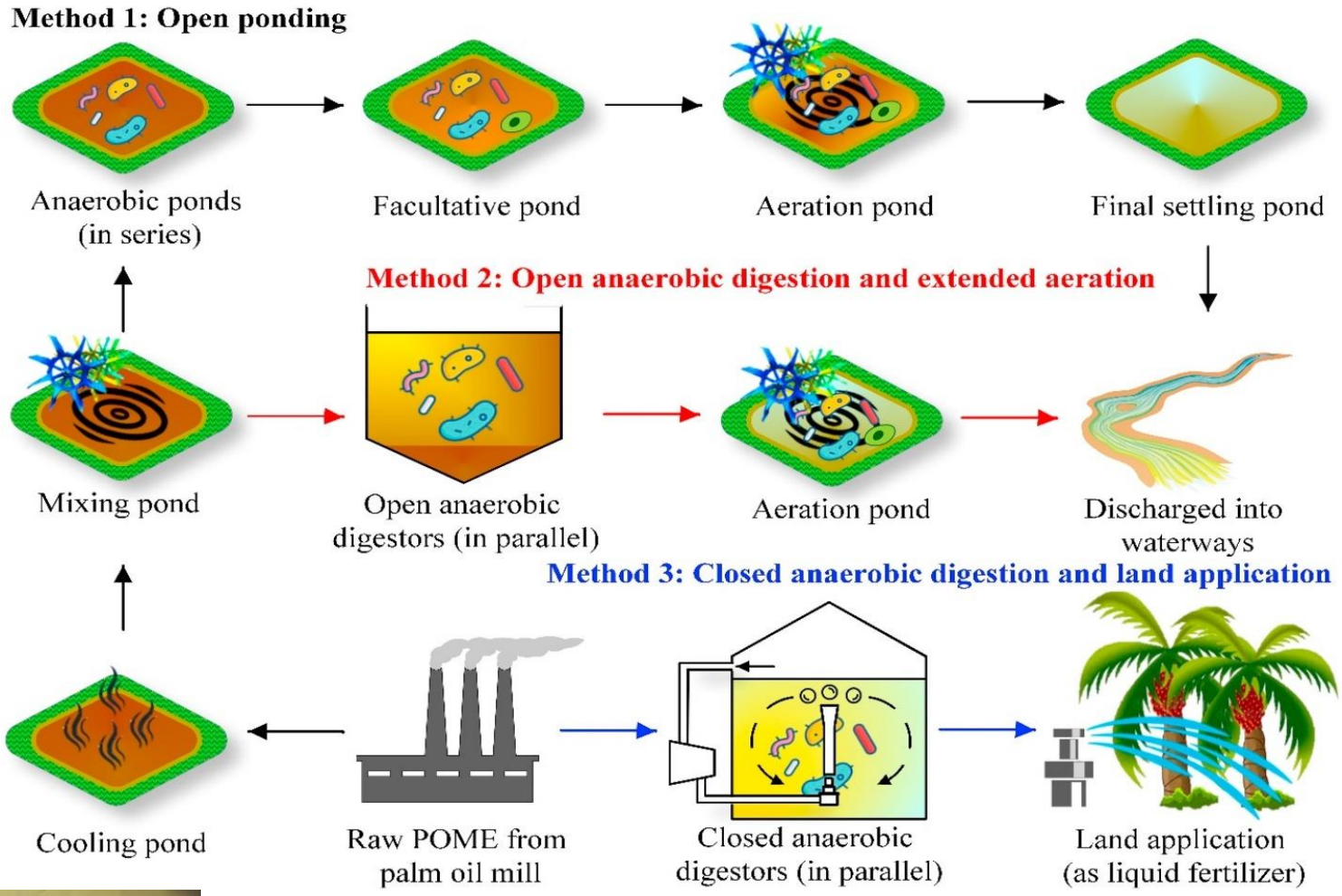
Parameters	Average discharge values	Standard discharge limits
Temperature (°C)	85	–
COD (mg/L)	50,000	100
BOD_5 (mg/L)	25,000	50
pH (no unit)	4.7	5.0–9.0
Oil and grease (mg/L)	4000	100
Total solids (mg/L)	40,500	–
Suspended solids (mg/L)	18,000	400
Ammoniacal nitrogen (mg/L)	35	–
Total volatile solids (mg/L)	34,000	–
Total nitrogen (mg/L)	750	150
Phosphorus (mg/L)	180	–
Magnesium (mg/L)	615	–
Boron (mg/L)	7.6	–
Calcium (mg/L)	439	–
Manganese (mg/L)	2.0	10
Zinc (mg/L)	2.3	10
Copper (mg/L)	0.9	10
Iron (mg/L)	46.5	50
Potassium (mg/L)	2270	–
Chromium (mg/L)	10.2	–

Native microbes of POME

Bacteria		Living habits		Fungi	Microscopic image	Living habits	
		Oxygen	Temperature			Oxygen	Temperature
Micrococcus luteus		Obligate aerobe	Mesophile	*Aspergillus fumigatus*		Obligate aerobe	Mesophile
Stenotrophomonas maltophilia		Obligate aerobe	Mesophile	*Aspergillus nomius*		Obligate aerobe	Mesophile
Bacillus cereus		Facultative anaerobe	Mesophile	*Aspergillus niger*		Obligate aerobe	Mesophile
Providencia vermicola		Facultative anaerobe	Mesophile	*Meyerozyma guilliermondii*		Obligate aerobe	Mesophile
Klebsiella pneumoniae		Facultative anaerobe	Mesophile				
Bacillus subtilis		Facultative anaerobe	Mesophile				

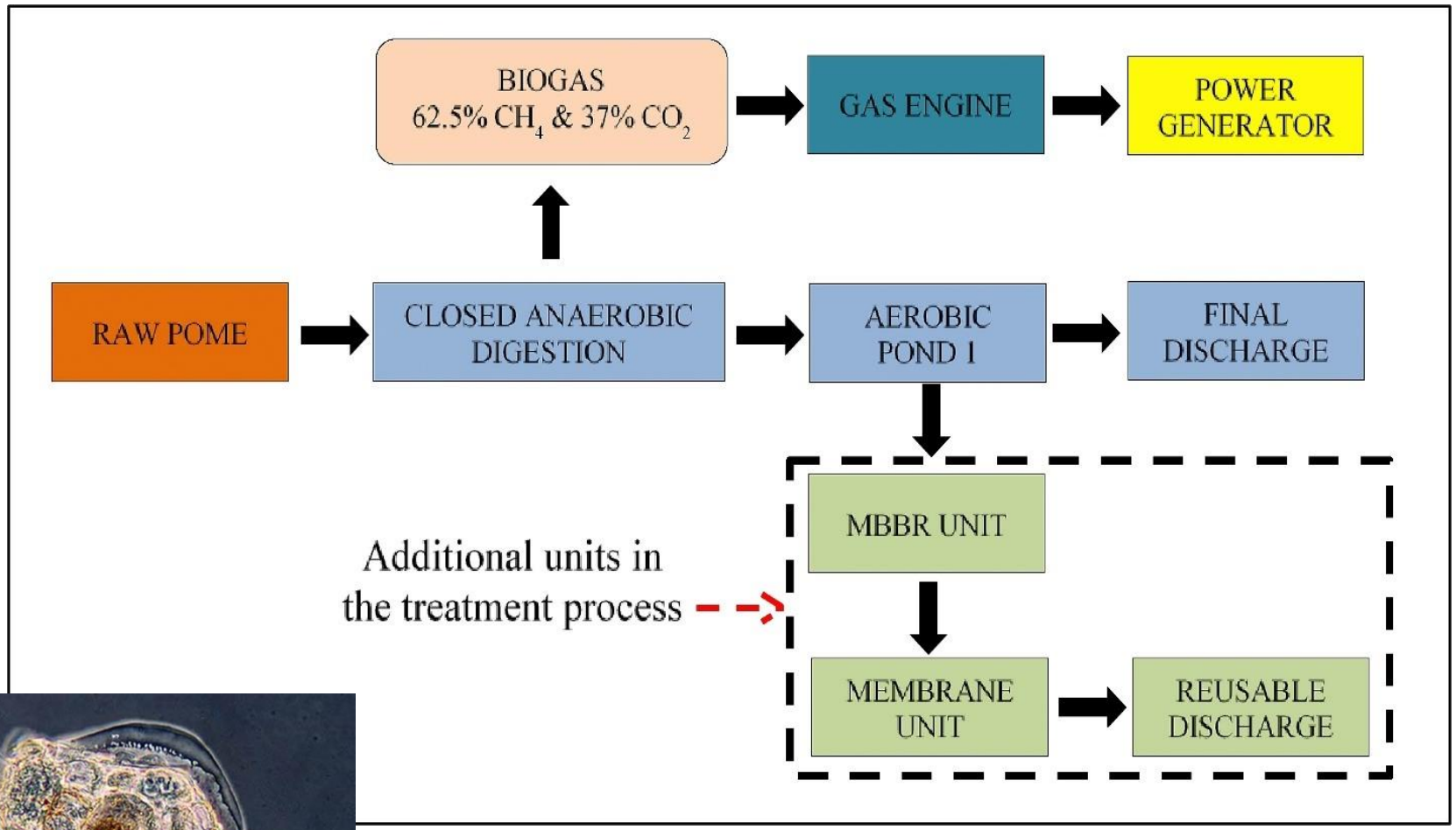
POME treatment methods





POME treatment

Aerobic treatment process



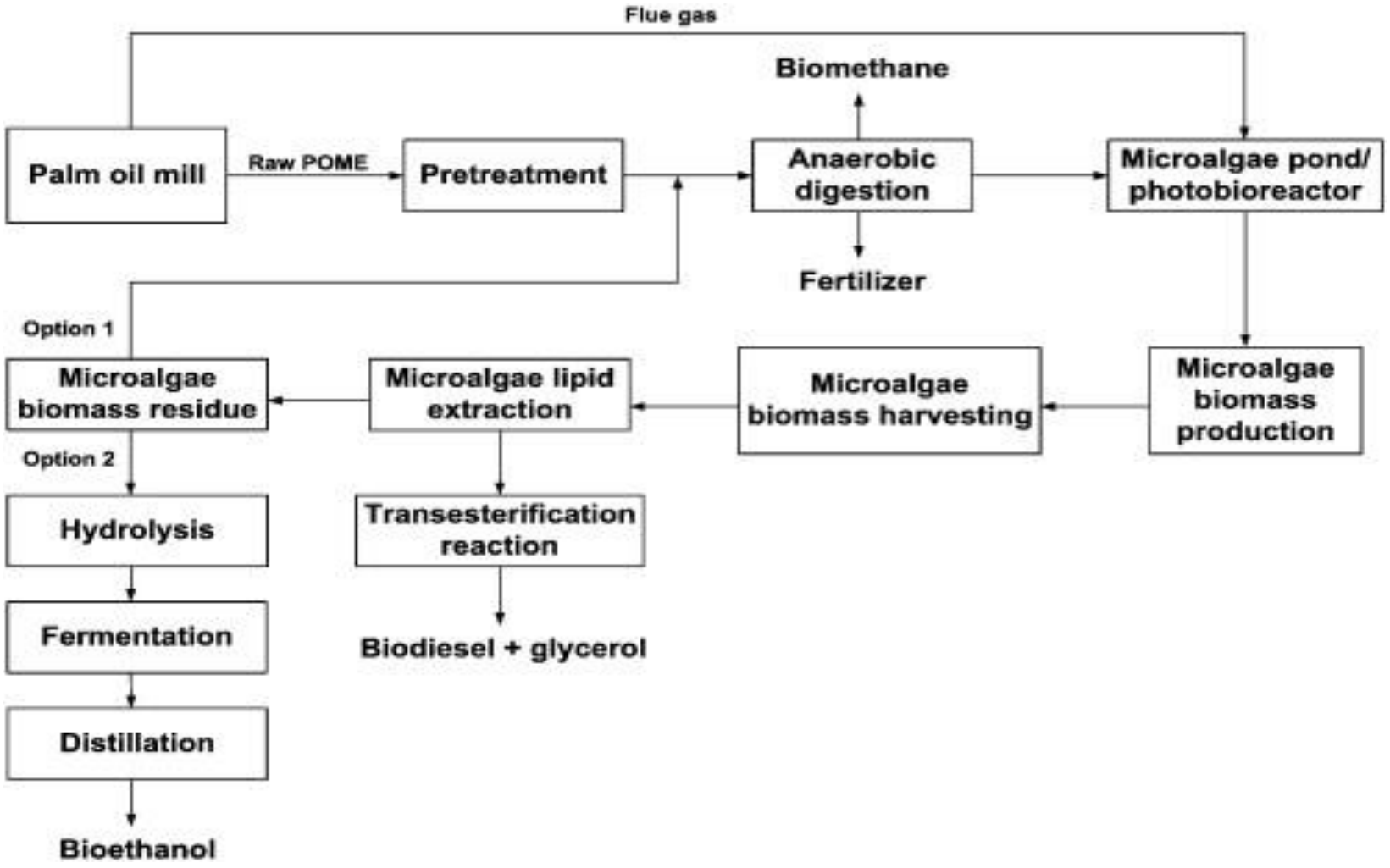
Oil Palm Liquid waste handling

Discharge into inland watercourse: 267 mills have been given the permission to discharge their liquid wastes into inland watercourse. They are normally, (1) the ponding system as well as (2) the open tank digester and extended aeration system effluent are discharged into inland watercourse

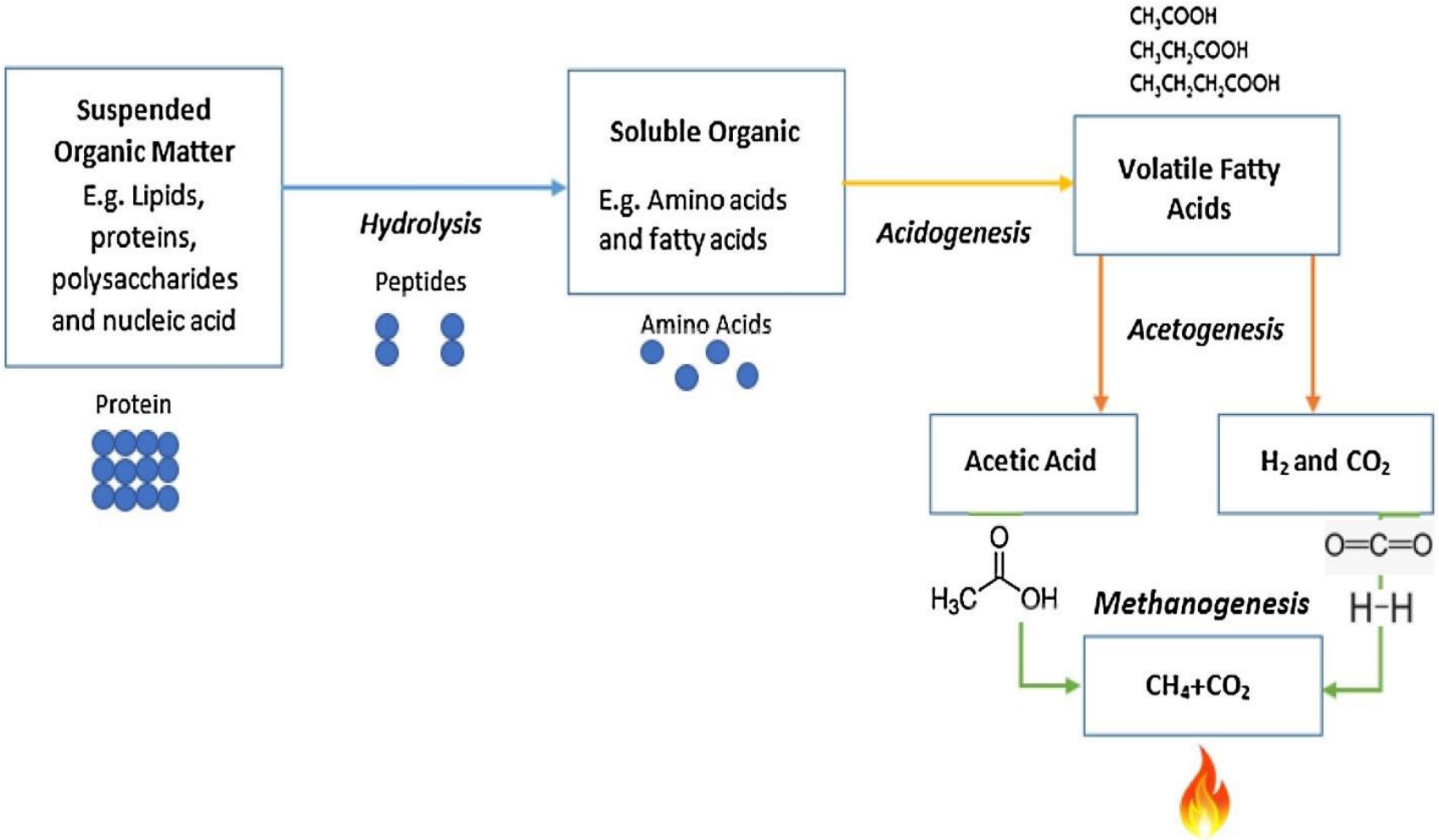
Land disposal: Supernatant from the (1) ponding system (typically anaerobic ponds) or (2) treatment ponds in the decanter-drier system, (3) stirred-tank digested POME, as well as (4) aerobic and (5) anaerobic digester bottom sludge are sources of POME utilized for controlled land application techniques.

Composting: 12 licensed prescribed premises in Malaysia were granted the permission to practice solitary composting. In most cases, anaerobic liquor from anaerobic ponds, and anaerobic sludge from open or closed anaerobic digested tanks are used for composting treatment at field scale.

Overview design of POME treatment incorporating with microalgae culture



Anaerobic Digestion



The generation of POME, biogas and CH_4 in selected FELDA mills in Malaysia

Palm oil mill	POME (m^3/ month)	Biogas (m^3/ month)	CH_4, measured value (m^3/month)	CH_4, reported value (m^3/month)
Felda Serting Hilir Mill	16,110	451,080	157,878	293,202
Serting Mill	9550	267,400	93,590	173,810
Tementi Mill	5154	144,312	50,509	93,803
Keratong 9 Mill	14,000	392,000	137,200	254,800
Keratong 2 Mill	4629	129,612	45,364	84,248
Keratong 3 Mill	5350	149,800	52,430	97,370
Bukit Kepayang Mill	7062	197,736	69,208	128,528
Triang Mill	10,258	287,224	100,528	186,696

Potential aspects for POME reutilization

- POME as the fertilizer
- POME as the live food for animals and aquacultural organisms
- POME as the renewable source of carotene
- POME as the fermentation medium

Current commercialized POME anaerobic digestion technologies and biogas utilization in Malaysia

Title	Anaerobic digestion technology
Biogas and electricity generation in Kuala Sungai Baru, Malaysia	Closed anaerobic digester
MY08-WWP-30, Methane Recovery in Wastewater Treatment, Pahang, Malaysia	Covered pond
Biogas Project at Anson Oil Mill	Closed anaerobic digester
Kilang Minyak Sawit Tg. Tualang Mill Wastewater Biogas Recovery and Utilization Project	Covered pond
Magenko Renewables (Penang) Wastewater Methane Avoidance and Energy Generation Project, Malaysia	Closed anaerobic digester
Palm Oil Mill Effluent Methane Recovery & Utilization System at QL Palm Oil Mill 1 at Tawau, Sabah	Closed anaerobic digester
FELDA Biogas Plant (Methane Recovery and Utilization) at Sungai Tengi Palm Oil Mill, Malaysia	Covered pond
Tian Siang Oil Mill (Air Kuning) Biogas Project	Closed anaerobic digester

https://www.thejakartapost.com/academia/2020/12/07/the-challenge-of-using-palm-oil-mill-effluent-to-generate-electricity.html

By-products of POME treatment systems

Gas, liquid and solid by-products

- Waste anaerobic granular sludge
- Biohydrogen
- Methane gas
- Volatile fatty acid
- Waste activated sludge
- Waste aerobic granules
- Water

References

1. Liew, W.L., et al., *Conventional methods and emerging wastewater polishing technologies for palm oil mill effluent treatment: a review.* 2015. **149**: p. 222-235.
2. Saad, M.S., M.D.H. Wirzal, and Z.A.J.J.o.E.M. Putra, *Review on current approach for treatment of palm oil mill effluent: Integrated system.* 2021. **286**: p. 112209.
3. Poh, P.E., et al., *Waste Management in the Palm Oil Industry: Plantation and Milling Processes*. 2020: Springer Nature.
4. Bakar, S.N.H.A., et al., *A review of moving-bed biofilm reactor technology for palm oil mill effluent treatment.* 2018. **171**: p. 1532-1545.
5. Cheng, Y.W., et al., *Holistic process evaluation of non-conventional palm oil mill effluent (POME) treatment technologies: A conceptual and comparative review.* 2020: p. 124964.
6. Ng, K.H., et al., *TiO2 and ZnO photocatalytic treatment of palm oil mill effluent (POME) and feasibility of renewable energy generation: a short review.* 2019. **233**: p. 209-225.
7. Alhaji, M.H., et al., *Photocatalytic treatment technology for palm oil mill effluent (POME)–A review.* 2016. **102**: p. 673-686.
8. Wu, T.Y., et al., *A holistic approach to managing palm oil mill effluent (POME): Biotechnological advances in the sustainable reuse of POME.* 2009. **27**(1): p. 40-52.
9. Cheng, Y.W., et al., *Identification of microbial inhibitions and mitigation strategies towards cleaner bioconversions of palm oil mill effluent (POME): A review.* 2020: p. 124346.
10. Wu, T.Y., et al., *Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes.* 2010. **91**(7): p. 1467-1490.
11. Ahmed, Y., et al., *Production of biogas and performance evaluation of existing treatment processes in palm oil mill effluent (POME).* 2015. **42**: p. 1260-1278.
12. Lam, M.K. and K.T.J.B.A. Lee, *Renewable and sustainable bioenergies production from palm oil mill effluent (POME): win–win strategies toward better environmental protection.* 2011. **29**(1): p. 124-141.
13. Hariz, H.B., M.S.J.E.S. Takriff, and P. Research, *Palm oil mill effluent treatment and CO 2 sequestration by using microalgae—sustainable strategies for environmental protection.* 2017. **24**(25): p. 20209-20240.
14. Khadaroo, S.N., et al., *Applicability of various pretreatment techniques to enhance the anaerobic digestion of Palm oil Mill effluent (POME): A review.* 2019. **7**(5): p. 103310.
15. Choong, Y.Y., et al., *Strategies for improving biogas production of palm oil mill effluent (POME) anaerobic digestion: A critical review.* 2018. **82**: p. 2993-3006.
16. Aziz, M.M.A., et al., *Recent advances on palm oil mill effluent (POME) pretreatment and anaerobic reactor for sustainable biogas production.* 2020. **119**: p. 109603.
17. Ohimain, E.I., S.C.J.R. Izah, and S.E. Reviews, *A review of biogas production from palm oil mill effluents using different configurations of bioreactors.* 2017. **70**: p. 242-253.


Thank You