R&D PROGRESS ON AIR POLLUTION CONTROL (APC) FOR EFB COMBUSTION AND ADVANCES OF POME TREATMENT

NASRIN ABU BAKAR, NU'MAN ABDUL HADI & NOR FAIZAH JAILANI
ENGINEERING & PROCESSING RESEARCH DIVISION

PRESENTATION OUTLINE

INTRODUCTION

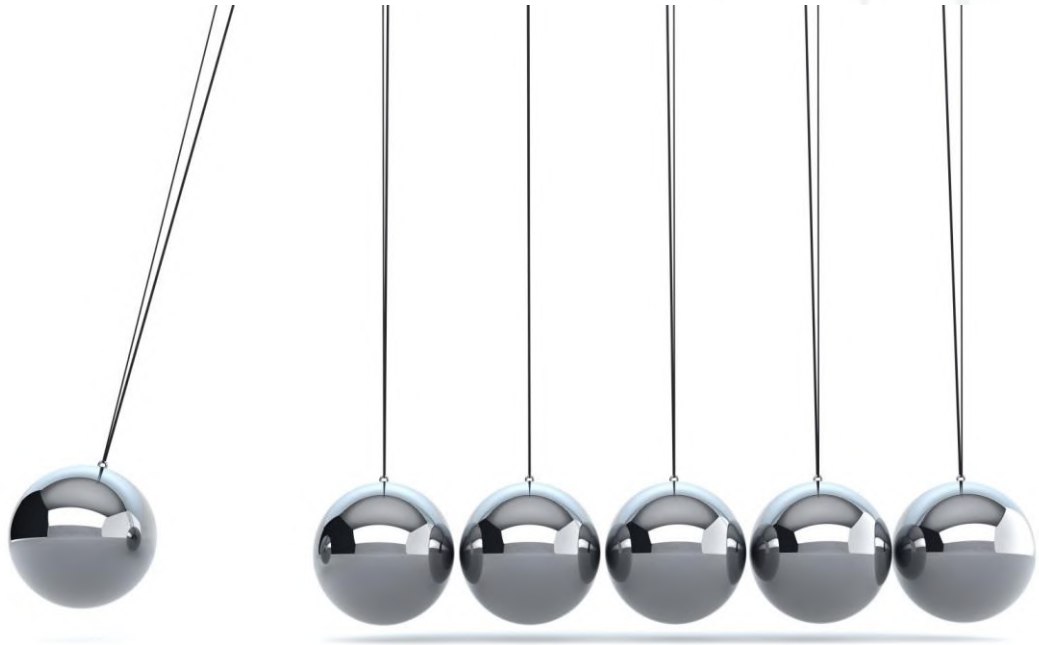
- EFB & POME – Current scenario

APC FOR EFB COMBUSTION

- EFB used as boiler fuel
- Alternatives to EFB disposal

ADVANCES OF POME TREATMENT

- Current research activities
- Alternatives to POME treatment



INTRODUCTION

- **EFB & POME** – the largest solid and liquid by-products (wastes) from POMs
- Annual production rate : > 21 million tonnes EFB and >60 million m^3 POME
- Disposal & treatment – long overdue issues for millers (without plantations)
- Recent stringent regulations imposed by the DOE
- Regulation obligation & compliance – with no/ direct economic return

MAJOR ISSUES ON ENVIRONMENTAL REGULATIONS COMPLIANCE OF PALM OIL MILLS

FINAL DISCHARGE LIMITS OF PALM OIL MILL EFFLUENT (POME)

- BOD 20/50 ppm – sensitive areas
- Proposed new monitoring parameters by the DOE – odour & color

PARTICULATE EMISSIONS FROM PALM OIL MILL BIOMASS BOILERS

- Clean Air Regulation 2014 (CAR 2014) - particulate emissions < 150 mg/Nm^3 & commitment to install air pollution control system (APCs)

WASTE MANAGEMENT OF EMPTY FRUIT BUNCHES

- Particulate emissions from EFB incinerator to comply to CAR 2014
- Garis Panduan Pelan Pengurusan Tandan Kosong Sawit (2021) - leachate issue

THE DOE'S DIRECTIVE ON EFB DISPOSAL

- EFB dumping is currently monitored by DOE through a guideline named "Garis Panduan Pelan Pengurusan Tandan Kosong Kelapa Sawit" (Bahagian Penguatkuasa Jabatan Alam Sekitar - February 2021).
- The guideline recommends concrete flooring & roofing, perimeter drain & slump pit for leachate collection - better management of EFB and ultimately prevent leaching of EFB to surrounding environment.
- Other method can be presented to the DOE - encourage millers to discuss alternative-suitable and cost-effective method (to overcome the EFB leachate issue directly with the state DOE)

- EFB disposal via incinerators is totally banned by the DOE.
- It is still permitted provided that EFB incinerator is equipped with air pollution control (APC) with particulate emissions complied to CAR 2014 permitted limits
- Sarawak POMs were granted to operate the existing incinerators (without APC) by 31 Dec 2024
- Solution: to install APC vs alternative EFB disposal methods

ISSUES ON CURRENT EFB DISPOSAL METHODS

EFB MULCHING

- Applicable to the mills with plantations
- Logistic/ labour cost : RM 12 -15 / t EFB
- Annual cost RM 1.2 – 1.5 million/ year (45 – 54 t/hr POM)
- Limited impact to yield improvement ??

EFB INCINERATOR

- Basic design without any APC
- Slow burning for bunch ashes
- Air pollution – white smokes
- Maintenance cost vs revenue from bunch ash sale?

EFB FIBRES AS BOILER FUEL – PRETREATMENT PROCESS

- A low-hanging fruit approach
- One single machine consists of press and cutter
- 2 stages process – shredder and press
- **Moisture content (41 – 43%)**
- **Size < 12 cm**
- Additional income via SPO from EFB juice (~ 0.25% to FFB processed)
- Additional POME volume - >10%

PRELIMINARY RESULTS OF ISOKINETIC SAMPLING

	EFB Power Plant	Mill A	Mill B	Mill C
APC	Multi-cyclone	Vorsep	Multi-cyclone + ESP	Multi-cyclone
Fuel used	100 % EFB	EFB + MF	EFB + MF + Biogas	EFB + MF + Biogas
Particulate emissions, mg/Nm^3	131.16	62 - 307*	79.6 - 90.6	604 - 606
CO_2, %	-	3.8	2.2	7.8
CO, ppm	-	133 – 1455	21.8 - 324	105
NOx,ppm	-	-	-	96
SOx, ppm	-	-	-	14

**before service*

BUNCH ASH QUALITY – EFB COMBUSTION

	BUNCH ASH	BOTTOM ASH	FLY ASH	BOTTOM ASH
Source	EFB incinerator	EFB boiler	EFB Boiler	EFB + Mesocarp fibre
P, %	0.66	0.95	2.29	1.88
K,%	36 - 50	20.52	17.74	17.02
Ca, %	9.53	4.49	11.70	5.87
Mg, %	1.58	2.07	5.71	2.76
Si, %	3.12	22.03	13.41	29.98

EFB INCINERATOR – POINTS TO CONSIDER

To design/ develop a new incinerator system

- Equipped with APC and basic devices (O_2 fan, auto deashing system etc) for controlled combustion

To use existing incinerator

- To retrofit with APC
- To channel white smoke to the boiler furnace/ APC system (Effect to the boiler??)

FUTURE WORKS

Gasifier system for EFB fibres

- To produce syngas for cofiring in biomass boiler
- Reduces palm biomass – facilitates particulate emission reduction

Development of EFB incinerator

- Explores the potential development of new incinerator design for EFB
- Requires EFB pretreatment

Special Task Force on Survey Related to Final Discharge of POME

- Establishment of '**Working Committee on Regulatory Issues on Environment**' to conduct a continuous study and engagement with the stakeholders and the DOE. Progress so far:

  i. Field Study Phase 1-3 (BOD 20) (2009 – 2011)
  ii. Phase 4: Taskforce on Kinabatangan (BOD 20) (40 mills located in 3 main river basins) 2012 - 2016
  iii. Taskforce on Colour: (7 mills with varied conditions) (2017 – 2019)
  iv. Taskforce on Ammonia (ammonia issues in Johor) (2017 – 2019)

- **Current effort (Beyond 2020):** MPOB are currently dealing with (new proposed regulation): **Environmental Quality (Prescribed Premises) (Crude Palm Oil Mill) Regulations 202X**

- **In-house R&D and collaboration with potential technology providers for new technology on BOD and colour removal**

New proposed limit in Environmental Quality (Prescribed Premises) (Crude Palm Oil Mill) Regulations 202X

Proposed Parameter Limits by DOE for Discharge into Inland Watercourse & Land

i) Proposed Parameter Limits for Discharge into Inland Watercourse	Limits According to Periods of Discharge	
Parameter, mg/L except for Temperature, pH and colour.	Existing limit (1 Jan 1984)	Proposed limit (202X)
Biochemical Oxygen Demand **(BOD_3) 3 days, 30°C**	100 (20 – 50)*	20
Suspended Solids	400	200
Oil and Grease	50	5
Ammoniacal Nitrogen	150	20
Total Nitrogen	200	-
pH	5.0 – 9.0	5.0 – 9.0
Temperature, °C	45	45
Colour, ADMI	-	100
ii) Proposed Parameter Limits for Discharge on Land (Land application)		
Biochemical Oxygen Demand (BOD_3) 3 days, 30°C	5,000**	2500

* Lower BOD for Sabah. Swak & Johor **or other limits specified by the Director General

MAJOR FINDINGS

ACTIVATED SLUDGE + CLARIFIER

< BOD 20
(60% compliance)

< BOD 50
(100% compliance)

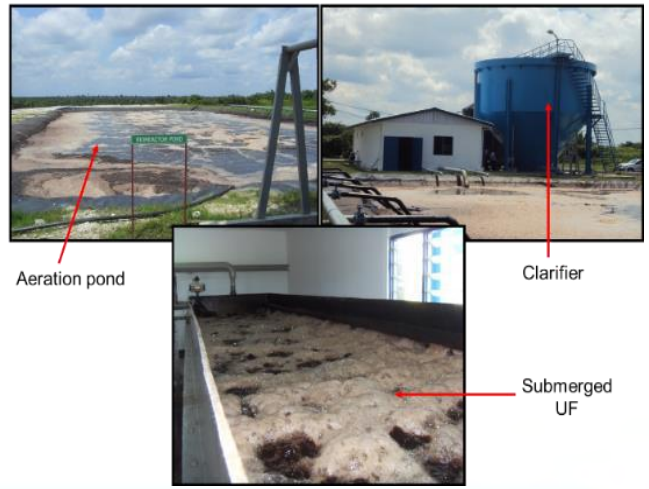
EXTENDED AERATION + STONE FILTER

EXTENDED AERATION + SAND FILTER

< BOD 20
(70% compliance)

< BOD 50
(80% compliance)

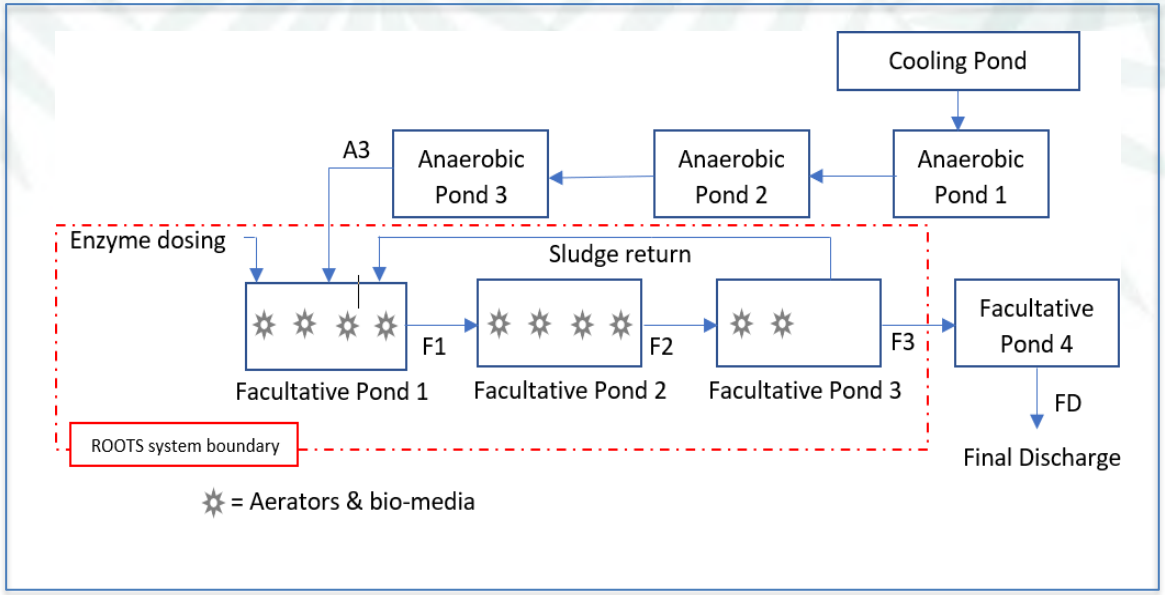
EXTENDED AERATION + MEMBRANE UF



NEW TECHNOLOGY FOR POLLUTANT AND COLOUR REMOVAL

Enzymatic Turbulence Aeration Biological System (ROOTS)

- ROOTS® system consists of **3 main components** namely **enzyme treatment, static aerator network and medium for bacterial growth**; has been duly installed at the Commercial 40 tph POM, Johor
- Inlet to ROOTS system: BOD >150 mg/L, SS>450 mg/L, AN>200 mg/L, O&G> 10, colour >2500 (after anaerobic pond)
- **BOD - 88% reduction (19 mg/L), Colour – 67% (815 ADMI), SS – 86% (65 mg/L) O&G -85% (2 mg/L) and AN – 98% (4 mg/L)**



Layout of ROOTS System

Diffuser & Bio-media installed in the facultative pond 1,2 & 3

Total HRT = 15 days

❖**Collaborator: Blue E Tech Sdn Bhd**

*ROOTS- Revolutionary Onsite Organic Treatment System

NEW TECHNOLOGY FOR POLLUTANT AND COLOUR REMOVAL

Activated Carbon Filtration System

Commercial Scale (50 m3 /hr , Mill at Kluang, Johor) – Commissioned in July 2023

Parameter	Final discharge pond	Aeration pond	Settling pond	Final discharge (after AC treatment)
pH	8.66	8.58	8.80	8.60
COD (mg L^{-1})	408	417	216	47
BOD (mg L^{-1})	63	52	33	ND (<2)
SS (mg L^{-1})	132	59	70	24
Colour (ADMI)	1730	830	405	14
AN (mg L^{-1})	ND (<2)	ND (<2)	ND (<2)	ND (<2)

Cost to be considered:

- Activated carbon consumption
- Energy for aeration

COLLABORATION ON COMMERCIAL SCALE OF PALM KERNEL SHELL-ACTIVATED CARBON FOR POME TREATMENT (MPOB-IOI GROUP)*

*Source: Zainal *et al*. (2023) MPOB PIPOC 2023

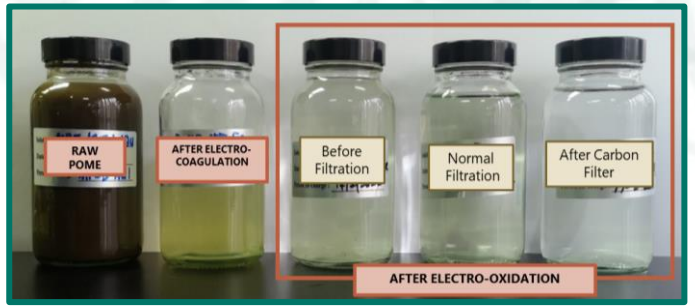
NEW TECHNOLOGY FOR POLLUTANT AND COLOUR REMOVAL

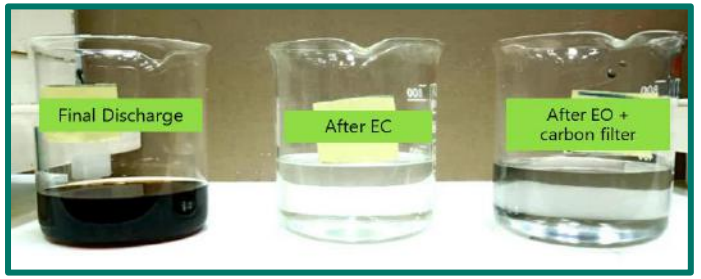
Hybrid Electrocoagulation & Electrooxidation Treatment System

- Hybrid Electrochemical technology through a combination of electrocoagulation (EC) and electrooxidation (EO) process to reduce/eliminate organics pollutant from the wastewater
- The technology has potential to produce non-potable quality treated water that can be applied for mill processing or boiler feed water

2 L Desktop evaluation kit

Electrocoagulation reactor | Electrooxidation reactor





Changes of POME colour throughout the treatment process for (a) raw POME; (b) anerobic treated POME; (c) Final discharge POME

Types of POME Samples Tested in 2-L Desktop Evaluation Kit and Its Characteristics

Parameter	Mixed Raw POME		Anaerobic treated POME		POME Final discharge	
	Before treatment	After EC-EO	Before treatment	After EC-EO	Before treatment	After EC-EO
pH	3.39	3.88	7.3	6.25	8.65	7.56
COD (mg L^{-1})	135,300	1239	15,300	206	1099	666
BOD (mg L^{-1})	60,992	12.93	528	12.42	35	10.44
SS (mg L^{-1})	53,400	40	3300	20	175	84
Colour (ADMI)	27,500	44	7175	24	3975	4
AN (mg L^{-1})	26	N.D	117	N.D	19	ND

*Cost to be considered: Electrode & energy consumptions

❖ **Collaborator: Apex Environmental Industries**

MAJOR FINDINGS & FUTURE WORKS

- **Technologies are available** to achieve BOD < 20 ppm but its consistency is a major challenge.
- **Colour reduction** has **no correlation** with **BOD reduction**
- **Toxicity studies** showed that POME samples with **20 < BOD < 100** mg/L and **colour about 1000** ADMI are **practically non-toxic**.
- **Technology to reduce colour** for POME is **still immature** and higher cost.
- **Proposed stringent limits are considerable and requires further engagement with stakeholders**

METHANE AVOIDANCE TECHNOLOGIES & STRATEGIES

MITIGATION STRATEGIES :

1.0 **POME utilisation** – biogas capture & composting of POME and EFB

2.0 **POME pretreatment** – oil recovery and solid removal

3.0 **POME elimination** via evaporation process

4.0 **Improved milling process** – less-water consumption and POME generation

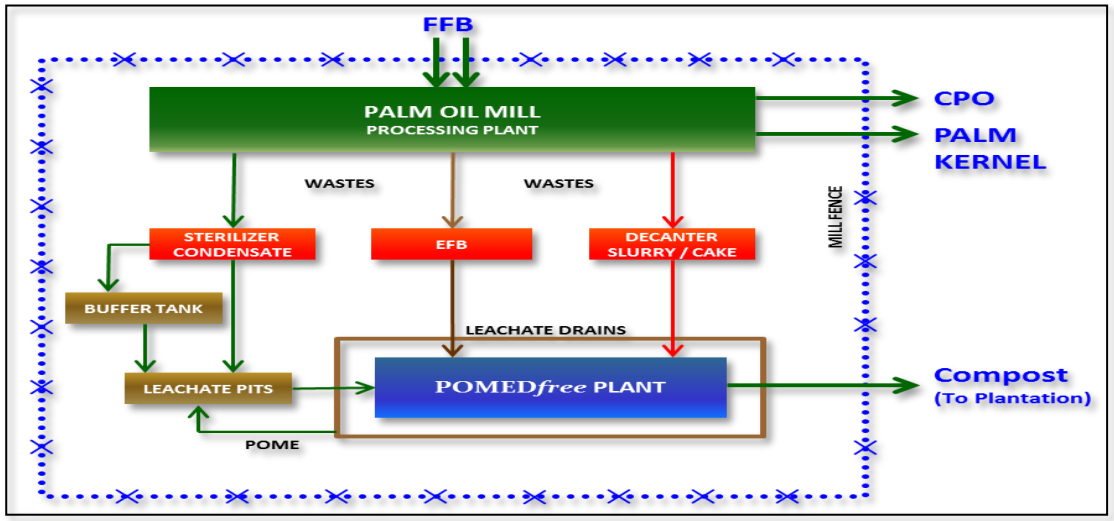





CO-COMPOSTING OF POME & EFB

Zero Discharge Technology for Palm Oil Mills (POMED*free*)*

- 100% Raw POME & EFB are utilized for composting
- Aerobic process – avoids/ minimises methane generation
- Temperature needs to be controlled
- Mills to control water consumption & POME generation
- Pricing - compost quality & applications



Composting Plant

POME – EFB mixing process
(POME spraying and EFB turning using a backhoe)

Composting Plant

Compost Windrow

Application of POME & Agitation of Compost

*source: Evers. Rahman *et al.* (2013). MPOB Information Series no 635

PRETREATMENT OF POME

Solid Removal Oil Recovery Sytem (SRORS)*

- Consists of **membrane and 3 phase decanter unit**
- **SRORS** is a combination filtration and separation process of raw POME into 3 components; 1) oil (recover from decanter), 2) suspended solid (as decanter cake) and 3) filtrate water (water with dissolved solid)
- **COD reduction rate ~ 60 - 70% -** oils recovery and solid removal from raw POME
- **Reduces GHG emissions during the anaerobic treatment and POME load to the existing POME treatment**
- Economic return – increase of OER

*source:https://welcome.yklgroup.com.my/srors.php; Liew *et al*. (2017). PIPOC 2017.

EVAPORATION OF POME

POMEvap by Alfa Laval (Towards zero liquid discharge in palm oil mills)*

- **TOTAL POME ELIMINATION PROCESS**
- POME is evaporated to produce **colourless distille water** and **concentrated POME**
- The water **(BOD 300 ppm & COD 500 ppm)** can be treated in aerobic ponds
- POME concentrate is further treated using decanter to recover the oil and heavy phase (recycle to the evaporator or used as potential solid fuel)

*source: Evers. R (2017) PIPOC 2017; https://www.alfalaval.com/industries/food-dairy-beverage/food-processing/fat-and-oil-processing/palm-oil-processing/pome-treatment/

CONCLUSION

- Make biomass (EFB) / POME-biogas energy plant (or avoidance) an integral part of the milling process.

- Benefit from additional revenue from power generated/ resource recovery, saving on the operational cost and potential income from displaced biomass etc

- Technologies for sustainable EFB disposal and POME treatment are available

Challenges are in the consistent operation & technology adoption

THANK YOU

| ACKNOWLEDGEMENT |

Palm oil millers, RE developers, technology providers
and individuals who were involved in this study

malaysianpalmoilboard **mpob_tweets** **Malaysian Palm Oil Board** **www.mpob.gov.my**

palmoilpedia