POPSIG Newsletter, Issue 22, Jan 2023

POPSIG

Greener Future with Palm Oil

A palm oil newsletter brought to you by:

IChemE Palm Oil Processing Special Interest Group

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Special Interest Group

Beyond Palm Oil: Connecting Life

WHAT'S IN THIS ISSUE

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IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

Palm Oil Processing Special Interest Group

Editor's Message

2022 has been filled with a wide variety of POPSIG events. POPSIG takes this great opportunity to thank our stakeholders and members for supporting us.

On 17 October 2022, IChemE announced that Sime Darby Plantation Research Sdn Bhd won the IChemE Malaysia Palm Oil and Sustainability Awards 2022. IOI Edible Oil Sdn Bhd received the Highly Commended prize at IChemE Malaysia Palm Oil Award 2022. POPSIG warmly congratulated the two companies for their excellent achievements in bringing positive impacts to the technological development of palm oil industry.

The Oils and Fats International Congress (OFIC) 2022 organised by MOSTA was officiated by the President of MOSTA YBhg Academician Tan Sri Emeritus Professor Datuk Dr Augustine S H Ong. OFIC 2022 highlighted the potentials and prospects of oil palm and its derived products.

NACES 2022 forum was organised with the theme of circular economy and industry symbiosis. The experts were invited to share what their organisations have achieved and what further needed to be done.

In November webinar, Dr Mohd Lokman Ibrahim (Senior Lecturer at UiTM) presented the novel technique to convert PFAD to biodiesel by catalytic and photocatalytic processes. Mr Karthi Subramaniam (Senior Process Engineer at Desmet Malaysia) delivered a talk at the student event in Heriot-Watt University Malaysia, while Ir Dr Lim Chun Hsion (Assistant Professor at Heriot-Watt University Malaysia) presented at the event in Xiamen University Malaysia.

POPSIG will reopen the applications for POPSIG Best Final Year Design Award, Student Research Project Bursary, Student Bursary for Travel, Palm Oil Video Competition, Infographic Competitions and many more from the first quarter of 2023.

POPSIG would like to express our sincere appreciation to Desmet Malaysia Sdn Bhd, Malaysian Palm Oil Council (MPOC), Kuala Lumpur-Kepong (KLK) Oleomas Sdn Bhd and Malaysian Oleochemical Manufacturers Group (MOMG) for their support to POPSIG. We wish everyone a very Happy New Year!

POPSIG gratefully acknowledges our sponsors

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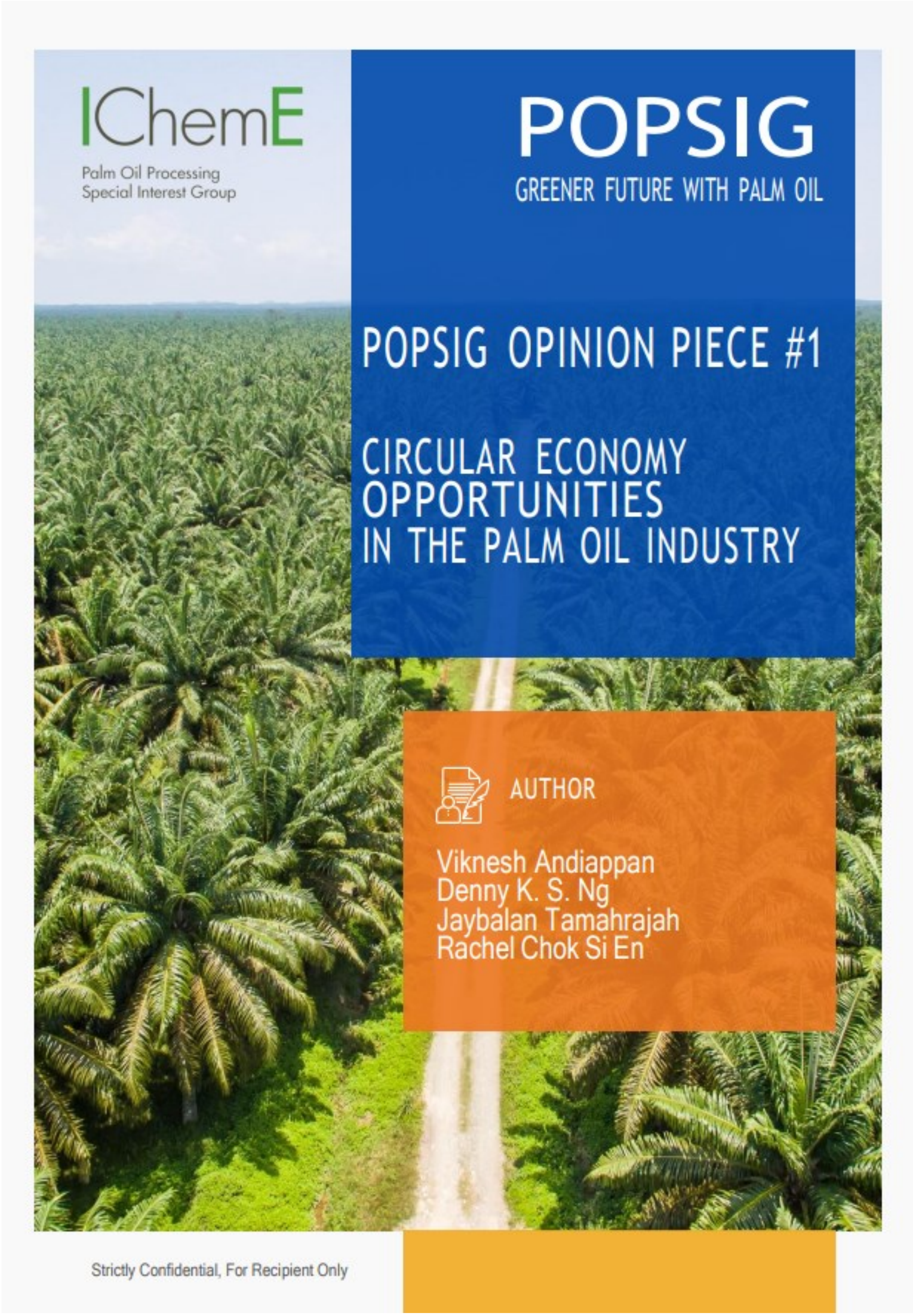
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GREENER FUTURE WITH PALM OIL
POPSIG OPINION PIECE #1
CIRCULAR ECONOMY OPPORTUNITIES IN THE PALM OIL INDUSTRY
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SUMMARY

A Summary of the Opinion Piece

Malaysia and Indonesia are the largest exporters of palm oil products globally. In view of sustainability, the industry is looking for ways to shift towards a circular economy. Circular economy involves the circular flow of materials to help reduce, reuse, and optimise material production and consumption. Therefore, the palm oil industry assumes an important role in producing sustainable palm oil products and are positioned to advance circular economy practices in their operations. The palm oil value chain covers three general stages: oil palm plantation, palm oil milling, and palm oil refining/processing. Several current practices in each of these stages fall under the circular economy umbrella. This opinion piece aims to provides insight from the practitioner's view on the industry's current practices that are circular, the opportunities for improved circular economy, and challenges that the industry must tackle to expand circular economy further. Lastly, key recommendations are proposed at the end of this opinion piece. This opinion piece points out areas where the industry can improve its resource efficiency and minimise its waste. This is an important stride for the industry as it aligns with its current efforts to make palm oil a more sustainablevalue chain.

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INTRODUCTION

A View on the Opinion Piece

In light of the world's shift to sustainable practices, circular economy has attracted significant attention over the last few years. A circular economy entails the circular flow of materials to help reduce, reuse, and optimise material production and consumption. Malaysia and Indonesia are the largest exporters of palm oil products globally, covering over 36% of the world's vegetable oil consumption. The palm oil industry has been a key economic contributor to these nations' gross domestic product. It has played a significant role in improving the economic welfare of people in these nations, lifting them out of poverty (New Straits Times, 2017). Therefore, these nations assume an important role in producing sustainable palm oil products and are positioned to advance circular economy practices in their operations. The palm oil value chain covers three general stages; oil palm plantation, palm oil milling, and palm oil refining/processing.

Several current practices in each of these stages fall under the circular economy umbrella. Despite that, each value chain stage possesses unique opporetunities to further expand its circular economy practices. Hence, it is important to identify the industry's current practices, opportunities, and barriers to expanding its circular economy practices. This document provides insight on the industry's current practices that are circular, the opportunities for improved circular economy, and challenges that the industry must tackle to expand circular economy further. Doing this will allow the industry to improve its resource efficiency and minimise its waste. This is an important stride for the industry as it aligns with its current efforts to make palm oil a more sustainable value chain.

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THE KEY CONCEPT OF CIRCULAR ECONOMY

Circular economy is "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended" [1]. A circular economy entails three key principles, which are 1) eliminating waste and pollution, 2) circulating products and materials (i.e., recycling), and 3) regeneration. In eliminating waste and pollution, waste and pollution is designed out of a given process. In other words, a process is designed in such a way that it is able to eliminate waste and pollution at the start [2]. As for recycling, the goal is to keep circulating materials within the process as a product. However, if the product can no longer be used, it can be used as raw materials for another process [3]. Lastly, regeneration involves regenerating nature by restoring its properties [4].

ELIMINATE
WASTE & POLLUTION

CIRCULATING
PRODUCTS & MATERIALS

REGENERATING
NATURE

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

Currently, there are several Circular Economy Activities had been applied in the palm oil value chain.The following provides a brief overview of the current practices in each value chain stage and maps out their connection to circular economy.

PLANTATIONS

01

Recycling, Regeneration

Plantations practice circular economy by utilising the wastes generated during harvesting and replanting cycles (i.e., oil palm frond (OPF) and oil palm trunk (OPT)). In addition, waste from the palm oil mills, such as empty fruit bunches (EFBs) and palm oil mill effluent (POME) are also returned to plantations.

02

Recycling, Regeneration

EFBs are returned to the plantation for mulching and composting. The POME is also applied during mulching for plantations close with the palm oil mill.

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

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PALM OIL MILLS

01

Eliminating Waste and Pollution

Fresh fruit bunches (FFB) are sterilised to deactivate enzymatic activity and loosen the fruitlet from the bunches. Sterilisation patterns from single- to triple-peak steam cycles are practised to enhance the crude palm oil extraction efficiency.

02

Recycling

During the extraction process, mills generate biomass such as palm pressed fiber (PPF), palm kernel shell (PKS), decanter cake (DC), EFB, and POME. PPF and PKS are used as feedstock for biomass boilers to generate steam and power generation (i.e., cogeneration) in palm oil mill.

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

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PALM OIL MILLS

03

Recycling

The excess PKS are being sold in the market as a coal replacement in power plants.

04

Recycling

DC is used as an ingredient in the ruminant feedstock and animal feed

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

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PALM OIL MILLS

05

REGENERATION

EFB can be converted to value-added products (e.g., pellet, biofertiliser, dried long fiber, etc.) or returned to the plantation as mulching material.

06

Recycling

POME is treated in an aenerobic system, such as a covered lagoon, anaerobic digesion tank, etc., to generate biogas (methane, carbon dioxide, etc.). The impurities in biogas (carbon dioxide, sulphur dioxide and water) are then removed, and purified biogas can be utilised as a fuel source in engines or boilers to generate heat and power for mill operations. This makes mills self-sufficient in energy.

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PALM OIL MILLS

07

Recycling

The purified biogas can also be further purified as bio-methane (more than 90% of methane) to be used as transportation fuels.

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

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PALM OIL REFINERY/ DOWNSTREAM PROCESSING

01

Recycling, Eliminating Waste and Pollution

Fatty acids (FA), glycerin (GLY), methyl esters (ME), fatty alcohols (FAL) etc. are generated as products in palm oil downstream refineries which they are then subsequently being used as raw materials for the other unit operations within the refineries.

02

Recycling, Eliminating Waste and Pollution

During the production, a portion of the raw materials and chemicals introduced to the systems remained unreacted and leave the production as waste streams. In response to this, separation units are used and optimised to improve recovery of these unreacted raw materials and chemicals from waste streams and improve overall process efficiency as well as economic viability.

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CURRENT CIRCULAR ECONOMY PRACTICES PRODUCTION

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PALM OIL REFINERY/ DOWNSTREAM PROCESSING

03

Recycling

Spent bleaching earth generated from refineries is deprived of its oil content by solvent extraction before disposal with no reuse of residual phospholipids.

04

Recycling

For biodiesel production, high chemical oxygen demand (COD) washing water generated from the purification of crude biodiesel is recycled back to the system after the oil layer and methanol recovery.

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OPPORTUNITIES FOR CIRCULAR ECONOMY

A Brief Story About The Opportunities

Other than the previously highlighted applications, there is potential for the palm oil industry to expand its circular economy operations. The following summarises key opportunities for expanding circular economy in the sector. These opportunities are included based on the eliminating waste and pollution, recyle and regeneration principles in circular economy.

PRODUCING VALUEADDED CHEMICALS AND MATERIALS

During the harvesting of FFB at the plantations, OPFs are removed and left at the plantation. Currently being underutilised, these wastes that contain high sugar and cellulose content can be used to produce ethanol or succinic acid.

Oil palm plantations also generate biomass such as OPTs during the replanting cycle. OPTs have high fiber content which can be further processed to be used as lumber, pulp and paperproducing materials, reconstituted boards, and bio-composites.

EFB can be converted into biochemicals via biological conversation technologies (e.g., fermentation, hydrolysis, etc.) and energy via thermal chemical conversation technologies (e.g., gasification, pyrolysis, etc.).

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OPPORTUNITIES FOR CIRCULAR ECONOMY

A Brief Story About The Opportunities

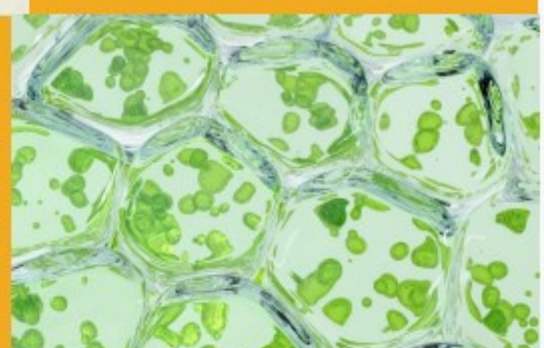
Other than the previously highlighted applications, there is huge potential for the palm oil industry to expand its circular economy operations. The following summarises key opportunities for expanding circular economy in the sector

PRODUCING ANIMAL FEED

OPFs have great potential for use as a roughage source or as a component in compound feed for ruminants, either fresh or processed as silage or pellet.

IMPROVING RECOVERY FROM WASTE

Recovery of raw materials from waste can be done via biological technologies. Biological technologies utilise enzymes to enhance the recovery of raw materials from waste streams and, hence, improve the process's overall efficiency.



GENERATING BIOGAS FROM BIODIESEL WASTEWATER

Washing water is generated from the purification of crude biodiesel. This results in wastewater with high strength chemical oxygen demand. Anaerobic digestion can be used to treat the wastewater while generating biogas. The biogas containing 64 – 74% of methane can be purified and utilised as boiler and transportation fuel [5].

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OPPORTUNITIES FOR CIRCULAR ECONOMY

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PRODUCING BIODIESEL FROM USED COOKING OIL

Used cooking oil (made from palm oil) can also be used to to produce biodiesel. This addresses the disposal of used cooking oil into the waterways and further reduces GHG emissions.

PRODUCING BIODIESEL FROM REFINERY WASTES

Blending Palm Fatty acid Distillates (PFAD) into biodiesel enablescarbon footprint reduction by its use in the transportation of oil palm products and raw materials [6].

PRODUCING NUTRIENTS, FOOD INGREDIENTS, ADDITIVES

New process routes can also be factored to increase the product pallet:

- Phospholipids of palm oil origin to produce lecithin [7,8]
- POME to β-carotene - a natural antioxidant.
- oPalm Pressed Fibre and PFAD to tocotrienol, tocopherols and tocomonoenols by means of extraction [9,10].

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OPPORTUNITIES FOR CIRCULAR ECONOMY

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INTEGRATED PROCESSING COMPLEX

There is a potential to integrate multiple technologies at a same site in a much large scale. This large scale integration can be in the form of a palm oil processing complex (POPC).

A POPC consists of palm oil mill, refinery, wastewater treatment, biogas system, and cogeneration system can be co-located to share resources. These resources may include (but not limited to) biomass, electricity, heating, and cooling.

Sharing of resources like energy will reduce the need to source energy from external parties such as the national grid.

Heat integration can also be implemented in a POPC to achieve a circular economy. Hot streams and cold streams can be paired together to achieve heat exchange via heat exchangers. This will then reduce the usage of fuel and fuel cost to produce energy.

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CHALLENGES

A Brief Story About The Challenges

The opportunities presented previously provide a basis for further exploration in the industry. However, these opportunities face challenges that need to be addressed. The following offers an overview of focus areas where further improvements can be made in order to push the industry to increase its circular economy activities.

TECHNOLOGY MATURITY

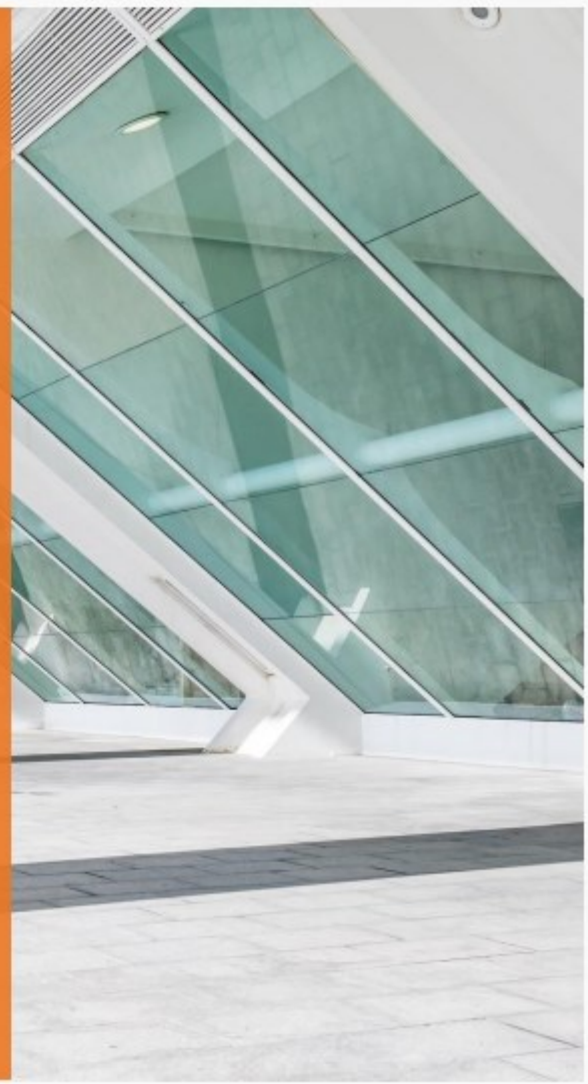
The opportunities proposed may have high potential but experience various levels of maturity. Some of these technologies may be at the development stage and are not ready for industrial scale implementation.

LABOUR SHORTAGE

·The expansion of circular economy and waste valorisation practices may require deployment of new technologies. This will require more labour and expertise on site to monitor and operate these technologies. At the present time, the industry is facing major challenges in securing labour for daily operations. Automation and digitalisation are an urgent need to address labour issues [11].

HIGH COST OF NEW PROCESSING ROUTES

The cost of expanding operations in the palm oil industry is still a key driving factor. New technologies to implement further circular economy pose a financial risk. This discourages stakeholders in the palm oil industry from investing in new processing routes



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QUANTIFYING CIRCULARITY

There is a need for a framework to quantify circularity. In other words, it is important for the industry to have a tested framework on what is deemed as sustainable and acceptable circularity. At the moment, frameworks are theoretical and have not been tested in the palm oil industry.

There is also an underlying question on the scope of circular economy within the industry - Would circular economy requirements be imposed on the industry, or will there be specific requirements assigned to each company in the industry?

TRACKING OF CREDITS

With regard to the POPC, the challenge is to quantify the benefit for operators to cooperate. These benefits may be monetary or environmental, but the uncertainty behind who reaps the benefits is an important issue.

In the case of a POPC, operators may closely integrate their operations to improve circular economy and reduce emissions. Important certification practices are gaining traction in the industry (e.g., Malaysia Sustainable Palm Oil Certification). Such certification incentivises operators to move their operations towards sustainable practices. However, the question remains on who among these operators will receive the premium or credit for such operations, especially when sharing of resources are involved.

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RECOMMENDATION

A Brief Story About The Recommendations

Key recommendations have been identified to address the focus areas discussed above;

Research and Development Support

R&D support and subsidy/financing for new technologies are necessary to help new processing routes reach sufficient maturity for industrial operations.

Industrial Revolution 4.0

Labour shortages suggest that it is appropriate to move the industry towards automation and digitalisation. This will encompass the increasing use of drones and robotics within in a framework of IR 4.0 to perform operations in the industry. This will help reduce the reliance on low-skilled labour vacancies and focus on generating high skilled opportunities to attract high skilled workers to the industry. In conjunction with this, labour upskilling programmes can be launched so that current employees can access higher-level skills.

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018

RECOMMENDATION

A Brief Story About The Recommendations

Key recommendations have been identified to address the focus areas discussed above;

Performance Indicator

Key performance indicators for circularity should be given attention so that the industry can better understand what is required to achieve higher levels of circular economy. Possible considerations may include (but are not limited to) overall process efficiency, percentage circularity per unit product, net emissions or water footprint per unit product.

Incentive

A monetary mechanism or framework must be put in place to incentivise stakeholders to implement circular economy including the utilization of new technologies. Doing so will reduce the high cost of new processing routes and increase involvement from stakeholders in the industry. Such framework should explicitly also define the scope for circular economy. This means that circularity targets and the actors responsible for meeting them must be clearly defined. In addition, the proposed framework must facilitate the tracking of credits within the palm oil value chain. Upon tracking, a fair mechanism must be put in place to allocate the beneficiaries of the premiums received when implementing circular economy.

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REFERENCE

[1] European Parliament. Circular economy: definition, importance and benefits. European Parliament News 2022.

[2] Ellen MacArthur Foundation. Eliminate waste and pollution. Ellen MacArthur Foundation n.d.

[3] Ellen MacArthur Foundation. Circulate products and materials. Ellen MacArthur Foundation n.d.

[4] Ellen MacArthur Foundation. Regenerate nature. Ellen MacArthur Foundation n.d.

[5] Phukingngam D, Chavalparit O, Somchai D, Ongwandee M. Anaerobic baffled reactor treatment of biodiesel-processing wastewater with high strength of methanol and glycerol: Reactor performance and biogas production. Chemical Papers 2011;65:644–51.

[6] Cho HJ, Kim JK, Ahmed F, Yeo YK. Life-cycle greenhouse gas emissions and energy balances of a biodiesel production from palm fatty acid distillate (PFAD). Appl Energy 2013;111:479–88.

[7] Teh KC, Lim SC, Andiappan V, Chew IML. Evaluation of Palm Oil Eco-Industrial Park Configurations: VIKOR with Stability. Process Integration and Optimization for Sustainability 2021;5:303–16.

[8] Choo YM, Bong SC, Ma AN, Chuah CH. Phospholipids from palm-pressed fiber. JAOCS, Journal of the American Oil Chemists' Society 2004;81:471–5.

[9] Mei HN, Yuen MC, Ah NM, Cheng HC, Hashim MA. Separation of vitamin E (tocopherol, tocotrienol, and tocomonoenol) in palm oil. Lipids 2004;39:1031–5.

[10] Maarasyid C, Muhamad II, Supriyanto E. Potential source and extraction of Vitamin E from palm-based oils: A review. Jurnal Teknologi (Sciences and Engineering) 2014;69:43–50.

[11] New Straits Times. Celebrating 100 years of Malaysian palm oil (Part 1). New Straits Times Online 2017.

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Webinar: Conversion of Refinery By-Product PFAD to Biodiesel by Catalytic and Photocatalytic Processes

On 07 November 2022, Dr Mohd Lokman Ibrahim, Senior Lecturer at Universiti Teknologi MARA (UiTM), Malaysia delivered a webinar to discuss about the photocatalytic reaction to convert PFAD into biodiesel. The webinar recorded 37 online participants.

With heterogenous catalytic reaction, Lokman demonstrated that the microwave and supercritical methanol systems increased the esterification reaction rate of PFAD.

Photocatalyst offers low cost, environment friendliness, complete degradation of pollutants, no production of secondary pollutions, and good performance for removing heavy metals in aqueous solution.

SOPB also launched and implements NDPE Policy throughout supply chain for the conservation of life on land. Internal career development programme is provided to deliver decent work experiences. Palm biomass is recycled to produce renewable energy. SOPB is committed to produce and sell high-quality products with sustainability certification.

Lokman emphasised that biodiesel needs to meet the international standard with the following reasons:

- Improve health and safety
- Facilitate global trade and market
- Improve suppliers' collaborations
- Advance innovations
- Support regulatory goals

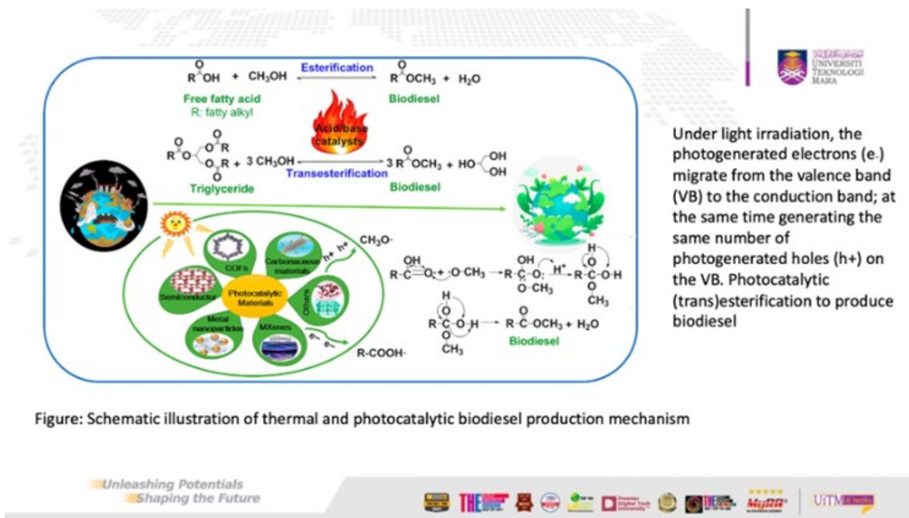
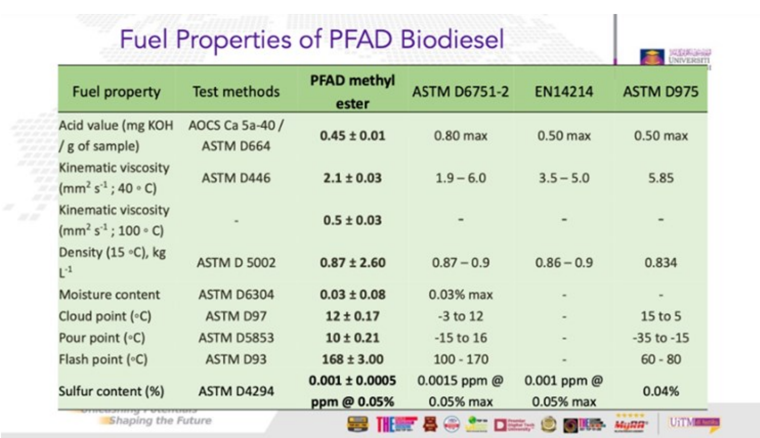


Figure 1: Thermal and photocatalytic biodiesel pro-



Fuel Properties of PFAD Biodiesel

Fuel property	Test methods	PFAD methyl ester	ASTM D6751-2	EN14214	ASTM D975
Acid value (mg KOH / g of sample)	AOCS Ca 5a-40 / ASTM D664	**0.45 ± 0.01**	0.80 max	0.50 max	0.50 max
Kinematic viscosity (mm^2 s^{-1} ; 40 ◦ C)	ASTM D446	**2.1 ± 0.03**	1.9 – 6.0	3.5 – 5.0	5.85
Kinematic viscosity (mm^2 s^{-1} ; 100 ◦ C)	-	**0.5 ± 0.03**	-	-	-
Density (15 ◦C), kg L^{-1}	ASTM D 5002	**0.87 ± 2.60**	0.87 – 0.9	0.86 – 0.9	0.834
Moisture content	ASTM D6304	**0.03 ± 0.08**	0.03% max	-	-
Cloud point (◦C)	ASTM D97	**12 ± 0.17**	-3 to 12	-	15 to 5
Pour point (◦C)	ASTM D5853	**10 ± 0.21**	-15 to 16	-	-35 to -15
Flash point (◦C)	ASTM D93	**168 ± 3.00**	100 - 170	-	60 - 80
Sulfur content (%)	ASTM D4294	**0.001 ± 0.0005 ppm @ 0.05%**	0.0015 ppm @ 0.05% max	0.001 ppm @ 0.05% max	0.04%

Figure 2: Fuel properties of PFAD biodiesel (Lokman, 2022)

Webinar: National Chemical Engineering Symposium (NACES) 2022 Circular Economy Forum

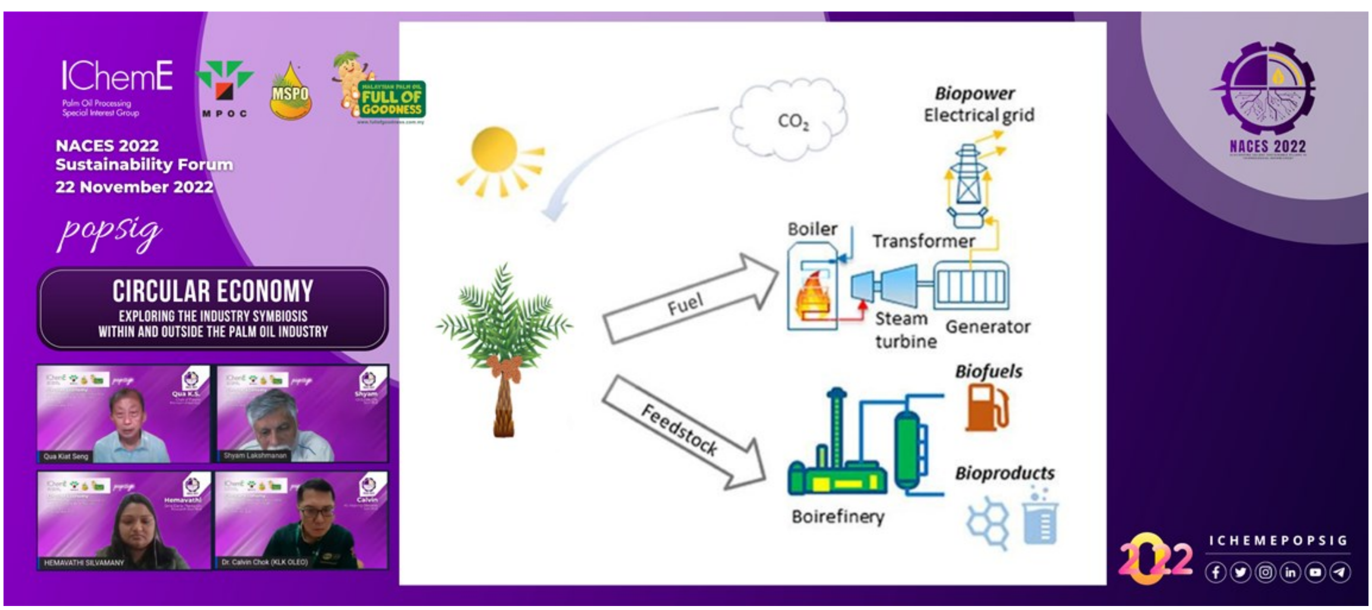
By Ir Qua Kiat Seng

In this forum the panelists are from the major plantation groups that have integrated operations across the supply chain. They are committed to combating climate change and its impacts. To this end they are already practicing reduce, reuse and recycle. In some instances they have gone further by exchanging waste and by-products with at least three parties thereby meeting the definition of industry symbiosis.

In Malaysia industrial parks that promote industry symbiosis are rare. In Sabah the POIC (Palm Oil Industrial Cluster) Lahad Datu is such a park that houses production of biodiesel, refinery, fertilizer, palm kernel crushing, warehousing, power plant, bulking installations, spent bleaching earth oil (SBEO) extraction, palm pellet/fibre, packing of cooking oil, processing and packaging of PKS & EFB etc. Recent site developments see Shell buying up Ecooils Sdn Bhd (SBEO extraction) and Gamalux Oils Sdn Bhd (also SBEO extraction) setting up a new oleochemical plant.

The panelists say that geographic proximity is not a necessity when it was pointed out that mills can be remote and refineries and oleochemical plants are located near ports. As the throughput of refineries increased tremendously it became near impossible to be supplied by just nearby mills. The mill has to be close to the estate as they are handling a large volume of FFB to produce just 22% of oil. Circular economy does not imply that it has to be local but where a material gets reused as much as possible and there is a value is using that material. So circular economy will still work whether it is regional, national and even global.

It is possible to work as a cluster where several mills send their biomass to a power generator near the grid. Mills are often in remote areas far from the grid and the electricity company is reluctant to lay cables to these mills. The solution is for the mills to send their biomass to the grid, literally, to green the grid. The mills get paid and they help the nation's net-zero aspiration.



There is abundance of palm biomass at nearly 180 million tonnes per annum valued at least RM10 billion that is largely unused. PKS is exported to Japan for their power plants and it makes an ideal mixture with coal for co-firing, allowing the plants to reduce their GHG footprint. Carbon pricing might in the future make it attractive for PKS to be retained in Malaysia.

Mills have the potential to not only be net-zero but make the electricity grid more green. Using a 60 tonne per hour mill as an example, the biogas from the POME treatment can generate 6MW of electricity. As the mill needs only 1.5MW the excess 4.5MW could be exported to the grid. As a result the mill does not have to burn EFB, MF and PKS which it can sell as biofuel. It does not make sense to send PKS to Japan incurring GHG emissions in shipping when it could be used to make our grid greener eg co-firing our coal power plants and helping Malaysia towards becoming carbon-neutral.

Industries should be willing to use the excess biomass. The cement industry use coal and should be happy to use biomass to reduce their GHG foot print. The Taiko bleaching earth plant in Indonesia uses biomass. Unilever Oleochemicals Indonesia uses PKS for their thermal oil heating.

The just launched National Energy Policy (DTN) 2022-2040 under Action Plan A6 led by MPIC is to enhance and unlock indigenous bio-based energy. The many stakeholders besides those from the palm oil industry will promote industry symbiosis as the nation moves towards its carbon-neutral goal of 2050.

Biomass is not only suitable for energy. Non-energy applications include oil palm trunks for furniture and EFB for paper.

Leading companies like Sime Darby, IOI and KLK are already practicing circular economy. Within the palm oil industry they can show other players by their example that it can be done. Outside the palm oil industry they are demonstrating how to engage these players as stakeholders profitably whilst reducing their GHG emissions.

Roadshow: Herriot-Watt University Malaysia

IChemE's Palm Oil Processing Special Interest Group (POPSIG), in collaboration with MPOC, organised Palm Oil Educational Roadshow at Heriot-Watt University Malaysia on 16 November 2022. The event recorded 20 participants.

The highlight of the event was the presentation by Mr. Karthi Subramaniam, Senior Process Engineer (Oleo Chemicals) at Desmet Malaysia Sdn Bhd. His presentation title was Edible Oil Processing.

The speaker presented the differences between soft and hard oils, refining process involving water degumming, neutralisation, bleaching and deodorisation. He also demonstrated the roles of chemical engineer in process design.

The participants shared their opinions about the sustainable technology to produce edible oils. Mr. Subramaniam also clarified the operating pressure range of deodoriser and the importance of water degumming in the palm oil processing.

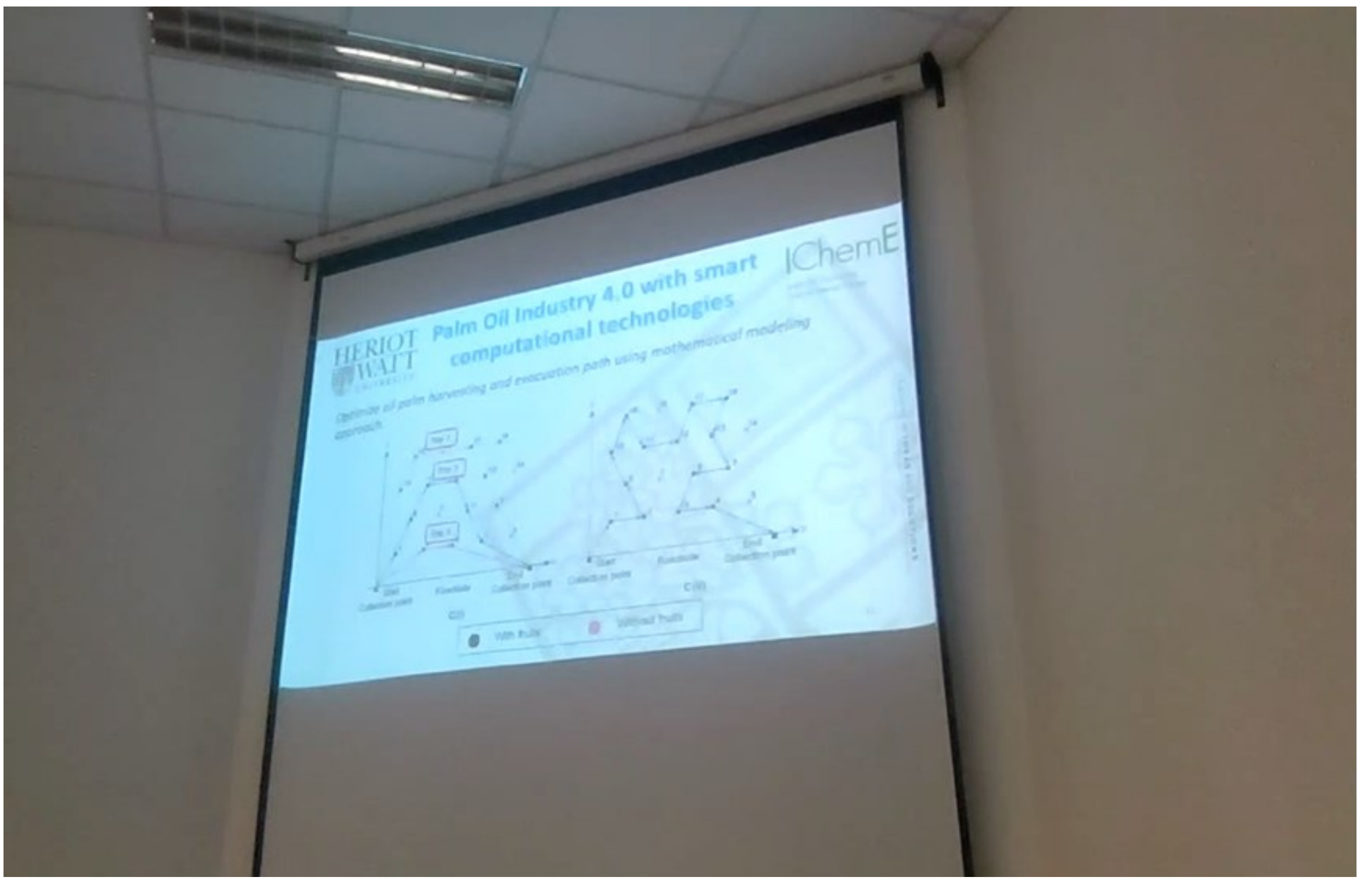
Roadshow: Xiamen University Malaysia

IChemE's Palm Oil Processing Special Interest Group (POPSIG), in collaboration with MPOC, organised Palm Oil Educational Roadshow at Xiamen University Malaysia on 5 December 2022. The event recorded 30 participants.

The highlight of the event was the presentation by Ir. Dr. Lim Chun Hsion, Assistant Professor at Heriot-Watt University Malaysia. His presentation title was The Potential and Challenges of Industry 4.0 in the Palm Oil Industry.

The speaker presented the optimisation method using mathematical modelling on oil palm harvesting and evacuation path. He also showed the challenges with smart computational technologies.

The participants shared their concerns about the drawbacks of the Industry 4.0 technology. Dr. Lim justified that the sustainability analysis was conducted based on ROI index, exposure time index and carbon footprint index.



Article: Phycoremediation As An A Post-Treatment of Palm Oil Mill Effluent (POME)

Written by Ng Sheng Tat
(USCI University)

POME is a brownish colloidal slurry generated from the palm oil industry during the crude palm oil extraction phase. It poses great environmental concerns due to its physiochemical properties that do not align with the legal wastewater discharge values set by the Department of Environment (DOE). Typically, it composes of 40500 mg/L total solids, 4000 mg/L of oily content, 50000 mg/L of Chemical Oxygen Demand (COD), and 25000 mg/L of BOD (Biological Oxygen Demand) (Tan, Wan Maznah, et al., 2022). COD is a measure of the oxygen amount required in the chemical oxidation process to break down the organic matter present in the water, while BOD is a measure of the oxygen amount required by microorganisms required to decompose organic matter through aerobic reaction. Annually, Malaysia alone produces approximately 50 million tons of POME and the trend is increasing due to the increase in the demand for palm oil products (Akhbari et al., 2019). Despite its detrimental environmental effects, the most conventional treatment method applied to POME is open ponding, which often fails to meet the legal requirements for wastewater discharge and is characterized by a high retention time of up to months. In Malaysia, more than 85% of POME is treated using this method (Tan, Wan Maznah, et al., 2022). As a result, a variety of post-treatment methods are being discussed to be implemented after open ponding treatment, as shown in Figure 1 below. In this article, the phycoremediation of POME will be discussed.

Phycoremediation is a biological treatment method that utilizes macro- or microalgae to remove waste components in the midst of encouraging the growth of the algae. The intuition of treating POME via phycoremediation comes from the fact that digested POME is a suitable medium for the growth of microalgae. Partially treated POME has excessive nitrogen and phosphorus content which polluted the water supply. Algae could utilize these organic and inorganic pollutants for their growth, naturally circulating the nutrients. This approach is cost-effective as it essentially does not require any auxiliary energy for the treatment, generating no secondary pollution. In a study comparing the suitability of Chlorococcum oleofaciens, Chlorella sorokiniana, and Scenedesmus quadricauda as the potential green microalgae for treating POME, it is found that Chlorococcum oleofaciens has demonstrated an exceptional growth rate of nearing 0.32 d-1 in lab scale treated POME, and successfully reduce the phosphorus, and nitrogen level up to 90 % removal, and achieve 65% of removal of soluble chemical oxygen demand (SCOD) (Tan, Lalung, et al., 2022).

Treating POME using phycoremediation method is especially attractive as the growth of algae in POME while utilizing the waste components helps in mitigating global warming by using atmospheric carbon dioxide as the raw material for growth (Tsai et al., 2017). As such, it helps in sequestrating carbon and producing oxygen during its growth which is driven by photosynthesis. The simplified nutrient uptake by a microalgae cell during photosynthesis is presented in Figure 2. The resulting algae can be used as feedstock for fertilizers or biofuel production. Recently, researchers have shifted their attention to investigate the feasibility of transferring the high-energy state electrons produced during photosynthesis to an electron mediator and subsequently an electrode. Upon completing the circuit, bioelectricity will be produced making it a microbial fuel cell (Ng et al., 2021). This is done by attaching a biophotovoltaic (BPV) device to microalgae for power generation. There is also rising attention to investigating if Haematococcus pluvialis and Chromochloris zofingiensis are suitable microalgae for POME treatment (Fernando et al., 2021). This is because they are the prospective sources of natural astaxanthin, which is an antioxidant used for curbing Parkinson's and Alzheimer's diseases, and even delaying the growth of cancerous cells (Fernando et al., 2021). Wastewater as the medium for such microalgae provides low-cost essential nutrients and water for their growth while treating the wastewater. Figure 3 demonstrates the positive growth of microalgae in different media.

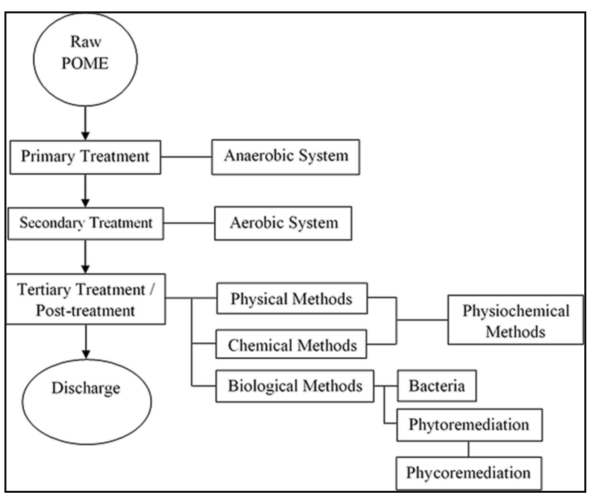


Figure 1: Potential POME post-treatment methods to be applied (Tan, Wan Maznah, et al., 2022).

The feasibility of treating POME using the phycoremediation method is still in the infancy stage whereby there are a few challenges that need to be overcome before its practical implementation. The POME is a brownish-cloudy wastewater with limited light penetration. The photosynthesis rate of algae for their growth is highly dependent on the light intensity, and for their maximum growth, the light intensity reaching the cells should be enhanced. The easiest method is to pre-treat the wastewater, which might be time, resource, or cost-consuming. For instance, diluting water for light penetration is water-consuming and not practical as it reduces the concentration of the nutrients that spurs the growth of the algae. The growth of algae is highly sensitive to the environmental condition of the medium. Factors such as pH, temperature, and nutrient concentration need to be optimized for the growth of the algae. Most of the algae have optimum growth at a pH range from 8.2 to 8.7, while the pH of POME may be as low as 4, demanding a preliminary treatment before phycoremediation (Tan, Wan Maznah, et al., 2022). The growth rate of the f the algae could be inhibited by the form of nutrients that is not bioavailable, which the algae difficult to uptake those nutrients. There is also difficulty in controlling the algal growth and harvesting the algae biomass once they are implemented on a large scale. This could lead to eutrophication if left uncontrolled.

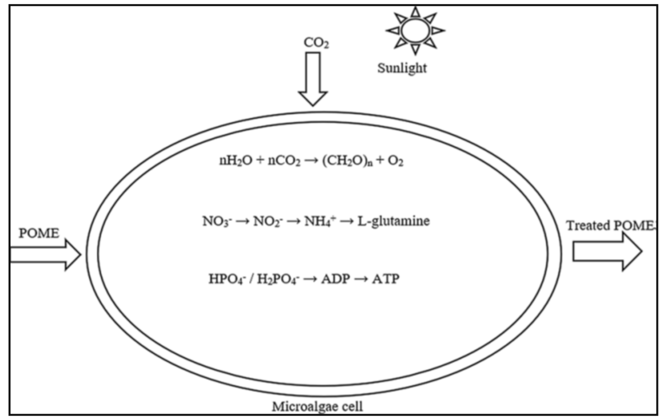


Figure 2: Nutrient uptake by microalgae in photosynthesis (Tan, Wan Maznah, et al., 2022).

In a nutshell, phycoremediation is one of the potential solutions to treat POME in light of its environmental friendliness which is aligning with the goal of the circular economy. Nevertheless, findings from the research are much needed to implement this method on a practical scale. Researchers should focus on finding a suitable species of algae that is well-suited to survive and thrive in the POME environment. There is also a need to investigate if phycoremediation could be used as a stand-alone treatment without the need for pretreating the POME. All the challenges mentioned above should be sufficiently addressed so that the benefits of this treatment could be fully leveraged.

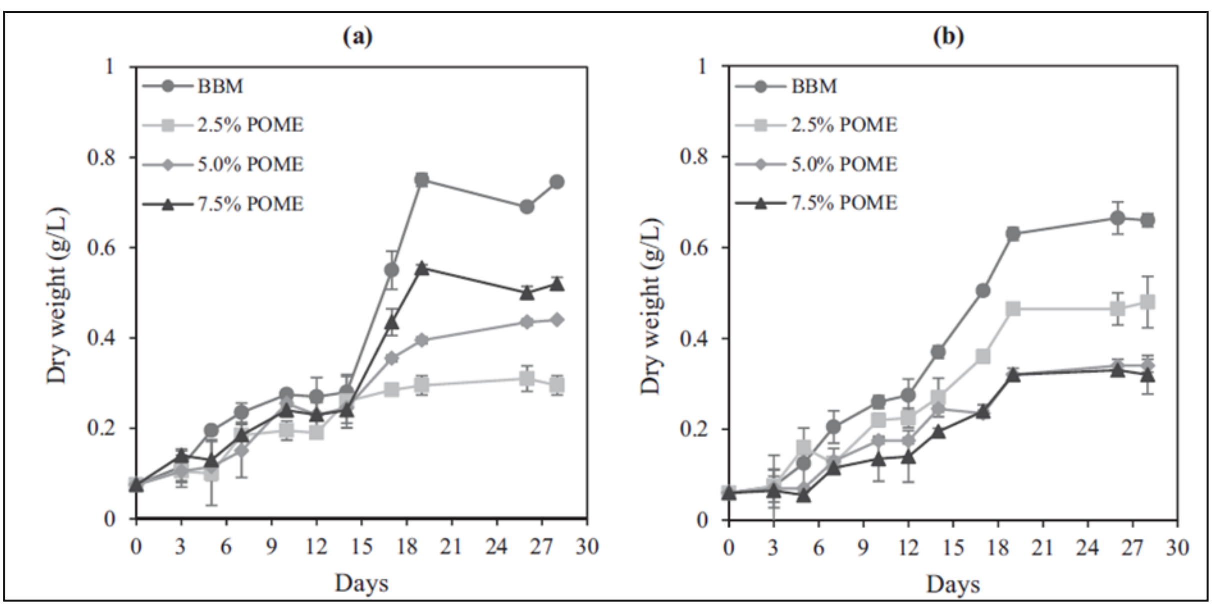


Figure 3: Growth curves of (a) *H. pluvialis* and (b) *C. zofingiensis* cultivated in Bold's Basal Medium (BBM) and 2.5%, 5.0% and 7.5% palm oil mill effluent (POME) (Fernando et al., 2021).

References

Akhbari, A., Kutty, P. K., Chuen, O. C., & Ibrahim, S. (2019). A study of palm oil mill processing and environmental assessment of palm oil mill effluent treatment. *Environmental Engineering Research*, *25*(2), 212–221. https://doi.org/10.4491/eer.2018.452

Fernando, J. S. R., Premaratne, M., Dinalankara, D. M. S. D., Perera, G. L. N. J., & Ariyadasa, T. U. (2021). Cultivation of microalgae in palm oil mill effluent (POME) for astaxanthin production and simultaneous phycoremediation. *Journal of Environmental Chemical Engineering*, *9*(4), 105375. https://doi.org/10.1016/j.jece.2021.105375

Ng, F.-L., Phang, S.-M., Thong, C.-H., Periasamy, V., Pindah, J., Yunus, K., & Fisher, A. C. (2021). Integration of bioelectricity generation from algal biophotovoltaic (BPV) devices with remediation of palm oil mill effluent (POME) as substrate for algal growth. *Environmental Technology & Innovation*, *21*, 101280. https://doi.org/10.1016/j.eti.2020.101280

Tan, K. A., Lalung, J., Wijaya, D., Ismail, N., Wan Omar, W. M., Wabaidur, S. M., Siddiqui, M. R., Alam, M., & Rafatullah, M. (2022). Removal of Nutrients by Using Green Microalgae from Lab-Scale Treated Palm Oil Mill Effluent. *Fermentation*, *8*(11), 658. https://doi.org/10.3390/fermentation8110658

Tan, K. A., Wan Maznah, W. O., Morad, N., Lalung, J., Ismail, N., Talebi, A., & Oyekanmi, A. A. (2022). Advances in POME treatment methods: Potentials of phycoremediation, with a focus on South East Asia. *International Journal of Environmental Science and Technology*, *19*(8), 8113–8130. https://doi.org/10.1007/s13762-021-03436-6

Tsai, D. D.-W., Chen, P. H., & Ramaraj, R. (2017). The potential of carbon dioxide capture and sequestration with algae. *Ecological Engineering*, *98*, 17–23. https://doi.org/10.1016/j.ecoleng.2016.10.049

Article: Overcoming the Uncertainties in Sustainable Palm Oil Production with Machine Learning

Written by Yeow Teck Ann
(Xiamen University Malaysia)

Oil palm is one of the most valuable energy crops. Oil palm is found to have one of the highest oil productivity among all the energy crops - producing 3.62 ton per hectare per year as shown in Figure 1 [1]. Palm oil is also an important manufacturing raw material for many chemical and edible oil products. In addition to that, the fibrous palm biomass waste generated can be supplied as the abundant raw material for thermal degradation energy generation. Due to such high commercial value, a surging trend in palm oil plantation has been observed.

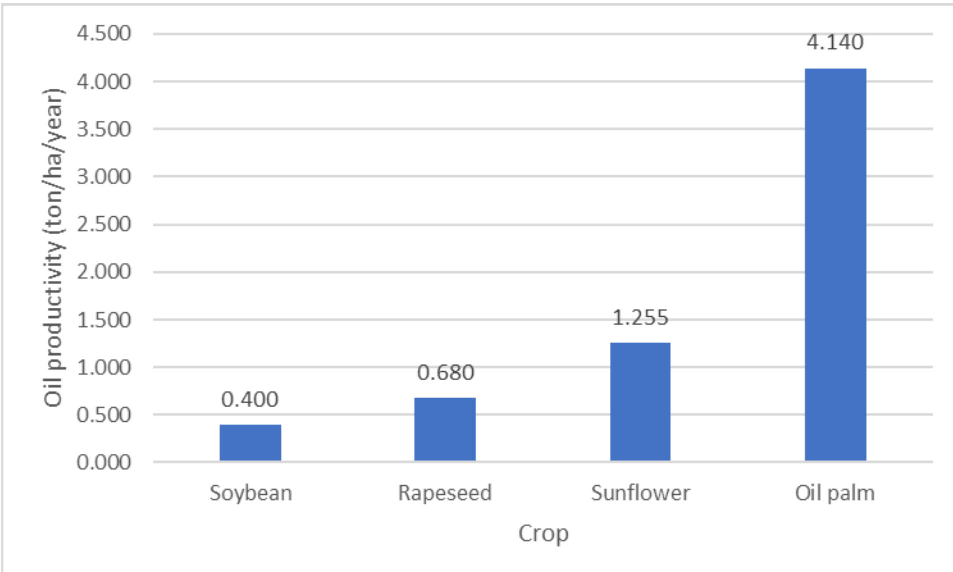


Figure 1: Comparison of oil productivity between energy crops [1,2,3]

The recent expansion of palm oil plantation has resulted in severe environmental impacts due to rapid deforestation. In the effort to stop deforestation, the European Parliament has even voted to forbid the use of palm oil for biodiesel production [4]. Due to the international pressure, both Malaysia and Indonesia, the major palm oil players have passed Malaysia Sustainable Palm Oil (MSPO) and Indonesia Sustainable Palm Oil (ISPO) scheme respectively to ensure the sustainability of palm oil production. In Malaysia, the MSPO has been launched in 2013 to promote the production of Certified Sustainable Palm Oil (CSPO). However, the monitoring of CSPO production faces challenges as its production is associated with high inconsistency and uncertainty. The production of palm oil starts from the plantation, followed by harvesting and milling of the palm fruit for palm oil extraction. Different parameters need to be gauged at each stage, hence, generating different types of data. In general, these parameters can be classified into two groups, in which the first group consists of those that affect the yield of palm fruit bunch and the second group that consists of those that affect the quality of extracted oil and its oil recovery rate (OER) in the milling process. Both groups have been summarised in Table 1 and 2 respectively with their effect studied to the overall CSPO production.

The parameters listed in Table 1 and 2 are just a few of many that would influence the overall CSPO production. More comprehensive reviews of the influencing parameters could be found in [17] and [33]. As seen from both tables, each parameter is being quantified differently thus they would result in the collection of different form of data. Such inconsistent set of data cannot be easily interpreted by the conventional analytical tools and thus hindering the prediction for CSPO production. Therefore, the adoption of Industrial Revolution 4.0 (IR 4.0) technologies by the palm oil sector for the handling of these complex data is inevitable for forecasting purposes [40].

Lately, machine learning has received a lot of attention and it has been applied successfully in many fields. Machine learning algorithm exploits mathematical operations to train machines to 'learn' through data. The machine gains 'experience' by simply learning the correlation between the input and output through mathematical operations while ignoring the mechanisms between them as shown in Figure 2. This simplifies the prediction process for complex problems. Since the production of CSPO is associated with high uncertainties, machine learning will be helpful as it allows the researchers to estimate the outcome of the problems without being needed to go through a series of intensive manual analysis. Most importantly, machine learning does not restrict the type of input data unlike the conventional analytical tools. Apart from the empirical (numerical) data, data in the image and audio format can also be fed to the algorithms, enhancing the flexibility for data collection. Therefore, machine learning could be one of the most important IR 4.0 tools to make the production of CSPO more predictable.

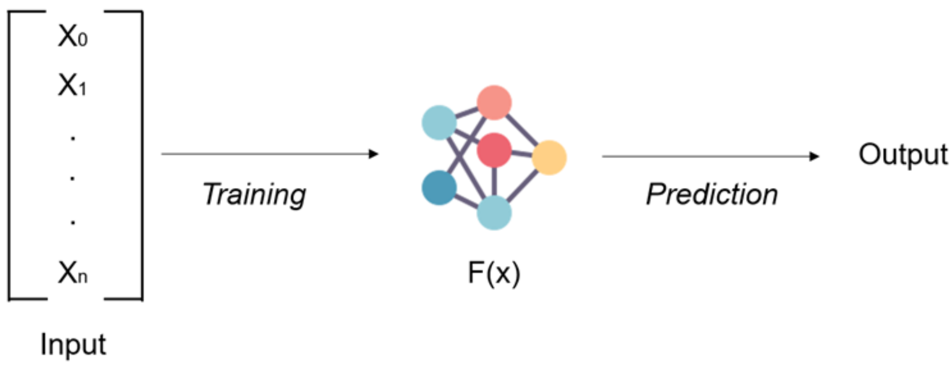


Figure 2: The learning process of the typical 'supervised' machine learning algorithm

Several machine learning algorithms have been applied to forecast the production of palm oil. For instance, Bayesian network trained by a range of environment, agronomic and management data for the prediction of oil palm yield had reached an accuracy of 75% [41]. The palm oil plantation owners could exploit this model to better monitor the production of oil palm based on their desired yield level. Another study conducted to predict the ripeness of fresh fruit bunch (FFB) based on real FFB images using artificial neural network (ANN) achieved overall accuracy of 70% [42]. The use of FFB images as the training data by the ANN allows better prediction than the conventional linear regression model which relies on empirical input data. This would allow the farmers in making more informed decision while avoid harvesting juvenile FFB. Despite that, the images of FFB are more easily available than other empirical parameters and thus, accelerating the process for data collection and model training. In addition to that, the convolutional neural network (CNN) had been applied to classify juvenile and mature oil palm from other crops, reaching accuracy of close to 96% and 93% respectively [43]. In essence, the machine learning algorithms could potentially improve the production of CSPO by allowing the researchers in utilising various unstructured data that are easily available from palm oil plantation fields and palm oil mills.

However, as a saying goes, 'garbage in and garbage out'. If the data fed to the machine learning algorithms is not representative and accurate, it would result in poor prediction by these algorithms. Therefore, the quality of the collected data must be assured. Instead of relying on labour for data collection which is prone to errors, Internet of Things (IoT) sensors could be employed to collect data with higher precision. However, the affordability of IoT sensors by the small-medium-enterprises (SME) in the palm oil sector imposes challenges for the adoption of machine learning. In addition to that, most of the technicians in the current palm oil sector are not familiar with such technology and would require intensive training. It is recommended that the government should step in and provide the necessary assistance such as monetary and technical supports for these enterprises to overcome the technological transition.

Table 1: Significant parameters that affect the palm fruit bunch yield

Parameter	Studied effect	Related references
Solar radiation	The reduction in 3 MJ of solar radiation $m^{-2}day^{-1}$ due to haze would result in 15-20% annual fruit bunch yield loss.	[5, 6, 7, 8]
Cultivating tempera-ture	The cultivating temperature at 20 and 17.5 ˚C would cause three and seven times slower seedling growth than at 25 ˚C. At 15 ˚C, seedling growth will be inhibited.	[9, 10, 11]
Soil condition	Type of soil would affect the fruit bunch yield. For instance, shallow soil could yield less than 30 ton $ha^{-1}year^{-1}$ of fruit bunches, biochemically constrained soil could yield 20-30 ton $ha^{-1}year^{-1}$ of fruit bunches. On the other hand, some soils are not suitable for oil palm plantation such as course and sandy soil, and heavy clays would result in large yield loss.	[5, 12, 13, 14, 15, 16]
Micro-nutrient sup-ply through fertilisa-tion	Micro-nutrient such as nitrogen, phosphorous, potassium, boron, copper and zinc have significant impact to the growth of the oil palm. Deficiency or over-supply of these nutrients would result in imbalanced growth of oil palm. Detailed ef-fect about each nutrient can be found in the reference.	[17]
Frond quantity of oil palm	The quantity of frond would indicate the frequency of prun-ing carried out on the particular oil palm. The more the fronds are found on an oil palm, the less frequent the prun-ing is done to it. Over-pruned oil palm tends to yield scarcer fruit bunches. For instance, oil palm with frond quantity of 8, 16, 24, 32 and 40 yielded 2, 12, 19, 24 and 25 ton of fruit bunches per hectare of land occupied.	[9, 18, 19]
Pest	The existence of pest would deteriorate the growth of oil palm and eventually leads to fruit bunch yield loss. For in-stance, in a year, leave-eating insect would cause up to 50% yield loss, oryctes would cause about 50% yield loss and rats would cause about 5% yield loss.	[20, 21, 22, 23, 24, 25, 26]
Fruit bunch harvest-ing interval	The yield of fruit bunches was increased by 5-20% when the harvesting interval was reduced from 14 to 10 days.	[27, 28, 29, 30]
Ripeness ratio of palm fruit	A ripe palm fruit would consist of 58.3% lipid content while the under-ripe palm fruit would only consist 6% lipid and up to 80% of water. However, current practice is that most farmers reap palm fruit based on the observation of palm fruit's colour which is rather subjective to one's eyesight. Inexperienced farmers tend to reap under-ripe palm fruit resulting in overall oil yield loss.	[31]

Loose fruits	Loose fruitlets are always found to be scattered in the ground of the plantation area. These fruitless are detached naturally from the fruit bunch and normally not collected. It was estimated that these loose fruitlets would have accounted for 4-6% of	[32]

Table 2: Significant parameters that affect the quality of extracted oil and its oil extraction rate (OER) in milling process

Parameter	Studied effect	Related references
Time interval between harvesting of palm fruit and fruit reception at palm oil mill	The total duration needed to deliver the palm fruits to palm oil mill must be monitored stringently and kept at minimal. The quality of oil extracted from fresh fruit bunch would deteriorate as the result of oil hydrolysis by the naturally occurring lipase found in the fruit bunches. On the other hand, the loose fruits would also need to be milled as soon as possible to avoid oxidation from taking place which deteriorate the quality of oil extracted.	[32, 33]
Amount of impurities in the oil extracted	The amount of impurities in crude palm oil extracted should be limited. These impurities usually cause poor quality of the final oil produced. Based on Malaysian standard, content of free fatty acid, moistures, glycidyl esters and 3-monochloropropanediol should be limited at 5%, 0.25%, 1 ppm and 2.5 ppm respectively.	[34]
Operating conditions and duration during the sterilisation of fruit bunches	Typically, in the sterilisation of palm fruits will be carried out with steam at 2-2.8 barg in the duration of 60-90 minutes. However, such long duration of sterilisation process tends to damage those loose and under-ripe fruits and their oil being released into the condensate causing oil loss. Other researchers proposed that shorter sterilisation period with higher temperature would increase the OER.	[17, 35, 36]
Operating pressure during the pressing of the palm fruitlets	After digestion, the pulverised fruitlets would be pressed for oil extraction using either single or double-screw press. The pressure of the press must be controlled so that it does not break the nuts which contain high amount of lauric acid which is a source of contamination to the oil extracted.	[37]
Solvent chosen for residual oil recovery from palm waste	The major palm waste produced from palm oil mill are the empty fruit bunch (EFB), press fibre (PF) and POME sludge. These three sources of waste would cause 1.6% of oil loss and thus, it is imperative to recover the residual oil from them. Most commonly applied recovery technique is the solvent extraction. Therefore, the selection of solvent becomes critical. For instance, recovering oil from EFB by applying n-hexane would improve OER by 0.5% as compared to subcritical water which improved only 0.34%.	[17, 38, 39]

References

[1] Lam, M., K., Lee, K., T, Rahmanmohamed, A. (2009). Life cycle assessment for the production of biodiesel: a case study in Malaysia for palm oil versus jatropha oil. Biofuels Bioprod Biorefin :601–12.

[2] Tsukahara K, Sawayama S. Liquid fuel production using microalgae. J Jpn Petrolueml Inst 2005;48:251–9.

[3] Vladimirov, V. P., Chugunov, E. M., Mostyakova, A. A., & Ilgamov, A. A. (2020). Sunflower productivity and gross oil production on the grey forest soil of the republic of Tatarstan under the use of growth regulators. BIO Web of Conferences, 17, 00020. https://doi.org/10.1051/bioconf/20201700020

[4] Winners and losers from the proposed ban on palm oil (Eco Business article) › ISCC System. (n.d.). https://www.iscc-system.org/eco-business-winners-and-losers-from-the-proposed-ban-on-palm-oil/

[5] Paramananthan, S. (2000). Soil requirements of oil palm for high yields. In: Goh, K.J.(Ed.), Managing Oil Palm for High Yields: Agronomic Principles. MalaysianSociety of Soil Science and Param Agricultural Surveys, Kuala Lumpur, pp.18–38.

[6] Henson, I., E. (2000). Modelling the effects of ‘haze’ on oil palm productivity andyield. J. Oil Palm Res. 12 (1), 123–134.

[7] Goh, K., J. (2000). Climatic requirements of the oil palm for high yields. In: Goh, K.(Ed.), Managing Oil Palm for High Yields: Agronomic Principles. MalaysianSociety of Soil Science and Param Agricultural Surveys, Kuala Lumpur, pp. 1–17.

[8] Caliman, J., P., Southworth, A., Jatmika, A., Bangun, D., Asmono, D., Sutarta, E., S., Pamin, K., Guritno, P., Prawirosukarto, S., Wahyono, T., Herawan, T., Hutomo,T., Darmosarkoro, W., Adiwiganda, Y., T., Poeloengan, Z. (1998). Effect of droughtand haze on the performance of oil palm. In: Proceedings of the InternationalOil Palm Conference ‘Commodity of the Past, Today, and the Future’, 23–25September 1998, International oil Palm Research Institude, Medan, pp250–274.

[9] Hartley, C., W., S. (1988). The Oil Palm (Elaeis Guineensis Jacq.). Longman GroupLimited, London.

[10] Henry, P. (1958). Croissance et développement chez Elaeis guineensis Jacq. de lagermination a la première floraison. Revue Générale de Botanique 66, 5–34.

[11] Olivin, J. (1986). Study for the siting of a commercial oil palm plantation. Oléagineux41 (3), 113–118.

[12] Goh, K., J., Chew, P., S., Teo, C., B. (1994). Maximising and maintaining oil palm yields oncommercial scale in Malaysia. In: Chee, K.H. (Ed.), Proceedings of the 1994Internation Planters Conference on Management for Enhanced Profitability inPlantations. Incorporated Society of Planters, Kuala Lumpur, pp. 121–141.

[13] Gurmit, S., Tan, Y.P., Rajah Padman, C.V., Lee, F.W. (1986). Experiences on thecultivation and management of oil palms on deep peat in United PlantationsBerhad. In: Second International Soil Management Workshop: ClassificationCharacterization and Utilization of Peat Land, 7–18 April 1986, Thailand &Malaysia.

[14] Paramananthan, S. (2013). Managing marginal soils for sustainable growth of oilpalms in the tropics. J. Oil Palm Environ. 4, 1–16.

[15] Mutert, E., Fairhurst, T., H., von Uexküll, H., R. (1999). Agronomic management of oilpalms on deep peat. Better Crops Int. 13 (1), 22–27.

[16] Paramananthan, S. (2003). Land selection for oil palm. In: Fairhurst, T., Härdter, R.(Eds.), The Oil Palm—Management for Large and Sustainable Yields. Potash &Phosphate Institute of Canada, Potash & Phosphate Institute, InternationalPotash Institute, Singapore, pp. 27–58.

[17] Woittiez, L., S., Van Wijk, M., T., Slingerland, M., Van Noordwijk, M., & Giller, K., E. (2017). Yield gaps in oil palm: A quantitative review of contributing factors. European Journal of Agronomy, 83, 57–77. https://doi.org/10.1016/j.eja.2016.11.002

[18] Henson, I., E. (2002). Oil palm pruning and relationships between leaf area and yield− A review of previous experiments. Planter 78, 351–362.

[19] Corley, R., H., V., Hew, C., K. (1976). Pruning. In: Corley, R.H.V., Hardon, J.J., Wood, B.J.(Eds.), Oil Palm Research. Elsevier Amsterdam, pp. 307–313.

[20] Wood, B., J. (1977). The economics of crop protection in oil palms. PANS 23 (3),253–267.

[21] Wood, B., J., Corley, R., H., V., Goh, K.H. (1973). Studies on the effect of pest damage onoil palm yield. In: Wastie, R.L., Earp, D.A. (Eds.), Advances in Oil PalmCultivation: Proceedings of the International Oil Palm Conference, 16–18November 1972. Incorporated Society of Planters, Kuala Lumpur, pp. 360–377.

[22] Cahyasiwi, L., Wood, B., Lubis, F., Caudwell, R. (2010). The economics of Oryctesattack in oil palm replants. In: Proceedings of the International Oil PalmConference, 1–3 June 2010, Yogyakarta

[23] Sushil, K., Mukhtar, A. (2008). Impact of various methods of management ofrhinoceros beetle, Oryctes rhinoceros Linn. in oil palm. J. Appl. Zool. Res. 19 (2),157–162.

[24] Wood, B., J., Liau, S., S. (1984). A long-term study of Rattus tiomanicus populations in anoil palm plantation in Johore, Malaysia: II. Recovery from control and economicaspects. J. Appl. Ecol. 21 (2), 465–472, http://dx.doi.org/10.2307/2403422.

[25] Wood, B., J., Chung, G., F. (2003). A critical review of the development of rat control inMalaysian agriculture since the 1960. Crop Prot. 22 (3), 445–461, http://dx.doi.org/10.1016/S0261-2194(02)00207-7.

[26] Puan, C., L., Goldizen, A., W., Zakaria, M., Hafidzi, M., N., Baxter, G., S. (2011). Relationships among rat numbers, abundance of oil palm fruit and damagelevels to fruit in an oil palm plantation. Integr. Zool. 6 (2), 130–139, http://dx.doi.org/10.1111/j.1749-4877.2010.00231.x.

[27] Donough, C., R., Cock, J., Oberthür, T., Indrasuara, K., Gatot, A., R., Dolong, T. (2013). Estimating oil content of commercially harvested oil palm fresh fruitbunches—A step towards increasing palm oil yields. Poster Presented at thePIPOC 2013 International Palm Oil Congress and Exhibition, 19–21 November2013, Kuala Lumpur.

[28] Lee, J., S., H., Ghazoul, J., Obidzinski, K., Koh, L., P. (2013). Oil palm smallholder yieldsand incomes constrained by harvesting practices and type of smallholdermanagement in Indonesia. Agron. Sustain. Dev. 34 (2), 501–513, http://dx.doi.org/10.1007/s13593-013-0159-4.

[29] Corley, R., H., V. (2001). Ripening, harvesting and oil extraction. Planter 77 (906),507–524.

[30] Donough, C. (2003). Harvesting study at IJM plantations QTR centre. Presentationfor the Seminar on Managing Soils of Miri-Bintulu Area, 8–11 December 2003,Sarawak.

[31] Harun, N., H., Misron, N., Sidek, R., M., Aris, I., Ahmad D.,Wakiwaka, H., Tashiro, K. (2013). Investigations on a novel inductive concept frequency technique for the grading of oil palm fresh fruit bunches. Sensors 13(2):2254-2266.

[32] Henson, I., E. (2012). Ripening, harvesting, and transport of oil palm bunches. In O. Lai, C., Tan., C., Casimir (Eds.), Palm oil: Production, processing, characterization, and uses (pp. 137–162). Urbana: AOCS Press. https://doi.org/10.1016/B978-0-9818936-9-3.50008-3.

[33] Chew, C. L., Ng, C. S., Hong, W. L., Wu, T. Y., Lai, O. M., Low, L. E., Kong, P. S., & Chan, E. S. (2021). Improving Sustainability of Palm Oil Production by Increasing Oil Extraction Rate: a Review. Food and Bioprocess Technology, 14(4), 573–586. https://doi.org/10.1007/s11947-020-02555-1

[34] Craft, B., D., Nagy, K., Seefelder, W., Dubois, M., Destaillats, F. (2012). Glycidyl esters in refined palm (Elaeis guineensis) oil and related fractions. Part II: Practical recommendations for effective mitigation. Food Chemistry, 132(1), 73–79. https://doi.org/10.1016/j.foodchem.2011.10.034.

[35] Yunus, R., Zurina, Z., A., Syafiie, S., Ramanaidu, V., Rashid, U. (2016). Effect of high pressurized sterilization on oil palm fruit digestion operation. International Food Research Journal, 23, 129–134. https://pdfs.semanticscholar.org/c99d/fabf2f88f02664fb0418e56bdc4dfce2b6de.pdf.

[36] Loh, T., T., Loh, T., W. (2010). FFB decoring technology revolutionizes palm oil milling process. Palm Oil Engineering Bulletin, 97, 29–45. http://palmoilis.mpob.gov.my/publications/POEB/poeb97.pdf.

[37] Obibuzor, J., U., Okogbenin, E., A., Abigor, R., D. (2012). Oil recovery from palm fruits and palm kernel. In: O. Lai, C., Tan, & C. Casimir (Eds.), Palm oil: Production, processing, characterization, and uses (pp.299-328). Urbana: AOCS Press. https://doi.org/10.1016/B978-0-9818936-9-3.50014-9

[38] Yunos, N., S., H., M., Baharuddin, A., S., Yunos, K., F., M., Hafid, H., S., Busu, Z.,Mokhtar,M., N., Sulaiman, A., Som, A., M. (2014). The physicochemical characteristics of residual oil and fibers from oil palm empty fruit bunches. BioResources, 10, 14–29. https://bioresources.cnr.ncsu.edu/BioRes_10/ BioRes_10_01_14_Yunos_Physicochem_Charac_Residual_Oil_OPEFB_5668.pdf.

[39] Kurnin, N., A., A., Ismail, M., H., S., Yoshida, H., Izhar, S. (2016). Recovery of palm oil and valuable material from oil palm empty fruit bunch by sub-critical water. Journal of oleo science, 65(4),283–289. https://doi.org/10.5650/jos.ess15209.

[40] Lim, C. H., Lim, S., How, B. S., Ng, W. P. Q., Ngan, S. L., Leong, W. D., & Lam, H. L. (2021). A review of industry 4.0 revolution potential in a sustainable and renewable palm oil industry: HAZOP approach. Renewable and Sustainable Energy Reviews, 135, 110223. https://doi.org/10.1016/j.rser.2020.110223

[41] Chapman, R., Cook, S., Donough, C., Lim, Y. L., Vun Vui Ho, P., Lo, K. W., & Oberthür, T. (2018). Using Bayesian networks to predict future yield functions with data from commercial oil palm plantations: A proof of concept analysis. Computers and Electronics in Agriculture, 151, 338–348. https://doi.org/10.1016/j.compag.2018.06.006

[42] Shabdin, M. K., Shariff, A. R. M., Johari, M. N. A., Saat, N. K., & Abbas, Z. (2016). A study on the oil palm fresh fruit bunch (FFB) ripeness detection by using Hue, Saturation and Intensity (HSI) approach. IOP Conference Series: Earth and Environmental Science, 37, 012039. https://doi.org/10.1088/1755-1315/37/1/012039

[43] Mubin, N.A., Nadarajoo, E., Shafri, H.Z., Hamedianfar, A. (2019). Young and mature oil palm tree detection and counting using convolutional neural network deep learning method. Int. J. Remote Sens. https:// doi.org/10.1080/01431161.2019.1569282.

News: IChemE Malaysia Palm Oil Award 2022: Sime Darby Plantation Research Sdn Bhd crowned the winner of the year while IOI Edible Oils Sdn Bhd named Highly Commended recipient

As the world transitions into a low-carbon or carbon neutral economy, businesses are driven towards ensuring that their processes and production comply to relevant environmental and sustainability standards. Sime Darby Plantation (SDP) has long committed to sustainable practices and continue to play a leading role in shaping a sustainable future for the palm oil industry. Through its Research and Development initiatives, both direct and indirect environment as well as sustainability targeted outcome have been achieved in the past. One of the innovative breakthroughs in milling process efficiency improvement is a process developed by Sime Darby Plantation Research (SDPR) and Novozymes, an enzyme developer, on the application of bio-based enzymes to enhance oil recovery. The combination of a bio-based raw material and the expected increase in oil recovery aligns well to the overall objectives of sustainable operations and carbon neutrality. The enzymes in this innovation are designed to release trapped residual oil in unbroken cells that are found in the process fluids arriving from the mill's press operations. The enzyme features thermophilic properties that enables dosing into the Diluted Crude Oil (DCO) prior to entering the Vertical Clarifier Tank (VCT). The key highlights of the innovation, apart from the enzyme design, is the standalone dosing system that consist of an enzyme skid, dosing pump, an inline mixer and an automated process management system that ensures optimum dosing rates and data analysis with minimal human intervention. The enzyme treatment operates on a four to six hour targeted "process window" that is available between the dosing point and separation process in the VCT. The outcome is the realization of additional free oil at the top layer of the VCT and reduced amount of trapped oil in the emulsion layer and tank underflow. The process can be easily adopted due to relatively low investment cost on the retrofits required to the existing milling process. Implementation of the enzyme programme has been carried out on a commercial scale at SDP oil mills since 2020. The measurement of success of the programme is in the oil extraction rate (OER) achieved at the respective mills. To-date, average OER increments of 0.72% have been recorded for the 10 SDP mills installed with the dosing system. Revenue generation from the dosing programme is estimated at RM6.0 million/mill/year for SDP and, potentially RM2 billion/year, if deployed in all oil palm mills in Malaysia. On top of owning the intellectual rights (IP) of the current enzyme dosing system, SDP continues to develop solutions to enhance milling processes, especially on the use of enzymes with robust features such as temperature tolerance or satisfactory effectiveness at lower temperature environments. The enzyme application methods would also require further R&D work to explore effectiveness at the different milling process stages. Recently, the SDPR bio-enzyme team was acknowledged for their efforts in the enzyme development programme at SDP. The team received IChemE Malaysia's awards in 2 categories: Palm Oil and Sustainability. As local winners of the award, SDPR is automatically shortlisted as one of the contenders representing Malaysia for the Sustainability Award at IChemE Global Awards which will be held in Manchester, UK, on the 17th of November, 2022. The award is a recognition and at the same time, a motivation for the team to continue its journey towards rolling out more R&D initiatives that will realize larger sustainable and environmental goals for SDP. It is a privilege and honour to represent Malaysia and the Palm Oil Industry at an international event.

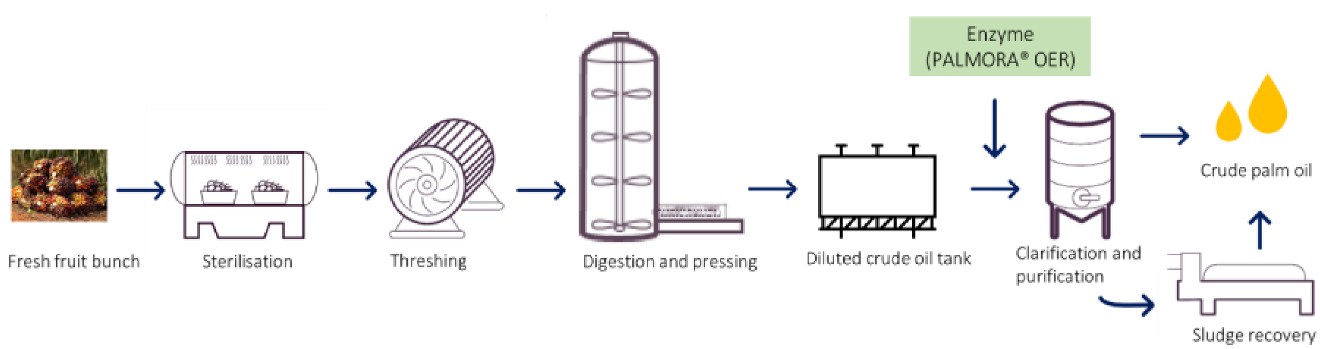


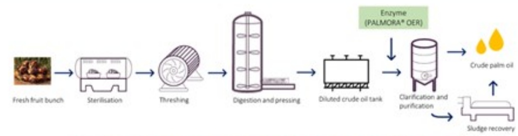
Figure 1: Process flow of enzyme application at palm oil mill.

Sime Darby Plantation Research Sdn Bhd

Enzyme Application at Diluted Crude Oil

Project team :

- From left to right: Muliadi Mustaner, Dr Shiraz Aris, Nik Suhaimi, Mohammed Faisal, Hemavathi Silvamany, Aiman Hakim
- Not in picture: Nik Farid Mat Yassin, Dr Izhar Khairi



Process flow of Enzyme application at Palm Oil Mill

News: Congratulations YAB Dato's Sri Haji Fadillah bin Haji Yusof on his new appointment as the Deputy Prime Minister of Malaysia and Minister of Plantation and Commodities

News: Congratulations YB Datuk Siti Aminah Aching on her new appointment as the Deputy Minister of Plantation and Commodities

News: Congratulations YBhg Datuk Zurinah Binti Pawanteh on her new role as the Secretary General of KPK

News: Dr Viknesh Andiappan for being named as the Winner of the Processes 2022 Young Investigator Award

Processes 2022 Young Investigator Award

Nomination deadline (**expired**): 31 July 2022
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Dear Colleagues,

We are pleased to announce that the winner of the *Processes* 2022 Young Investigator Award is Dr. Viknesh Andiappan.

Dr. Andiappan currently serves as an Associate Professor at the Swinburne University of Technology Sarawak Campus. His research interests are in netzero energy supply chains, net-zero energy systems, process integration and optimisation, operations research, sustainable agriculture planning and industrial symbiosis planning and optimisation. Dr. Andiappan received his Ph.D. in 2016 and has an outstanding publication record, comprising over 70 Scopus-indexed publications and presenting several papers at various conferences. Viknesh Andiappan's Scopus Scientific Citations number is 707, and his Hirsch index is 15, which includes two primary research articles from the middle of the previous decade with more than 50 citations each. Please join us in congratulating Dr. Andiappan for his outstanding achievements.

As the awardee, Dr. Andiappan will receive an honorarium of CHF 2000, an offer to publish a paper free of charge before the end of July 2023 in *Processes* after peer-review.

We would like to thank all the nominators from various fields of study for their participation and all the Award Committee Members for their evaluation of the many excellent nominations.

Processes 2022 Young Investigator Evaluation Committee

News: 2022 December Gathering

News: 2022 December Gathering

News: 2022 December Gathering

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CEO Day @UKM

14 JANUARY 2023

8.00 am - 5.00 pm

Dewan Canselor Tun Abdul Razak (DECTAR)

Highlights:

01 Interact and Engage with Malaysian Industry CEOs

02 Career & Internship Opportunities

03 TikTok Competition

04 Palm-based Food Product Development Competition

05 Sustainable Product Innovation from Palm Waste Competition

06 Cooking Demonstrations by Famous Chef

07 Attractive Prizes to be Won

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UPCOMING EVENTS

DATES	EVENTS
14 January 2023	Event: MPOC's CEO DAY@UKM
13 February 2023	Webinar: Conversion of Refinery By-product PFAD to Biodiesel by Catalytic and Photocatalytic Processes
4-5 March 2023	Roadshow: National Chemical Engineering Exposure Camp (NCEEC) 2023 – Universiti Malaya
6 March 2023	Webinar: The role of sustainable palm oil in protecting biodiversity and ecosystems
16 March 2023	Roadshow: University Roadshow @ UPM 2023
20 March 2023	Roadshow: UPM Site Tour to Industry
26 March 2023	Roadshow: IChemE Student Chapter Festival 2023 (Day 1, physical) – Universiti Malaya
1 April 2023	Roadshow: IChemE Student Chapter Festival 2023 (Day 2, virtual) – Universiti Malaya
3 May 2023	Roadshow: University Roadshow @ USM 2023
8 May 2023	Webinar: TBA
10 May 2023	Roadshow: USM Site Tour to Industry
12 June 2023	Webinar: TBA

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