OPTIMIZATION OF OPERATING PARAMETERS IN MICROBIAL CONSORTIUM (AB-101) PREPARATION AND APPLICATION IN PALM OIL MILL EFFLUENT (POME) PRIMARY TREATMENT

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For my beloved mother, Sarimah binti Bakri; father, Abidi bin Mahmood; and my wife, Azri Amnani Maulad Sapuan

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ABSTRACT

Polluting characteristics of palm oil mill effluent (POME) urge palm oil mills to implement numerous technologies to further treat POME after the primary treatment system to comply the effluent discharge standard limit posed by Department of Environment (DOE) Malaysia. However, microbial consortium (AB-101), a dark-brown liquid fermented product of various type of fruits and plants was introduced to improve the conventional biological treatment process in order to comply the standard without tertiary treatment. It is mixed with selective nutrients and effluent to prepare end product (bio-activator) that is inoculated into anaerobic ponds of POME to enhance anaerobic digestion. Therefore, the purpose of this research is to evaluate and optimize the operating parameters in microbial consortium (AB-101) application, such as; (i) volume percentage of AB-101 in bio-activator preparation process; (ii) volume percentage of molasses in bio-activator preparation process molasses; and (iii) dosage of the bio-activator. The optimization of these operating parameters is conducted via Response Surface Methodology (RSM). Meanwhile the evaluation and comparison of AB-101 performance under original and optimized operating parameters are based on physico-chemical characteristics of treated POME. The optimum operating parameters values obtained were as follows; 0.01 % v/v of AB-101 in bio-activator, 9.96 % v/v of molasses in bio-activator; and 43.8 ppm of bio-activator dosage. These optimum operating parameters resulted in the following POME characteristics reduction percentage: biochemical oxygen demand (BOD) = 92.9%, chemical oxygen demand (COD) = 65.3%, total suspended solid (TSS) = 93.4% and oil and grease = 95.5%.

ABSTRAK

Ciri-ciri yang boleh mencemarkan daripada efluen kilang kelapa sawit (POME) menggesa pemilik kilang kelapa sawit menggunakan pelbagai teknologi bagi melakukan rawatan lanjut kepada POME untuk mencapai tahap tetapan efluen yang ditetapkan oleh Jabatan Alam Sekitar (JAS) Malaysia. Walau bagaimanapun, campuran mikroorganisma (AB-101), cecair berwarna perang gelap hasil produk penapaian pelabagai jenis buah dan tumbuhan telah diperkenalkan dan diperkatakan mampu menggalakkan keberkesanan rawatan konvensional bagi mencapai tahap efluen yang ditetapkan, tanpa sebarang penambahan teknologi lanjutan. Ia dicampur bersama nutrisi dan air sisa tertentu untuk menjadikannya bio-aktivator, yang merupakan produk akhir yang didos ke dalam kolam anarobik POME bagi menggalakkan rawatan pertama POME, iaitu penghadaman anarobik. Oleh yang demikian, kajian ini bertujuan untuk menilai dan mengoptimumkan parameter operasi dalam penggunaan AB-101 seperti yang berikut; (i) peratusan isipadu AB-101 dalam bio-aktivator (ii) gula hitam (*molasses*) yang digunakan dalam proses penyediaan bio-aktivator; dan (iii) isipadu dos bio-aktivator. Proses pengoptimuman parameter operasi tersebut dijalankan menggunakan '*Response Surface Methodology (RSM)'*. Manakala, proses penilaian dan pembandingan prestasi AB-101 menggunakan nilai parameter operasi asal dan optimum adalah berdasarkan ciri-ciri fizikal-kimia POME yang dirawat. Nilai optimum parameter operasi yang diperoleh adalah seperti berikut; 0.01 % (v/v) AB-101 di dalam bio-aktivator; 9.96 % (v/v) molasses di dalam bio-aktivator; dan 43.8 ppm dos bio-aktivator, Parameter operasi yang optimum ini mencapai kadar peratus penurunan parameter air sisa sawit seperti yang berikut; permintaan oksigen biokimia *(BOD)* = 92.9 %, permintaan oksigen kimia *(COD)* = 65.3 %, jumlah pepejal terampai *(TSS)* = 93.4 % dan jumlah minyak *(oil and grease)* = 95.5%.

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LIST OF SYMBOL AND ABBREVIATION

AB-101	-	Microbial Consortium Serial Name
AD	-	Anaerobic Digestion
Adj, R^2	-	Adjusted R^2
ANOVA	-	Analysis of Variance
BOD	-	Biochemical Oxygen Demand
C	-	Carbon
CCD	-	Central Composite Design
CH_4	-	Methane
COD	-	Chemical Oxygen Demand
C/N	-	Carbon to Nitrogen Ratio
DOE	-	Department of Environment
EFB	-	Empty Fruit Bunch
EPS	-	Extracellular Polymeric Substance
F	-	Food
F/M	-	Food to Microorganisms Ratio
LB-EPS	-	Loosely Bound Extracellular Polymeric Substance
LOF	-	Lack of Fit
M	-	Microorganisms
N	-	Nitrogen
ppm	-	Parts per Million
POME	-	Palm Oil Mill Effluent
Pred. R^2	-	Predicted R^2
RSM	-	Response Surface Methodology
R^2	-	Coefficient Of Determination
TB-EPS	-	Tightly Bound Extracellular Polymeric Substance
TSS	-	Total Suspended Solid
VFA	-	Volatile Fatty Acid

CHAPTER 1

INTRODUCTION

1.1 Project Background

POME is a viscous and brownish liquid which composed of 95–96% water, 0.6–0.7% oil and 4–5% total solids (TS), including 2–4% suspended solid (SS), mainly debris from the empty fruit bunch (EFB) (Parman *et al.*, 2019). It is acidic (pH 4–5) and discharged directly in a hot condition (80–90 °C) due to heat from sterilization and vigorous mechanical processes (Choong, Chou and Norli, 2018; Zuber *et al.*, 2019). Even worse, POME possesses polluting characteristic such as organic load contents with high chemical oxygen demand (COD) and biological oxygen demand (BOD), about 51,000 mg/L and 25,000 mg/L, respectively, on average (Choong *et. al.*, 2018). Hence, it has high potential to diminish dissolved oxygen for aquatic lives, and eventually causes water pollution, depletes food sources and causes extinction of species in long run. Therefore, it is an obligatory to treat POME prior to its discharge.

According to Department of Environment (DOE) (2015), current regulation of Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977, P.U.(A) 342/77 with effective date of enforcement on the 1st July of 1989 requires the parameters as follows: BOD less than 100 mg/L, total suspended solid (TSS) below 400 mg/L, oil and grease (O&G) below 50 mg/L, Ammoniacal Nitrogen (AN) below 150 mg/L and pH ranges from 4.5 to 9.0 as summarized in the following Table 1.1 (Handajani, *et. al.*, 2020; Federal Subsidiary Legislation, 2015). In recent years, DOE has revised the standard discharge limit for BOD from 100 mg/L to 50 mg/L and gradually to 20 mg/L. TSS limit value is also reduced from 400 mg/L to 200 mg/L (Bello and Abdul Raman, 2017; Lokman *et al.*, 2021). Therefore, various technologies have been practiced by palm oil mills throughout Malaysia for treating POME effectively.

Table 1.1: Characteristics of POME from previous studies (Handajani *et. al*., 2020)

No.	Parameters	Unit	Discharged limit
1	Biochemical Oxygen Demand (BOD)	mg/l	100 (Sabah & Sarawak = 20 mg/l)
2	Chemical Oxygen Demand (COD)	mg/l	-
3	Total Suspended Solid (TSS)	mg/l	400
4	Oil and Grease	mg/l	50
5	Ammoniacal Nitrogen	mg/l	50
6	pH	-	6-9

Conventional biological treatment of anaerobic digestion is the most common treatment strategy due to its relatively lower capital and operational cost from its relatively simple design and minimal energy consumption via open ponding system (Tan and Lim, 2019). Anaerobic pond or digester is used to degrade organic load with the absence of oxygen via anaerobic digestion (AD). AD is the main part of the biological treatment process that heavily relies on the mutual and syntrophic interaction of a consortium of microorganisms to breakdown complex organic matter into soluble monomers, such as amino acids, fatty acids, simple sugars and glycerol (Anukam *et al.*, 2019).

However, this process appears to be time consuming as the indigenous bacterial population responsible for the degradation requires high amount of time to adapt into the environment before starting to consume organic matters. Nevertheless, it is still not able to comply with high effluent discharge standard limit. As a result, a microbial consortium product was applied into the anaerobic ponds to boost enzyme activity performance and efficiencies in the AD process at several palm oil mills in Johor. The product, known as microbial consortium or AB-101, was founded in Jakarta Timur, Indonesia and manufactured in Johor, Malaysia. It has been claimed that it may help achieve the quality of effluent discharged as prescribed by the DOE without using any tertiary treatment. Tertiary treatment is a common solution for mills that have poor performance of conventional primary and secondary treatment systems. In addition, it is commonly associated with high capital and operational costs.

Microbial consortium AB-101 is a thick dark-brown liquid, fermentation product of various type of fruits and plants. The details of ingredients and manufacturing process are kept proprietary by the manufacturer due to ongoing preparation for the patent application. Moreover, no chemicals are added throughout the manufacturing process. It is non-toxic and biodegradable. AB-101 is used by industries by inoculating the acclimatized microbial consortium AB-101 (bio-activator) into the industrial effluent treatment system (IETS) to improve the quality of the final effluent discharged. In POME treatment particularly, microbial consortium AB-101 is acclimatized by premixing it with molasses and a portion of raw POME prior to be used. Molasses is used as carbon source to improve carbon to nitrogen (C:N) ratio meanwhile raw POME is used to utilize specific indigenous microorganisms in the POME to actually improve their synergy with the microorganisms in the AB-101. The mixture of enriched and acclimatized microorganisms is addressed as bio-activator. The bio-activator is dosed into the anaerobic pond as advised by the product manufacturers team, from Indonesia that designs this method application procedure based on previous industrial application and internal research.

The inoculation of bio-activator AB-101 into anaerobic digestion of POME helps improving the synergic reaction among microbial community in the effluent and enhancing the degradation of organic pollutants. During isolated acclimatization process, it intensifies the growth of the specifically required microorganisms with respect to the culprit pollutants present in the effluent. Thus, it indirectly improves the anaerobic degradation of POME as a whole. AB-101 possesses several track records in industrial application within Johor which achieved average BOD results of 15-60 mg/L for discharged or treated POME. All of these industries possessed no tertiary treatment within the bio-activator AB-101 application period. Therefore, these track records lead to a collaboration with the AB-101 manufacturing company with UTHM to initiate an analytical study to evaluate and optimize the application of this product in POME treatment.

This particular research is hopefully adding significant values to the industries to resolve the POME issues that have been contributing to several pollution cases in Malaysia. Besides it hopefully resolves the commercial issues encountered by industries on implementing not just effective solutions, but especially cost-effective. Nevertheless, knowledge transfer initiative between industry and academia has been majorly focusing on either additional pretreatment or tertiary treatment rather than improvision on the existing primary or secondary treatment. Hence, commencement of this research hopefully encourages more research basing on improvement on the existing system as well as disclose the immense potential within the existing system if further optimized or enhanced.

The main objectives of this project are to evaluate and optimize the application of microbial consortium (AB-101) in POME primary treatment by manipulating the main operating parameters involved. The three operating parameters or parameters this research focuses on are the volume percentage of microbial consortium AB-101 used to prepare the bio-activator, the volume percentage of molasses used to prepare bio-activator and the dosage of bio-activator inoculated into POME. The current operating parameters as practiced by the industry were first evaluated through the characterization of the treated POME. Then, the operating parameters were optimized using Response Surface Methodology (RSM). Lastly, the characteristics of the treated POME were compared under original and optimum operating parameters.

1.2 Problem Statement

POME has a very concerning characteristics especially the organic load contents indicated by high COD and BOD averaging about 50,000 mg/L and 25,000 mg/L, respectively (Lokman *et al.*, 2021). It has the potential to cause water pollution, food sources depletion and extinction of species in the long run (Tan and Lim, 2019). However, conventional POME treatment system that is mostly practiced by palm oil industry via ponding system is generally ineffective and inconsistent. It only able to remove BOD and COD to an average of 100-200 mg/L and 800 mg/L, respectively (Johan and Zahari, 2017; Zainal *et al.*, 2017). Unfortunately, these values do not comply with the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977, P.U.(A) 342/77 which requires standard discharge limit of BOD below 100 mg/L or 20 mg/L (Zainal *et al.*, 2017). Even though some mills actually recorded the BOD below 20 mg/L via only open ponding system, the results are significantly inconsistent

Therefore, in order to eradicate the inefficiency of the conventional open ponding system, most mills have considered alternative primary treatment, or additional pretreatment to improve overall POME treatment. However, most of these proposed technologies are hindered due to its impracticality. As an example, chemical treatment via coagulation-flocculation has been approached by a few mills for POME primary treatment to replace or used before anaerobic digestion. Despite of having high quality results at significantly lower retention time, it actually creates other issues, such as; it produces sludge with heavy metals content that requires appropriate and costly disposal method; and the chemicals might inhibit the follow-up secondary treatment, which is aerobic treatment system by intervening with the microorganisms' respiration and metabolism rate.

As cost is just as important as performance when selecting the most practical solution to a particular problem in industries due to its large application, similar to the previous issue from alternatives primary or pretreatment technologies, most mills have started to implement additional tertiary treatment. The most commonly approached tertiary treatment is membrane filtration system. However, in spite of its excellent performance, there is limited number of full-scaled or long-term application due to its drawbacks such as it requires high capital and operational cost (Chan and Chong, 2018; Foo, 2019). Thus, AB-101 has started to attract the attention of palm oil mill owners as it has the potential to improve the existing ponding system with no capital investment required for additional technology or system installation as well asit possesses very low operational cost due to its simple method of application. However, product manufacturer does not have sufficient data to optimize the application of AB-101 in enhancing anaerobic treatment of POME. The current non-optimized practices may contribute to technical and cost inefficiencies. Thus, this study was designed to determine the optimum operating parameters to prepare and apply AB-101 to enhance primary POME treatment.

1.3 Research Objectives

(i) To evaluate physicochemical characteristics of POME treated by bio-activator AB-101 under original operating parameters.

(ii) To optimize operating parameters in preparation and application of bio-activator AB-101 in treating POME via Response Surface Methodology (RSM).

(iii) To compare the physicochemical characteristics of POME treated by AB-101 under optimized and original operating parameters.

1.4 Scopes of Research

(i) Evaluation of current performance of AB-101 is conducted by characterizing the treated POME in terms of chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solid (TSS) and oil and grease (O&G), under original operating parameters as follows: (i) AB-101 volume percentage = 0.2 %, (ii) molasses volume percentage = 7.5 %, (iii) bio-activator AB-101 dosage = 100 ppm in pilot-scaled batch test experiment.

(ii) The range of values of the operating parameters (independent variables) to be optimized are determined as follows; (i) percentage volume of AB-101 in bio-activator (0.1 – 1.0 %); (ii) percentage volume of molasses in bio-activator (0 - 10.0 %); (iii) dosage of bio-activator inoculated into POME (20 – 80 ppm) and COD reduction percentage as response.

(iii) Optimization of AB-101 operating parameters in treating POME are conducted via RSM from Design Expert software, justified via lab-scaled batch test experiments and verified via analysis of variance (ANOVA).

(iv) Evaluation of the performance of AB-101 under optimized operating parameters through characterization of treated POME in terms of COD, BOD, TSS and oil and grease in pilot-scaled experiment.

(v) The AB-101 performance in treating POME under original and optimized operating parameters based on the POME characteristics and working mechanism of AB-101 in treating POME in anaerobic condition is proposed accordingly.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the relevant information, results and methodology from previous studies. The chapter consists of subtopics encompassing palm oil industry statistical figures, palm oil mill effluent (POME) as byproduct as well as its characteristics, existing technology for its treatment especially conventional biological treatment via anaerobic digestion. Moreover, literature on microbial consortium-based product is reviewed thoroughly. Lastly, literature on RSM as an optimizing tool from previous studies is elucidated, including its statistical interpretation and regression analysis.

2.1 Palm Oil Mill Effluent (POME)

United States Department of Agricultural (USDA) Economic Research Service reported that palm oil production in Malaysia has increased since 1965 to 1985 from 151,000 ton/year to 3,018,000 ton/year, respectively (Ender, 1994). The production escalated to 19,919,331 ton/year and 19,516,141 ton/year in 2017 and 2018, respectively, (Malaysian Palm Oil Board , 2019). In 1990, there were 261 palm oil mills operating and producing a total processing capacity of 42,874,000 fresh fruit bunch per year (FFB/year) (Azman, 2014). In 2018, the number of mills has increased to 451 with a total capacity almost tripling to 112,442,000 FFB/year (Malaysian Palm Oil Mill Board , 2019).

The main feed or raw materials for palm oil milling process is free fruit bunch (FFB) and the main products are crude palm oil (CPO) and kernel. Throughout the production process line, by-products are generated from different points (Foong *et al.*, 2017). Amongst all the byproducts, POME is the most concerning due to its polluting characteristics and large volume with respect to the CPO produced. For every 100 tons of FFB processed, 67 tons of POME are produced, while the main product CPO, is only 22 tons (Chin *et al.*, 2019; Foo, 2019; Onoja *et al.*, 2019). In other words, POME tripled compared to the main product. As the second largest palm oil producer worldwide, Malaysia generates a substantial volume of POME as byproduct (Chin *et al.*, 2019).

POME is a combination of wastewater streams generated from three main processing stages at the mill, namely sludge clarification (0.4 t/t FFB), sterilization condensate (0.2 t/t FFB) and effluent from wet separation of kernel and shell (0.07 t/t FFB) (Foo, 2019). Every ton of CPO produced will generate about 3.05 ton of POME as depicted in Figure 2.1 (Choong, Chou and Norli, 2018). . Apart from the production of CPO and kernel as the main products, palm oil milling process also produces POME, empty fruit bunch (EFB), mesocarp fiber (MF) and kernel shell (KS) as by-products (Nyakuma, 2015).

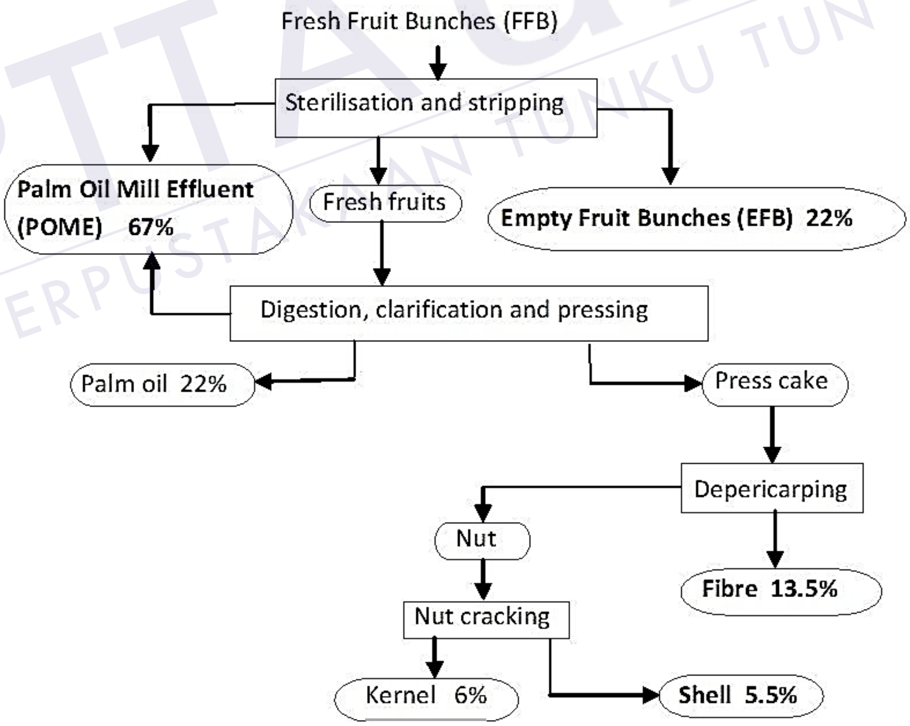

Figure 2.1: Production of Main and By-products from Palm Oil Mills (Nyakuma, 2015)

The main products, which are CPO and kernel oil are extracted from the main raw materials, FFB (Albakri *et al.*, 2019). Table 2.1 exhibits the comparison of products based on wet and dry FFB. A wet basis is where the substance moisture content, or water percentage associated with the substance is taken into account during calculation. Meanwhile, the dry basis refers to calculation without moisture content of substance. In wet basis, the total percentage of main products and by-products of milling process is 136% with respect to FFB, portraying that the products are more than the feed (FFB). Apparently, the remaining 36% is the amount of water added throughout the process which will further generate POME as one of the by-products (Abdullah and Sulaiman, 2013; Nyakuma, 2015). Based on Table 2.1, it portrays that POME majorly comprises a significant amount of water. Out of 67% POME produced, 60.7% is solely water and the remaining 6.3% is impurities such as organic pollutants (e.g. carbohydrates, lipids, protein and cellulase) (Tan and Lim, 2019).

Table 2.1: Percentage of main products and by-products generated from FFB

Type	**Name**	**Wet FFB Basis**		**Dry FFB Basis**	
		Tons/hect.	**% FFB**	**Tons/hect.**	**% FFB**
IN	FFB	20.08	100	10.6	100
	TOTAL (in)	**20.08**	**100**	**10.6**	**100**
OUT *(main product)*	CPO	4.42	22.0	4.42	41.7
	Kernel	1.20	6.0	1.20	11.4
OUT *(by-product)*	EFB	4.42	22.0	1.55	14.6
	POME	13.45	67.0	0.67	6.3
	MF	2.71	13.5	1.63	15.4
	Shell	1.10	5.5	1.10	10.4
	TOTAL (out)	**27.30**	**136.0**	**10.6**	**99.8**

Besides POME, the other by-products are in solid form including; mesocarp fiber (MF) and kernel shell (KS) which are commonly used as fuel for boilers to generate steam used for the mill operations throughout CPO production. These MF and KS are widely used as fuel due to their combustible features such as; high volatile content, low size variation, easy handling features, and low biological activity induced by their low moisture content (Loh, 2016; Yahayu *et al.*, 2018; Chin *et al.*, 2019). EFB has lower oil content compared to MF and KS, and it is used as mulching material as it is also environmentally harmless in contrast to POME (Mohd Yusof *et al.*, 2019; Yoo *et al.*, 2019).

2.1.1 Characterization of POME

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POME comprises organic materials, such as lignin (4700 ppm), carotene (8 ppm), phenolic (5800 ppm) and pectin (3400 ppm) (Khadaroo *et al.*, 2019). In fact, lignin-tannin compound generated from lignocellulosic hydrolysis which recalcitrant to biological treatment via conventional ponding system is responsible for the dark brownish black color of POME (Bello and Abdul Raman, 2017). POME also has a very concerning physico-chemical characteristics as summarized in Table 2.2from previous studies. Accordingly, the average biochemical oxygen demand (BOD) ranges from 15,600 to 27,000 mg/L, chemical oxygen demand (COD) ranges from 25,000 to 51,000 mg/L, total suspended solid (TSS) ranges from 18,000 to 29,500 mg/L, oil and grease (O&G) ranges from 2,000 to 8,935 mg/L and pH is in the range of 3.6 to 4.3 for POME.

Table 2.2: Characteristics of POME from previous studies

Reference	**BOD (mg/L)**	**COD (mg/L)**	**TSS (mg/)**	**O&G (mg/L)**	**pH**
Chan and Chong, 2018	25,000	50,000	18,000	6,000	4.2
Aziz *et al.*, 2019	27,000	57,500	29,500	8,935	4.3
Zainal *et al.*, 2017	25,000	51,000	18,000	5,000	-
Lokman *et al.*, 2021	15,600	25,000	20,000	2,000	3.6

Despite the concerning characteristics, POME is technically non-toxic as no chemicals are added throughout the CPO extraction process from FFB (Chan and Chong, 2018; Foo, 2019). However, high organic content with low carbon to nitrogen ratio results in the formation of bad odor that will inevitably become a nuisance to vicinity community (Foo, 2019). POME is also proven to have high concentrations of carbohydrates, proteins, nitrogen compounds, lipids and minerals that enable it to be used in various biotechnology applications such as fermentation media, antibiotics, bio-insecticides, polyhydroxy alkenoates (PHA), organic acid sources, enzymatic platforms, and hydrogen sources (Abdullah and Sulaiman, 2013; Chan and Chong, 2018).

POME has appreciable oil and grease (O&G) contents, averaging about 2,234 to 27,166 mg/L, including bound fatty acids, free fatty acids (undecylenic acid, palmitic acid and cyclopentane undecanoic acid), and hydrocarbons (2,3-

dimethylbutan) (Cheng, Y. W., Lee, Z. S., Chong, C. C., Khan, M. R., Cheng, C. K. Ng, 2019). Several trace minerals and metals have also been found in POME as reported from previous studies. In addition, the macro nutrients present are as follows: potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P) of 1575.2, 431.0, 161.2 and 138.2 mg/L, respectively. Meanwhile, the micro nutrients present are sodium (Na), iron (Fe), manganese (Mn) and copper (Cu) of 93.1, 91.0, 3.9 and 1.7 mg/L, respectively (Nadirah *et al.*, 2019). Thus, POME requires treatment before being discharged into water bodies and AB-101 is one of the potential treatments for which its operating parameters can be optimized.

2.1.2 Implication of Untreated POME Discharge

The polluting characteristics of POME not simply just affecting the environment, it also increases the complexity of national economy and social aspects. Disposal of POME before treatment is strictly prohibited because it can disrupt the aquatic ecosystem and pollute water due to POME discharge contains microorganisms that will compete with the aquatic life mainly on the uptake of oxygen. This occurrence will ultimately cause the aquatic life to have less oxygen, slowly hindering the growth of the marine life and, eventually, causing the extinction of the latter (Khadaroo *et al.*, 2019; Tan and Lim, 2019). Also, a huge amount of nutrients such as phosphorous, nitrogen and potassium in POME is one of the biggest contributors for potential algae growth medium and eventually uncontrollably causing eutrophication, an extreme algal growth on the surface of the water (Mosunmola and Olatunde, 2020). Nevertheless, POME also contributes to global climate change when released into open-air holding ponds for primary treatment via anaerobic digestion (AD). AD process ends up generating and releasing methane, carbon dioxide and hydrogen sulphide (H_2S) as final product (Mosunmola and Olatunde, 2020).

As the second largest crude palm oil mill producer worldwide, palm oil industry in Malaysia is one of the economy and trading symbols that has been a crucial value to Malaysia value (Mosunmola and Olatunde, 2020). In spite of that, there are huge crisis recently faced by national palm oil industry including international banning movement especially from European Union (EU), United States of America (USA) and India (Ishak, 2020; Jadhav, 2020; VOA News, 2020). All these bans were

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