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## ABSTRACT

The palm oil industry in Malaysia is one of the largest producers of agroindustrial wastewater known as Palm Oil Mill Effluent (POME). POME is highly organic in content which is acidic, thick, dark in colour, with high levels of chemical oxygen demand, ammonical nitrogen, orthophosphate, nitrate, nitrite, total suspended solids, and total solids. Due to high organic load, the raw POME has to be digested anaerobically to reduce the pollutant level, in order to meet the effluent discharge standard for palm oil mills. The objective of the present study is to investigate the potential of selected microalgae to grow in POME and anaerobic liquor (AL) as well as to assess the biochemical composition of the biomass and finally the percentage of pollution reduction obtained. Nine microalgae strains from the University of Malaya Algae Culture Collection (UMACC) which are *Chlorella vulgaris* UMACC 001, *Scenedesmus* UMACC 010, *Scenedesmus* UMACC 036, *Scenedesmus* UMACC 068, *Ankistrodesmus convolutus* UMACC 101, *Nannochloris bacillaris* UMACC 109, *Chlorococcum oviforme* UMACC 110, *Chlamydomonas augustae* UMACC 246 and *Chlorella* UMACC 300 were screened for growth and biochemical composition using flask cultures. Of nine strains, *Chlorella* UMACC 300 (specific growth rate ( $\mu$ ) =  $0.35 \pm 0.02 \text{d}^{-1}$  and  $39.88 \pm 2.73\%$  DW of lipid), *Chlorella vulgaris* UMACC 001 ( $\mu = 0.32 \pm 0.02$  and  $40.61 \pm 2.78\%$  DW of lipid), *Scenedesmus* UMACC 036 ( $\mu = 0.30 \pm 0.05 \text{d}^{-1}$  and  $32.75 \pm 1.01\%$  DW of lipid) and *Ankistrodesmus convolutus* ( $\mu = 0.28 \pm 0.02 \text{d}^{-1}$  and  $38.89 \pm 2.70\%$  DW of lipid) were selected to grow in different concentrations of POME and anaerobic liquor. The *Chlorella* UMACC 300 showed better tolerance to grow in higher concentrations of POME and AL. *Chlorella* UMACC 300 which grew in 25% AL (Bold Basal Medium, BBM) produce biomass of  $677.33 \pm 11.37 \text{ mg L}^{-1}$  with  $39.98 \pm 0.38\%$  DW protein,  $19.12 \pm 0.12\%$  DW carbohydrate and  $43.44 \pm 0.92\%$  DW lipid on day 16 of culture period. This *Chlorella* UMACC 300

also produced higher pollution reduction when compared with other three selected microalgae, whereby it attained  $87.66\pm 0.59\%$  reduction of chemical oxygen demand (COD),  $65.38\pm 2.51\%$  ammonical nitrogen,  $78.56\pm 6.54\%$  orthophosphate,  $45.24\pm 4.12\%$  nitrate and  $42.13\pm 11.81\%$  nitrite. The second best strain which grew in different concentrations of POME and AL was *Chlorella vulgaris* UMACC 001 followed by *Scenedesmus* UMACC 036 and *Ankistrodesmus convolutus* respectively. The results obtained from this study shows that *Chlorella* UMACC 300 which was isolated from POME is tolerant of POME and AL and may be a potential species to be used for POME and AL treatment.

## ABSTRAK

Industri kelapa sawit merupakan penyebab utama kepada bahan pencemar agroindustri yang dikenali sebagai efluen kilang kelapa sawit (POME). POME merupakan pencemar yang mempunyai kandungan organik yang tinggi dan bersifat asid, pekat, berwarna gelap dan mengandungi keupayaan kimia oksigen, ammonikal nitrogen, orthofosfat, nitrat, nitrit, total suspended solid and total solid. Disebabkan oleh kandungan organik yang tinggi, POME perlu dicerna secara anaerobik untuk mengurangkan kandungan bahan pencemar sebelum disalur keluar dari kilang pemprosesan minyak kelapa sawit, bagi memenuhi 'Discharge Standards' yang ditetapkan untuk kilang kelapa sawit. Objektif utama dalam kajian ini adalah untuk mengkaji potensi mikroalga terpilih untuk bertumbuh di media POME dan POME dicerna (AL) yang disediakan menggunakan kepekatan yang berbeza, bagi menilai kandungan biokimia and peratusan penurunan kandungan pencemar. Untuk itu, sembilan microalga dari 'University Malaya Algae Culture Collection' ia itu *Chlorella vulgaris* UMACC 001, *Scenedesmus* UMACC 010, *Scenedesmus* UMACC 036, *Scenedesmus* UMACC 068, *Ankistrodesmus convolutus* UMACC 101, *Nannochloris bacillaris* UMACC 109, *Chlorococcum oviforme* UMACC 110, *Chlamydomonas augustae* UMACC 246 and *Chlorella* UMACC 300 telah dikaji untuk mengenalpasti kandungan biokimia menggunakan sistem kultur. Daripada sembilan mikroalga *Chlorella* UMACC 300 (kadar pertumbuhan sesifik ( $\mu$ )=0.35±0.02d<sup>-1</sup> dan 39.88±2.73%DW lipid), *Chlorella vulgaris* UMACC 001( $\mu$ =0.32±0.02 dan 40.61±2.78%DW lipid), *Scenedesmus* UMACC 036 ( $\mu$ =0.30±0.05d<sup>-1</sup> dan 32.75±1.01%DW lipid) and *Ankistrodesmus convolutus* ( $\mu$ =0.28±0.02d<sup>-1</sup> dan 38.89±2.70%DW of lipid) telah dipilih untuk dikulturkan di dalam POME dan AL media yang disediakan menggunakan pelbagai kepekatan. *Chlorella* UMACC 300 menunjukkan toleransi yang tinggi untuk tumbuh di dalam POME dan AL yang berkepekatan tinggi. *Chlorella* UMACC 300 turut menunjukkan

pertumbuhan yang tinggi di dalam 25% AL (BBM) dengan  $448.00 \pm 18.33$  mg L biomass,  $27.70 \pm 0.93$  %DW protein,  $1.60 \pm 0.07$  %DW karbohidrat dan  $30.67 \pm 1.38$  %DW lipid. Mikroalga ini turut mencatatkan peratusan penurunan kandungan pencemar yang tinggi, dimana  $87.66 \pm 0.59$  % penurunan COD,  $65.38 \pm 2.51$  % ammonikal nitrogen,  $78.56 \pm 6.54$  % orthofosfat,  $45.24 \pm 4.12$  % nitrat and  $42.13 \pm 11.81$  % nitrit. Mikroalga *Chlorella vulgaris* UMACC 001 menunjukkan toleransi kedua tetinggi untuk bertumbuh di dalam POME dan di dalam AL. *Chlorella* UMACC 300 merupakan mikroalga yang mempunyai toleransi yang tinggi untuk bertumbuh di dalam POME media dan dapat mencapai peratusan penurunan pencemar yang tinggi. Keputusan yang diperoleh melalui kajian ini menunjukkan bahawa mikroalga yang berasal daripada POME mempunyai toleransi yang tinggi untuk bertumbuh di dalam POME dan di dalam AL, dimana mikroalga ini lebih sesuai untuk digunakan merawat POME dan AL.

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## LIST OF ABBREVIATIONS

BBM	-	Bold' Basal Medium
CDM	-	Clean Development Mechanism
CER	-	Certified Emission Reduction
Chl-a	-	Chlorophyll-a
COD	-	Chemical Oxygen Demand
CPO	-	Crude Palm Oil
DEE	-	Department of Environmental Enforcement
DW	-	Dry Weight
EQA	-	Environmental Quality Act
FA	-	Fatty Acid
FAME	-	Fatty Acid Methyl Esters
FFB	-	Fresh Fruit Bunch
FGB	-	First Generation Biofuel
GC	-	Gas Chromatography
GHG	-	Green House Gases
GW	-	Global Warming
HEPES-		4-(2-Hydroxyethyl)-1-piperazineethanesulfonic acid
HRAP	-	High Rate Algal Pond
HRT	-	Hydraulic Retention Time
IPCC	-	Intergovernmental Panel for Climate Changes
MAS	-	Membrane Anaerobic System
MUFA-		Monounsaturated Fatty Acid

NaOH	-	Sodium hydroxide
OD	-	Optical Density
pH	-	Potential of hydrogen
PHA	-	Polyhydroxyalkanoates
POME	-	Palm Oil Mill Effluent
PUFA	-	Polyunsaturated Fatty Acid
RPM	-	Rotates per Minute
SBR	-	Sequencing Batch Reactor
SFA	-	Saturated Fatty Acid
SGB	-	Second Generation Biofuel
STR	-	Solid Retention Time
TDS	-	Total Dissolved Solid
TGB	-	Third Generation Biofuel
TS	-	Total Solid
TSS	-	Total Suspended Solid
TVS	-	Total Volatile Solid
UMACC	-	University of Malaya Algae Culture Collection

## LIST OF SYMBOL AND UNITS

%	-	percent
$\mu$	-	specific growth rate
$\mu\text{g}$	-	micro gram
cell / mL	-	cells per millimetre
$\text{d}^{-1}$	-	per day
g	-	gram
mg / L	-	milligram per liter
$^{\circ}\text{C}$	-	degree Celcius
$\text{OD}_{620\text{nm}}$	-	Optical density at 620nm
psi	-	pound per square inch
Rpm	-	revolution per minute
v/v	-	volume per volume
w/v	-	weight per volume

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- I. 25% AL(distilled water)
- II. 25% AL(BBM)
- III. 25% Raw POME (distilled water)
- IV. 50% AL (distilled water)
- V. BBM(control)

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A. *Chlorella* UMACC 300

- I. Chemical Oxygen Demand
- II. Orthophosphate
- III. Ammonical Nitrogen
- IV. Nitrate
- V. Nitrite

B. *Chlorella vulgaris* UMACC 001

- I. Chemical Oxygen Demand
- II. Orthophosphate
- III. Ammonical Nitrogen
- IV. Nitrate
- V. Nitrite

C. *Scenedesmus* UMACC 036

- I. Chemical Oxygen Demand
- II. Orthophosphate
- III. Ammonical Nitrogen
- IV. Nitrate
- V. Nitrite

D. *Ankistrodesmus Convolutus* UMACC 101

- I. Chemical Oxygen Demand
- II. Orthophosphate
- III. Ammonical Nitrogen
- IV. Nitrate
- V. Nitrite

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- II. *Chlorella vulgaris* UMACC 001
- III. *Scenedesmus* UMACC 036
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