NAME OF RIG / CENTRE:

INDUSTRIAL PROCESS RELIABILITY & SUSTAINABILITY (INPRES)

CoRe: FMIA

(FRONTIER MATERIALS AND INDUSTRIAL APPLICATION)

UNIVERSITI TEKNOLOGI MARA

FACULTY OF CHEMICAL ENGINEERING

TIER 5 – RESEARCH INITIATIVE GROUP (RIG)

Name of RIG	**:**	**INDUSTRIAL PROCESS RELIABILITY & SUSTAINABILITY (INPRES)**
Tier	**:**	**5**
Leader	**:**	**Dr. Azil Bahari Alias**
CoRe	**:**	**Frontier Materials and Industrial Application (FMIA)**
Registered Faculty	**:**	**Chemical Engineering**
Registration date (Senate Approval)	**:**	
UiTM Niche Area	**:**	**Chemical & Advanced Materials**
RIG Niche Area	**:**	**Research on corrosion engineering , process safety and environmental engineering focuses on industrial applications.**

DEFINITION

- **Reliability engineering** is a sub-discipline of systems engineering that emphasizes dependability in the lifecycle management of a product.
- **Sustainable engineering** is the process of designing or operating systems such that they use energy and resources sustainably, in other words, at a rate that does not compromise the natural environment, or the ability of future generations to meet their own needs.

Niche Area

Reliability

Corrosion

Process Safety

Industrial Process

Environment
(Industrial Waste)

Sustainability

Process System Engineering

Niche Area and Relevance of RIG

Industrial Process Reliability and Sustainability research group is formed to champion research on corrosion engineering, process safety and environmental engineering (solid, water and air) focusing on the industrial applications.

- Activities emphasize on the following areas:

1. Environment: Research on industrial air pollution: Dioxin, Dispersion model (Bayesion Theorem, SPSS, Monte Carlo, ARCGIS), Greenhouse Gases management (CO_2, CH_4,CFC, N_2O, etc), Toxic Gases management (NOX,SOX,etc),and Air Pollution Control Design – (SCRUBBER, CYCLONE. etc.)
2. Environment: Research on industrial wastewater treatment (physical, chemical, biological approach), wastewater unit design (primary, secondary, tertiary), and high rate algal ponds (HRAP)-nutrien removal into the biomass potential biofuel production.
3. Environment: Research on utilising industrial solid waste (waste to wealth concept) – sludge, biomass, industrial solid waste, MSW etc. , developing new material from waste to combat pollution, and industrial solid waste treatment technologies (thermal treatment technologies, composting, landfill).

Niche Area and Relevance of RIG

- Activities emphasize on the following areas (contd):

4. Process Safety: Research on Consequence Analysis, Facility Siting, Quantitative Risk , Inherent Safety Research and Offshore Safety, Refinery Process Safety.
5. Corrosion Engineering: Research on Corrosion Inhibitor Formulation and Testing, Investigation of Corrosion Mechanisms, Corrosion Prediction and Microbial Induced Corrosion.

BACKGROUND OF MEMBERS

BIL	NAMA	KELAYAKAN AKADEMIK	FAKULTI	BIDANG KEPAKARAN
1	DR. AZIL BAHARI BIN ALIAS	PhD	Kejuruteraan Kimia	Energy, Environment and Process Safety
2	PROF. DR. KU HALIM BIN KU HAMID	PhD	Kejuruteraan Kimia	Energy and Environment
3	PROF DR. KHUDZIR BIN ISMAIL	PhD	Sains Gunaan	Energy and Environment
4	DR NAJMIDDIN BIN YAAKOB	PhD	Kejuruteraan Kimia	Corrosion Engineering
5	DR. ZULKIFLI BIN ABDUL RASHID	PhD	Kejuruteraan Kimia	Energy, Environment and Process Safety
6	DR. ALAWI BIN SULAIMAN	PhD	Perladangan dan Agroteknologi	Energy, Environment and Process Safety
7	DR. NIK RAIKHAN BINTI NIK HIM	PhD	Kejuruteraan Kimia	Industrial Microbiology and Environment
8	PROF MADYA DR MOHD AZLAN BIN MOHD ISHAK	PhD	Sains Gunaan	Energy and Environment

INPRES ACHIEVEMENT(2015-2017)

PENCAPAIAN	2015	2016	2017
Master Degree – Enrolled/On-Going	40	52	55
Master Degree - Graduated	12	6	4
PhD – Enrolled/On-Going	18	22	23
PhD – Graduated	4	1	2
No. of research grants	34	35	28
Total value of research grants (RM)	8,441,605.00	8,257,800.00	7,785,716.00
Total publication (Indexed Journals)	18	32	36
Total publication (Non-indexed Journals)	6	14	15
IPR (Patent, Industrial design, Copyright)	2	5	5

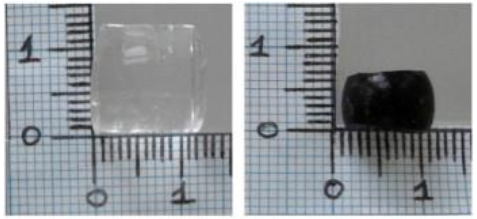
OTHER ACHIEVEMENT INPRES (2015-2017)

ACHIEVEMENT	2015	2016	2017
NO. OF CONSULTANCY/ INDUSTRIAL LINKAGE/ COLLABORATION (National & International)	5	10	15
NO. OF MEMBERSHIP OF PROFESSIONAL BODIES AND ASSOCIATIONS (National & International)	10 (IEM, BEM, ICheME)	10	12
NO. OF SPECIAL INVITATION/ APPOINTMENT/ EXPERTISE (National & International) incl. Keynote Speaker, Invited speaker, Thesis examiner, Judge, Reviewer, Panel, etc.)	16	25	24
NO. OF AWARDS/ RECOGNITION AND APPRECIATION (National & International)	15	16	18

INPRESS Research Group: Research highlights

1) Hydrogel Charsh (HC), a powerful adsorbent

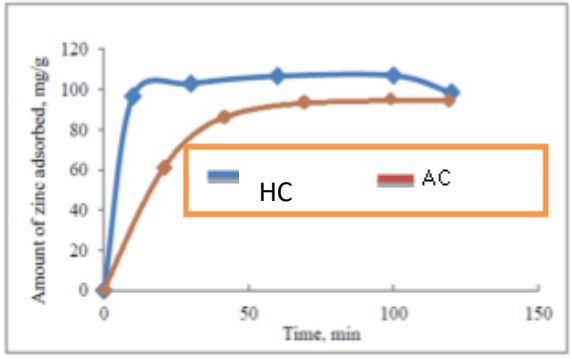
HYDROGEL CHARSH (HC) is a powerful adsorbent to remove unwanted pollutants (gas & liquid forms) and odor. The HC applications are on gas (SO_2, H_2S, and CO2) and water (heavy metals) filter to combat pollutions and also as a pet litter to tackle odor. HC is originated from combination of polymerize biomass with coal fly ash (waste) as a new improved adsorbent. The research focuses on waste to wealth concept, utilizing waste and adding values to the waste for environmental purposes. HC offers several benefits such as economical viable, high sorption capacity, shorter sorption time, longer lifetime usage and versatile adsorbent. The HC benefits exceeded the current activated carbon (AC) used for the same applications. The HC residues also are very stable and addition of these materials to the soil has the potential to improve soil quality.



Water filter

Pet litter

Gas filter



2) Improvement of Palm Oil Extraction Rate (OER) Through Oil Recovery from Wastes Towards Achieving Zero Waste Strategy

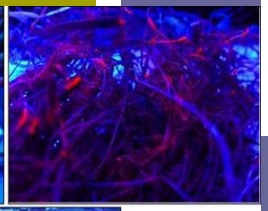
In Malaysia, millions of ton of oil palm biomass are disposed into the environment annually. The oil palm biomass include oil palm empty fruit bunches (OPEFB), palm oil mill effluent (POME) and oil palm decanter cake (OPDC). Improper disposal of these biomass could lead to soil, water and air pollution. Our study showed that these biomass still contain a small amount of residual oil. After careful investigation, the mechanism of residual oil presence in these biomass was identified and thus possible recommendations to separate the oil from the biomass were made. Interestingly once these biomass was freed from the residual oil, their uses could be enhanced through improved biochemical fermentation process such as in biomethanation and biocompositng. The oil free biomass could also be used for the production of biosugars and biocomposite polymer. The residual oil although could not be used as crude palm oil (CPO), it is still can be used to produce other biochemicals such as biodiesel, biogrease and biolubricant.. Towards the end, the final discharge effluent can also be treated and the cleaned water can be used back in the palm oil mill and therefore reducing the environmental impacts of the river water intake and discharge.

(a) Oil Recovery From Palm Oil Empty Fruit Bunches (EFB)

1. Completed Works: Mechanism of oil attachment



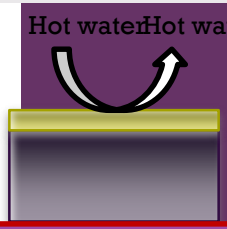


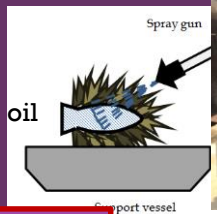


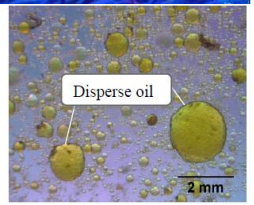

Oil loss- portion of oil impregnated onto the surface of EFB due to mechanical processes. Oil mainly located on the spikelet rather than the stalk

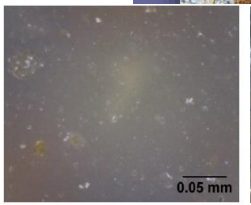
Oil presence confirmed using dye method

Mechanical processes (conveyor, sterilization, thresher equipment etc.) mainly contribute to the oil transfers from fruit to bunches









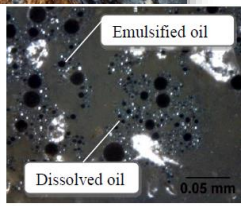
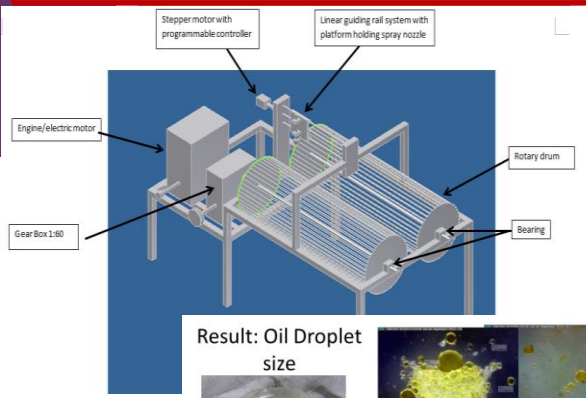
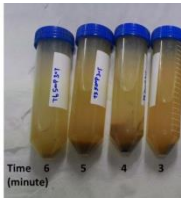


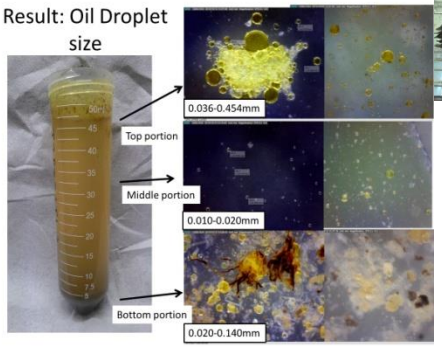
Fig 13. a) Collected product after HYSASE process, b) Oil droplet before gravimetric method (40x magnificent), c) Oil droplet after gravimetric method (470x magnificent), d) Oil droplet after gravimetric method with Black Sudan dye staining (470x magnificent).

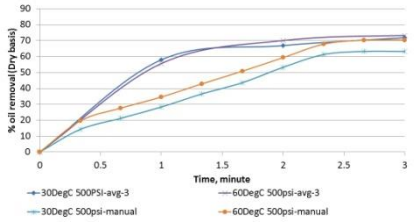
2. Completed Work: EFB oil recovery system (1st Concept)

3. Completed Work: EFB Oil Recovery (2nd Concept)



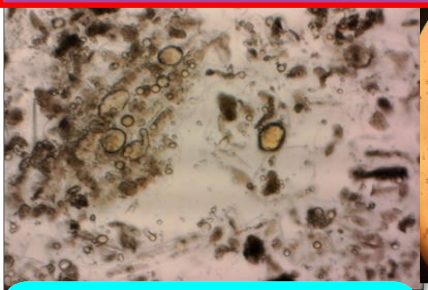




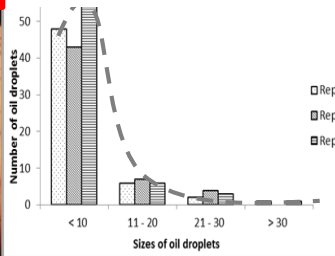


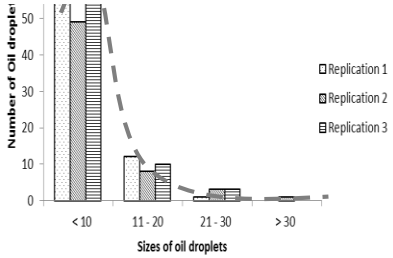
(b) Oil Recovery from Palm Oil Mill Effluent (POME)

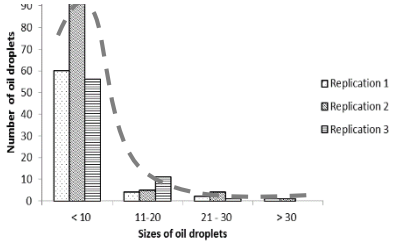
1. Completed Work: Mechanism of oil attachment

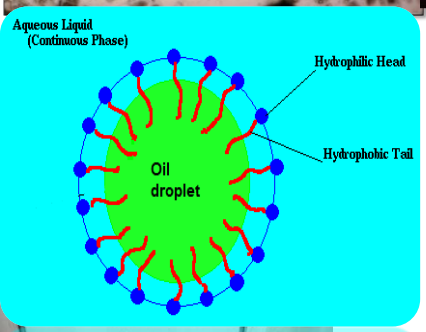


Sufficient evidence that; CPO presence mainly free and small droplet size (< 100 um).









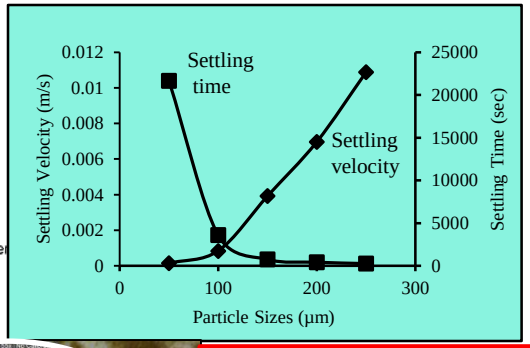
$$v_v = \frac{g}{18}\frac{D_v^2(\rho_l - \rho_v)}{\eta} \qquad (4.8)$$

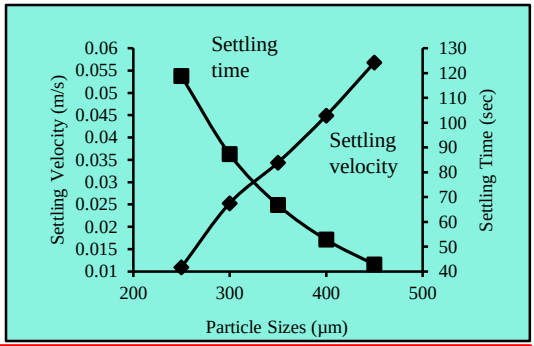
where

V_v	rising velocity of the bubble (m/s)
g	gravitational constant (9.81 m/s^2)
D_v	the bubble diameter (m)
ρ_l	the density of the liquid (kg/m^3)
ρ_v	the density of the vapour (kg/m^3)
η	the dynamic viscosity of the liquid (Pa s)

It is generally assumed that proper liquid degassing is achieved when bubbuls of 200 micron and larger are removed. In this case formula 4.8 can be simplified to:

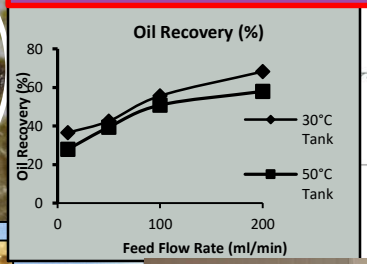
$$v_v = 2.2x10^{-8}\frac{(\rho_l - \rho_v)}{\eta} \qquad (4.9)$$

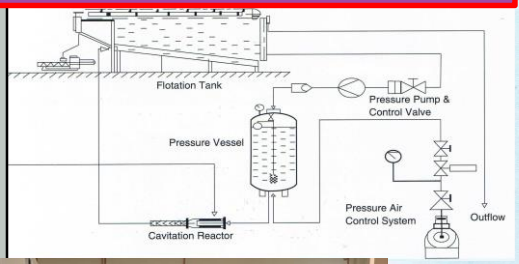




2. Completed Work: Small scale of oil recovery unit

3. Microbubbles Technique Dissolved Air Floatation Technology





(d) Oil Loss and Oil Extraction Rate (OER) Study

Clear indication of sources of oil loss in the mill – evaporation , sterilisation condensate, unstripped fruit bunches, hard bunches, hydrocyclone or claybath effluent, clarification section, empty fruit bunches and decanter cake.

Originality - A new method to representing OER performance which

OER			OIL LOSS	
RATING	RANGE	**INDICATOR**	RANGE	**RATING**
1	18.00 – 19.24	**LOW**	1.10 – 1.31	**4**
2	19.25 – 20.49	**AVERAGE**	1.32 – 1.54	**3**
3	20.50 – 21.74	**HIGH**	1.55 – 1.77	**2**
4	21.75 – 23.00	**VERY HIGH**	1.78 – 2.00	**1**

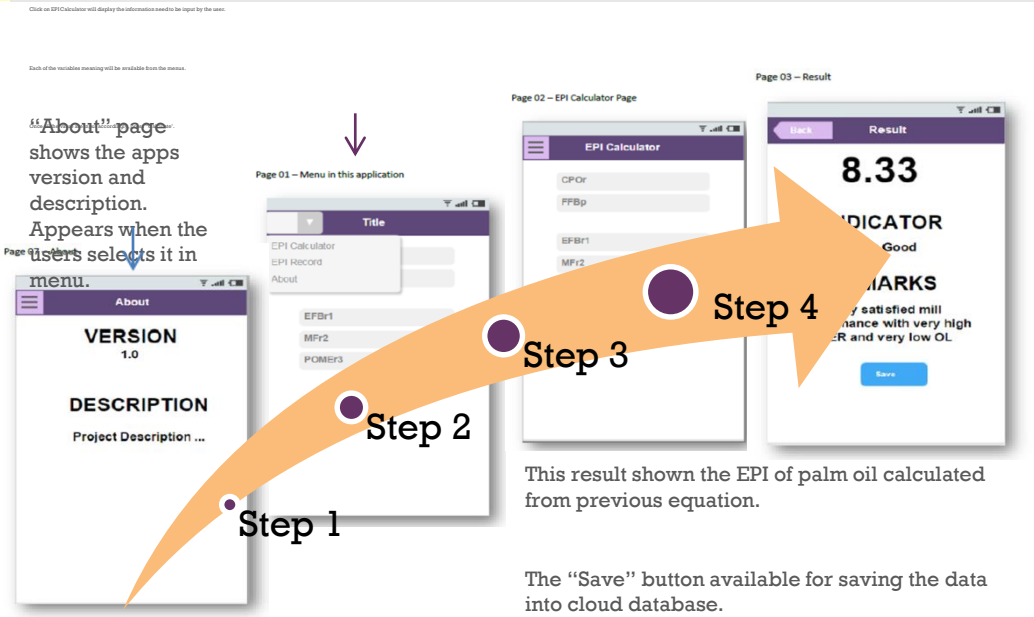
OEROL PI	RANGE	INDICATOR
1	1.00 – 1.72	**POOR**
2	1.73 – 2.26	**AVERAGE**
3	2.27 – 2.99	**GOOD**
4	3.00 – 4.00	**EXCELLENT**

(c) Oil Recovery from Oil Palm Decanter Cake (OPDC)

1. Completed work : Green solvent (d-limonene) used to recover oil in OPDC. The OPDC contained approximately 12.55±3.15% (dry). d-limonene successfully recovered 100% of oil with 90% recycling rate.

RCPO content in OPDC' [% dry basis]	**12.55±3.15**	
	d-limonene	n-hexane
RCPO recovery [%]	**100**	**100**
Solvent recovery [%]	**90**	**70**
Carotene [ppm]	**756.16**	**614.67**
C16:0 Palmitic acid	**39.22**	**47.99**
C18:1n9c Oleic acid	**31.05**	**37.36**

Pilot Scale Ultrasonic Assisted Soxhlet Extraction



This result shown the EPI of palm oil calculated from previous equation.

The "Save" button available for saving the data into cloud database.

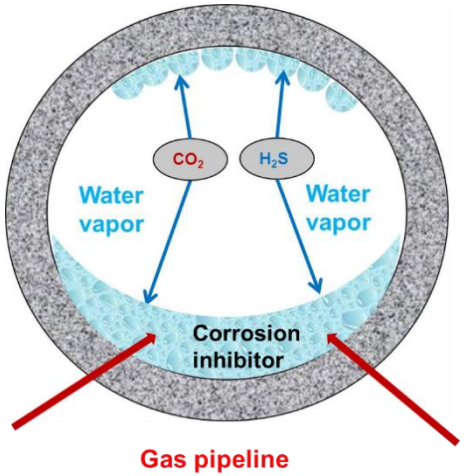
3) Biomass as potential alternative fuels

The IEA's World Energy Outlook reveals that fossil fuels will continue to dominate the energy mix; with 95% of the additional energy demands between 1995 and 2020 will be met by fossil fuels. Therefore, coal will become more important both as an energy source and as the source for organic chemical feedstock in the 21st century. Equally important, biomass is considered to be potential for the renewable energy sources in the future. It already supplies 15% of world's total energy consumption. Biomass is also a source of a large variety of chemicals and materials. Biomass resources that can be used for energy production cover a wide range of materials such as forestry residues, energy crops, organic wastes, agricultural residues, etc. Agricultural waste, readily available biomass, is produced annually worldwide and is vastly under utilized.

4) Oil and Gas Pipeline Corrosion Mechanism and Mitigation

The internal corrosion of pipelines occurs during the transportation of fluids, usually in multiphase form and containing gaseous or liquid hydrocarbons, water or brine, acidic gases such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S), organic acids, bacteria and often entrained solids (sand). The presence of these acidic gases, bacteria and water has the potential to accelerate corrosion in pipelines which are normally made of carbon steel. The mechanism on the corrosion need to be further understood before any mitigation method is proposed. Thus, the researches highlight are:

- **Top of the Line Corrosion in CO_2/H_2S Environments**
- **CO_2/H_2S pipeline corrosion mechanism**
- **Development of volatile and non-volatile corrosion inhibitor**
- **Microbial Induced Corrosion**
- **Development of Biocide in Oil and Gas Application**



Pipeline exploded due to corrosion

5) Accident Modeling and Consequences Analysis

Consequence analysis is an evaluation of the predicted outcome from an incident and how it affects the surrounding equipment and people. It is one of the main components of risk assessment and can be used to optimize plant layout, reduce the risk from an unacceptable level by improving design, develop an emergency preparedness plan, and assess the mitigation system. By using consequence models, consequence analysis includes the prediction of the magnitude of potential jet and pool fire, Boiling Liquid Expanding Vapour Explosion (BLEVE), vapour dispersion, toxic chemical release, and explosion caused by incidental release.

+6) Quantitative Risk Assessment

Transportation Risk Analysis for Hazardous Materials Transportation

A numerical procedure, which allows the coupling of time effectiveness and mathematical accuracy, will be developed for the individual risk evaluation, and therefore provides criteria for the route selection of hazardous materials transportation. User-friendly software on transportation risk analysis and the route selection can be developed based on this research. With sufficient data, the incident frequency of different road could be measured given the data of affecting parameters, and then the general models could be built to assess the incident frequency for any kind of road.

Continuous Operational Risk Assessment for a Chemical Process

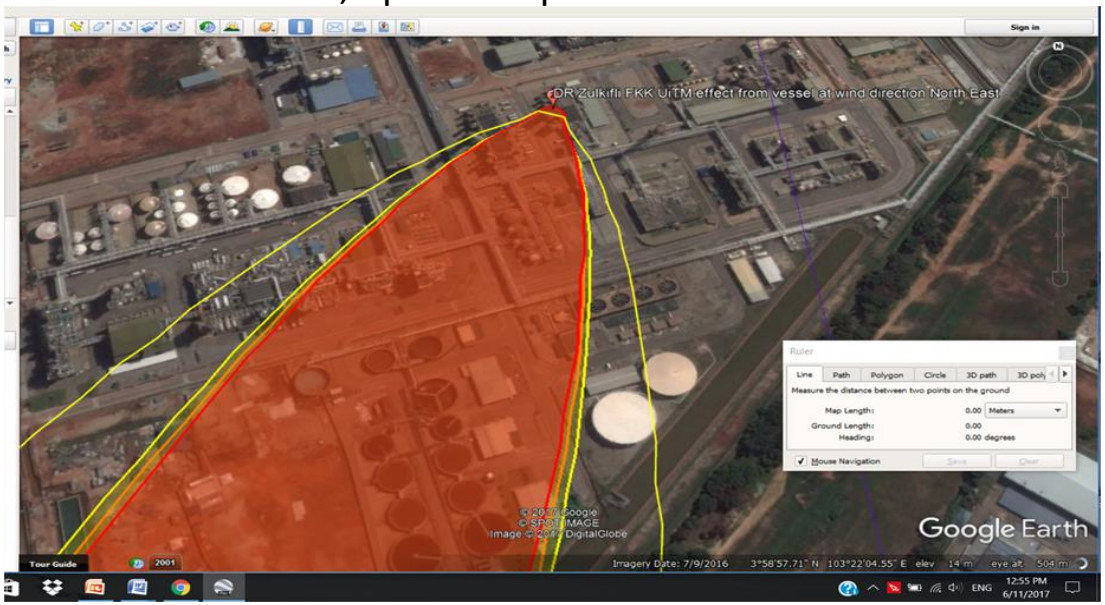
In this study, the methodology is designed for continuous operational risk assessment. Process variable evolution follows physical/engineering laws, and this evolution is also governed by the performance of the components within the system under assessment. Discrete event simulation is applied to study the stochastic process behaviour of a specific component. Then the process variable evolution directed along discrete event paths is simulated to obtain the real time probability of process variable to exceed safety boundaries.

Uncertainty Delimitation and Reduction for Improved Mishap Probability Prediction

It is important to increase accuracy of the results. Therefore, analysis on uncertainties associated with a QRA is crucial to evaluate the QRA, how close the evaluation is from reality, and how the risk is reliably identified to make good decisions that affect chemical process safety design.

7) Facility Siting

Facility siting and layout is a process for finding an optimal location for a chemical or petroleum processing site and then arranging the units and equipment. They are related to how to select a site, how to recognize and assess long-term risks, and how to lay out the facilities and equipment within that site. Appropriate siting and layout establishes a foundation for a safe and secure site. Facility layout optimization based on risk analysis-The purpose of this research is combining optimization concepts and safety concepts in a facility layout. The objective function is the sum of costs for land, piping, managing, protection devices and safety (risk). Based on real meteorological data and various hazardous facilities which have flammable materials, optimal separation distances and directions will be obtained.

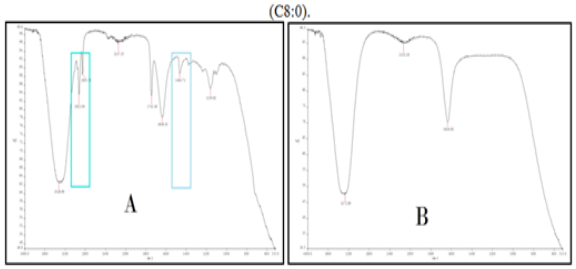


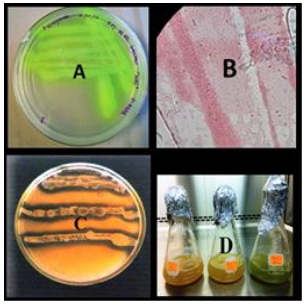
8) Offshore Safety, Refinery Process Safety

Some current and potential process-safety research for offshore applications include facility siting and layout, LOPA/SIS and SIL application in offshore facilities, QRA of offshore facilities (drilling and production), fire protection system (air curtain, water curtain, deluge, expansion foam), fire suppressant agent, and human error assessment.

9) Application of Microbial of Research in Chemical Engineering (Microbial Engineering)

Microbial engineering based technology has been practiced in my research activities along with other fields such as biotechnology, chemical engineering and alternative fuel development to study the role of microbes into a production of useful products and biorefinery based applications. As an Industrial Microbiologist, I have identified the importance of few industrial microbes such as Pseudomonas aeruginosa, Ochrobactrum anthropic, Pseudomonas luteola, Sphingomonas paucimobilis, Burkholderia cepacia, E.coli, Pseudomonas putida and Pseudomonas fluorescens. For example, the Accelerated Low-Water Corrosion (ALWC) has been confirmed to degrade maritime steel structure in Port Klang, Malaysia and was grouped as one of microbial induced corrosion (MIC) type. This study was performed to isolate, identify, and characterized the growth of the microbes that has induced ALWC in order to decide for the best treatment using understanding of its potential EPS through biofilm formation. Another interesting research is treatment of heavily oiled wastewater using Pseudomonas aeruginosa NR.22 producing usable free fatty acids (FFA) that has been used to produce biodiesel. Apart from this, enzymatic deinking of waste newspapers and laser jet waste paper has been research using fruits and microbes and managed to offer potential opportunities for changing the pulp & paper industry towards more environmentally friendly and efficient operations compared to conventional methods.





10) Biodiesel

Trans-esterification is a method to convert vegetable oils or animal fats into fatty acid methyl esters. Base catalyst such as sodium or potassium hydroxide and sodium or potassium methoxide are commonly used for trans-esterification. This process is carried out in batch mode, time consuming and requires several steps of processing units. In fact, such technology needs high investment and no longer competitive especially when the global oil price is low. Thus, new technology is required to overcome the problem and to cater low grade of feed stocks. With the believe that in case of methyl ester production, the role of catalyst can be replaced and enhancement of molecular collision can be done differently, ultrasonic wave and high speed mixing were exploited to transpire the NON CATALYTIC REACTION FOR METHYL ESTER PRODUCTION. Ultrasonic waves are longitudinal mechanical waves which generate cavitation bubbles as they transmit through a liquid medium. In chemical reaction, the progress of the reaction depends heavily on how quickly the reactants are brought together. For the reaction to occur, the pure reactants need to be homogenized at the molecular scale so that molecules can collide. If the mixing is fast enough, the intrinsic chemical kinetics governs the rate of production of new species. Based on this understanding, high speed mixing was introduced to enhance successful molecular collision of methyl ester reactants after gaining energy from ultra-sonic device. We have a very strong believe that most of catalytic chemical reactions nowadays can be replaced by using this technique. Probably, it is a breakthrough in chemical reaction engineering and inspires the green technology.

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