MINISTRY OF EDUCATION, INNOVATION AND TALENT DEVELOPMENT SARAWAK

Synthesis SARAWAK

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T : 082-356 834 . F : 082-356 934
E : meitd@sarawak.gov.my . W : meitd.sarawak.gov.my

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EDITORIAL LINE-UP

FOREWORD

from **MINISTER FOR EDUCATION, INNOVATION AND TALENT DEVELOPMENT SARAWAK**

As the Minister for Education, Innovation, and Talent Development Sarawak, it is an honor to present the foreword for the inaugural edition of Synthesis Sarawak magazine. This publication is brought to you by the Ministry of Education, Innovation, and Talent Development Sarawak (MEITD). We understand the importance of empowering the Sarawak community, particularly the youth, to become the driving force behind scientific and technological advancements. With this magazine, we hope to inspire future generations to pursue careers in Science, Technology, Engineering, and Mathematics (STEM), ensuring a continuous supply of skilled professionals who will contribute significantly to the growth and innovation of Sarawak.

The launch of the **Synthesis Sarawak** magazine signifies the Ministry's unwavering commitment to excellence in the pursuit of its goals and vision. This first edition showcases various achievements from our GLCs and partner universities, including Sarawak Tropical Peat Research Institute (TROPI), CRAUN Research Sdn. Bhd., Sarawak Biodiversity Centre (SBC), Sarawak Research and Development Council (SRDC), Sarawak Skills, Center for Technology Excellence Sarawak (CENTEXS), Curtin University Malaysia, Swinburne University of Technology Sarawak Campus, University of Technology Sarawak (UTS), i-CATS University College, and Institut Pendidikan Guru Tun Abdul Razak (IPGTAR), presented in publication form.

A special thanks to the article contributors and editorial board who have put so much determined effort into making this a success. The scientific achievements displayed in this edition are amazing. From biotechnology to precision engineering, from waste management to clean energy and from environmental protection to state-of-the-art chemical products. It is clear evidence that we have no shortage of expertise to spur the development in our beloved State. We hope that this magazine will continue to be a reflection of our progress and that this progress will never slow down. When it comes to moving forward, we are only limited by our imagination.

Thank you.

Yang Berhormat Dato Sri Roland Sagah Wee Inn
Minister for Education, Innovation and Talent Development Sarawak

Yang Berhormat Datuk Dr.
Haji Annuar bin Rapa'ee
Deputy Minister for Education, Innovation and Talent Development Sarawak I (Higher Education and Innovation)

Yang Berhormat Datuk
Francis Harden Hollis
Deputy Minister for Education, Innovation and Talent Development Sarawak II (Talent Development)

FOREWORD

from **PERMANENT SECRETARY MINISTRY OF EDUCATION, INNOVATION AND TALENT DEVELOPMENT SARAWAK**

In this inaugural issue, various articles are featured highlighting various achievements by universities and Sarawak based research agencies. The issue is a collection of reports and notable achievements in the areas of food technology, biotechnology, Internet of Things (IoT), and digital technology from industry players, academics, and various experts in their respective fields. Contributors for this first issue are from Sarawak Tropical Peat Research Institute (TROPI), CRAUN Research Sdn. Bhd. Sarawak Biodiversity Centre (SBC), Sarawak Research and Development Council (SRDC), Sarawak Skills, Center for Technology Excellence Sarawak (CENTEXS), Curtin University, Swinburne University of Technology Sarawak Campus, University of Technology Sarawak (UTS), i-CATS University College, and Institut Pendidikan Guru Tun Abdul Razak (IPGTAR).

Apart from introducing various products and sources of revenue, our main revenue which comes from palm oil needs to be constantly protected. In **"A Biological Threat to the Palm Oil Industry: *Ganoderma Boninense*"**, by Sarawak Tropical Peat Research Institute (TROPI) highlights how *ganoderma boninense* (basal stem rot fungus) may be a threat to the existing palm oil industry. Readers may take note that TROPI is constantly on the lookout for the well-being of the industry.

In the article, "**Mukah Sago Waste Treatment Pilot Plant: A Sustainable Solution to Sago Wastes**" by Craun Research Sdn. Bhd., the author presents ongoing large-scale efforts in converting processed crop waste (sago residue) into bioenergy. The author also introduces the anaerobic pond, a fascinating facility that transforms sago waste into biogas, serving as a clean energy source for electricity generation. This treatment plant has successfully enhanced the circular economy of the sago industry.

New products based on scientific development have always been the priority of various agencies in Sarawak such as **Sarawak Biodiversity Centre (SBC)**, reporting in the article titled **"The Hidden Treasure of Nature: The Journey of Sarawak's Unique Litsara Essential Oil"** various locally produced products that combines scientific results with the indigenous communities' knowledge were highlighted. With support from SBC, several communities have generated additional income streams, improving their socio-economic well-being. SBC has been at the forefront in the continuous development of local products such as **Litsara Essential Oil**.

Another agency actively engaging in enabling scientific findings into sustainable income is the Sarawak Research and Development Council (SRDC). One (1) SRDC-funded research project with immense potential is also highlighted. The project is highlighted in the article **"Innovations to Enhance Mobility and Aid Home Caregivers."** The project is undertaken by Curtin University Malaysia and Twintech Sdn Bhd respectively. The mobility device in development presents an innovative solution to move and transfer patients without lifting. The workings of the prototype dubbed "wondermock" are presented in the article showing that progress in such biomedical fields can be nurtured locally if the right efforts and motivations are given.

Sarawak has been constantly educating and investing resources in digital education and efforts to boost digital capability in increasing efficiency and economic growth. Among others, the Internet of Things (IoT) has been at the forefront of spearheading the digitalisation agenda, especially in the smart city context. In the article **"Using IoT to Monitor Water Level and Pressure"**, the author from Sarawak Skills presented a monitoring system for sustainable water flow developed utilizing water pressure sensors. These sensors produce signals to gauge the pressure within the pipe system. An innovative method has been devised to automatically transmit water pressure readings, indicating these values to users via smartphones and computers. This approach facilitates the swift identification of any issues within the water line.

Among the various Sarawak state agencies, CENTEXS (Center for Technology Excellence Sarawak) was established with the intention to train and upskill the young generation to meet the technical needs and requirements of the State industries focused on the trade of oil and gas, construction, manufacturing, and mechatronics, and guarantee a career upon completion of their training. In the article **"A Pathway to a Sustainable Future: CENTEXS towards Human Capital Development for Green Energy Transition"**, these efforts and facilities are highlighted. The state-of-the-art facilities in training include solar, wind, and hydrogen testbeds. These facilities are crucial in upskilling and reskilling the Sarawak youth in preparation for the State's vision to be a sustainable energy powerhouse in the region.

From the context of sustainability, waste to product has always been the epitome of sustainability ideals. From waste to chemical products, the article **"From Food Scraps to Eco-Enzyme Marvels: A Sustainable Multipurpose Organic Liquid"** by Curtin University Malaysia reports on ways to reduce waste by transforming it into useful

eco-enzymes. They also detailed the steps to produce eco-enzymes and explore their potential applications.

With new growth comes new challenges. With the increasing social media consumption, the problem of cyberbullying has now become a major issue on all fronts. Cyberbullying has been regarded as a long-standing problem among netizens and many have attempted to propose remedies for this problem. In the article entitled **"Cultivating Awareness of Cyberbullying Through Digital Intervention"**, by Swinburne University of Technology, the author investigated the factors associated with cyberbullying, encompassing elements like family interactions, psychological aspects, and factors related to awareness and personal encounters. Initial efforts to develop a game-based solution to curb the cyberbullying problem were also presented.

Sustainability has been a major theme in Sarawak's economic development. The featured article titled **"Sarawak Sustainability Resources for Engineered Timber Products"**, by the University of Technology Sarawak (UTS) introduces the Center of Excellence in Wood Engineered Products (CeWEP), aiming to enhance the involvement of the local Sarawak timber industry. Various initiatives have been implemented to diversify engineered wood products like plywood and particle board, ensuring their sustainability, durability, and versatility. Innovative Product such as cross-laminated parquet (Eco-CLP) was highlighted and proving Malaysia's potential as an innovative hub for wood products.

Sago has been a staple among indigenous groups in Sarawak and still holds much potential for product development. In the article **"Retrospective on Sago Palm Misimpression with Advanced Biotechnological Approach"**, by i-CATS University College, the author presented various applications of industrial biotechnology in developing novel sago-based products. These include bioethanol organic fertilizers, prebiotics, hand sanitizers, and animal feed.

Last but not least, an article on the empowerment of students in English proficiency was also featured. There is no shortage of concerns about the declining English proficiency among students. With awareness, there is no shortage of innovations in delivering and increasing efficiency in improving English proficiency in the State. It is wonderful to be able to capture some of these efforts in the article **"Act-Sing-Blend: Elevating Reading Proficiency Among Malaysian Young ESL Learners"** from the group of innovative educators from Institut Pendidikan Guru Kampus Tun Abdul Razak (IPGTAR). Positive improvements were recorded. This is indeed a long marathon race to continue to lift English proficiency while science and digital development continue to spur economic development.

A Latin phrase summarises our efforts, *carpe diem*. We should seize the day. Strive for progress in 2024. I want to congratulate the editorial team for their diligence, hard work, and commitment to the publication of Synthesis Sarawak

Datu Haji Azmi bin Haji Bujang
Permanent Secretary
Ministry of Education, Innovation and Talent Development Sarawak

A BIOLOGICAL THREAT TO THE OIL PALM INDUSTRY: *GANODERMA BONINENSE*

Herman Umbau Lindang, Lo Mei Lieng, Frazer Midot, Jee Mui Sie, Chin Mei-Yee, Saron Lau Yu Ling and Lulie Melling
Sarawak Tropical Peat Research Institute

Oil palm is renowned as the "golden crop of Malaysia" due to its highly profitable export earnings. Oil palm trees, (scientifically called *Elaeis guineensis*), the world's leading source of vegetable oil and fat due to its exceptional yield is the predominant species cultivated. Oil palm is widely grown in Asia, Africa, and Latin America, with Malaysia and Indonesia among the top producers and exporters, followed by Thailand, Colombia, and Nigeria. The high demand for palm oil is due to its availability and productivity advantage over other oil-producing crops such as soybean, sunflower, and rapeseed.

Malaysia, the second-largest palm oil producer in the world, contributed to 23.3% of global palm oil output and 31.1% of global palm oil exports in 2022. The total oil palm planted area in the country as of June 2023 was 5.65 million hectares. Of which Sarawak constitutes 28.7% of the oil palm planted area. Oil palm accounted for 37.1% of Malaysia agricultural gross domestic production in 2021. Hence, the sustainability of the oil palm industry is crucial for the country's future economic growth, social development, and environmental conservation.

However, the oil palm industry faces a significant threat from basal stem rot (BSR) caused by *Ganoderma boninense*. This disease is responsible for nearly one-third of global production losses and annual yield losses of up to USD 500 million (Zakaria, 2023). Consequently, Sarawak with 1.62 million hectares or 28.7% of the total oil palm planted area is the largest in Malaysia (MPOB, 2023), has also been severely impacted by BSR. This BSR disease also has been recorded in Africa, Cameroon, Colombia, Ghana, Papua New Guinea, Southern Thailand, and Tanzania.

Based on the climate projections, growing oil palms in Malaysia will become more challenging until 2100 due to an unsuitable climate. Rising temperatures, water stress, increased susceptibility to pests and diseases, yield reduction, and revenue losses drive this challenge. The productivity of oil palms may decline by 10 to 41%

with temperature increases of 1 to 4 °C (Sarkar et al., 2020). Furthermore, rising temperatures alter the ecology of various pests and diseases, affecting factors such as their reproductive ability. Consequently, these pests and diseases gain greater resilience to environmental changes and experience population surges, raising the risk of an epidemic or pandemic outbreak within the plantations. Malaysia's BSR incidence will increase significantly after 2050, along with an increase in oil palm death (Paterson, 2020). The adaptation of more virulent *Ganoderma boninense* strains to climate change could result in heightened disease risk for oil palm plantations. Besides, the oil palm trees are expected to be less resistant to *Ganoderma boninense* infections caused by the changing climate and the increasingly aggressive fungal strains.

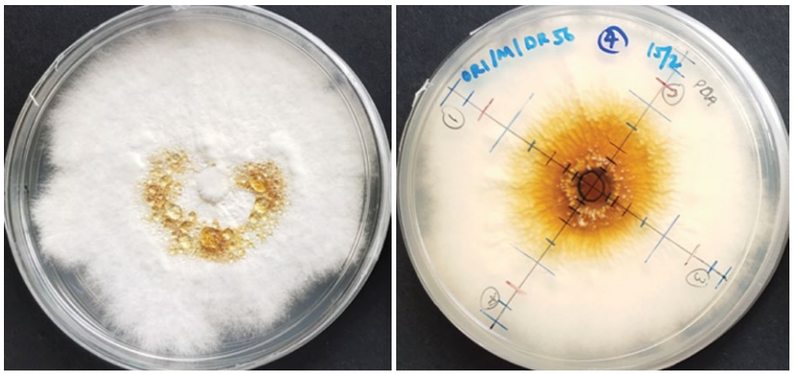
Picture 1: (A) The oil palm affected with basal stem rot disease, (B) *Ganoderma* fruiting bodies on the basal stem, and (C) decayed basal stem.

The BSR infection can be symptomless for a long period of time. Once the infection has reached 60 to 70 %, the symptoms begin to emerge. These symptoms, which resemble symptoms caused by drought and nutrient deficiency, are due to the basal decay restricting water and nutrient uptake by the oil palm tree (Picture 1A). BSR infection initially occurs through root contact with *Ganoderma inoculum* (e.g. infected roots or debris) in the soil and spreads to the basal stem area. The most obvious features of BSR are the emergence of fruiting bodies and the decay of the basal stem (Picture 1B & 1C). In severe cases, affected palm trees will die and topple. Numerous interventions, including mechanical (cultural), chemical, and biological approaches, have been developed to combat this disease. Nevertheless, these control

measures have only served as temporary solutions to extend the lifespan of the infected oil palm trees, hindering the long-term sustainability of the oil palm industry. Moreover, symptomless initial stages of infections make early detection challenging, further hampering disease management. Therefore, educating the community on how to recognise and manage BSR is vital for promoting early detection and reducing losses, contributing to a more sustainable oil palm industry.

In Sarawak, *Ganoderma boninense* has been identified as the main pathogen responsible for BSR in oil palm plantations (Midot et al., 2019). *Ganoderma boninense* is a white-rot fungi with a wide, fan-like structure with double-walled, truncate spores with inner layers ranging in colour from yellow to brown that grow on tree trunks. Pure cultures of *Ganoderma boninense* grown on malt extract agar are white on the surface, with a darkened (pigmented) undulating reverse surface that buckled the agar (Picture 2). *Ganoderma boninense* can switch behaviour as a hemibiotroph, switching from biotrophic to necrotrophic phase during infection (Bharudin et al., 2022). In the early infection, G. boninense acts as a biotrophic, absorbing nutrients from the host by colonising the root cortex and stem base while keeping the host cells intact (Rees et al., 2009; Chong et al., 2017). This phase is followed by the necrotrophic phase, where the *G. boninense secretes* cell wall-degrading enzymes (CWDEs) that eventually kill the host cells.

In Peninsular Malaysia, the aggressiveness of *G. boninense* isolates varied across the regions (Goh et al., 2014). Similarly, *Ganoderma spp.* in Betong, Balingian, and Miri, Sarawak also exhibits different levels of aggressiveness (Rakib et al., 2015; Lo et al., 2023). This variation in the aggressiveness of *Ganoderma* isolates is not unique to Malaysia. Similar observation has been reported in Indonesia (Breton et al., 2006) and Columbia (Castillo et al., 2022). It is important to study *G. boninense* aggressiveness because aggressiveness is one of the factors that determine the fitness of the pathogen.



Picture 2: Back and front view of *Ganoderma boninense* morphology on malt extract agar.

In conclusion, the Malaysian oil palm industry generates substantial revenue for the country, contributing to a range of Sustainable Development Goals (SDGs) outlined by the United Nations. Oil palm supports economic growth (SDG9, 12), poverty alleviation (SDG 1, 8, 10), and enhanced food security (SDG2), while also creating long-term employment opportunities (SDG1). Despite the environmental impacts arising through the large-scale expansion of monoculture plantations associated with greenhouse gas emissions (SDG13), sustainable agriculture practices such as using natural pesticides, implementing circular waste management, and adhering to Malaysian Sustainable Palm Oil (MSPO) certification, can effectively mitigate these negative environmental impacts.

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Sarawak Tropical Peat Research Institute (TROPI)

MUKAH SAGO WASTE TREATMENT PILOT PLANT: A SUSTAINABLE SOLUTION TO SAGO WASTES

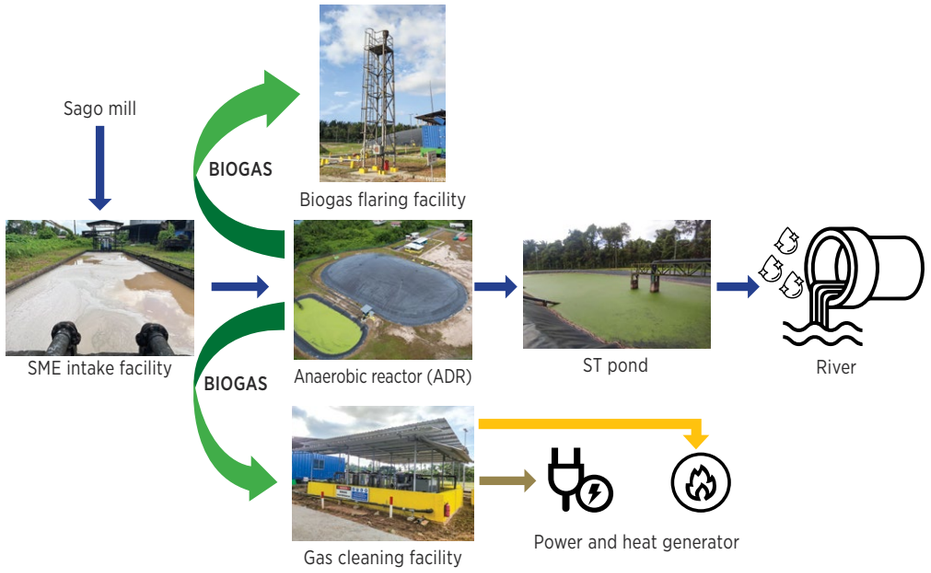
Daniel Chua Chun Haw and Sal Hazreen Bugam
CRAUN Research

Picture 1: Mukah Sago waste treatment pilot plant - the winner of ASEAN Renewable Energy Projects Award 2022 - Off-Grid power category.

The Mukah Sago Waste Treatment Pilot Plant (Picture 1), nestled in Mukah, Sarawak, Malaysia, is a groundbreaking project leading the way in the nation and the world by transforming sago waste into biogas. Developed by CRAUN Research Sdn Bhd in collaboration with Nitsei Sago Mill Sdn. Bhd., this plant kickstarted its operations in May 2019. The realization of this endeavour was made possible through the generous financial support extended by both the Federal and Sarawak state government.

Started as a research project aimed at solving the environmental problems plaguing the local sago industry in Sarawak, which over time, the research has steadfastly progressed and gradually translates itself into practical implementation at a larger scale. This proof-of-concept pilot plant was established with the objectives to recover, treat, utilize and value-add sago processing wastes. It stands proudly at Kampung Tabo Mukah, setting a precedent as the first of its kind not only in Malaysia, but also worldwide, capable of both treating sago waste, as well as producing bio-energy.

From the context of waste generation, the heart of the issue for the Sago industry lies in the process of starch processing itself. Sago starch processing is a water-intensive process, which leads to generation of a large volume of sago mill effluent (SME) daily. With an average of 78 tons discharged for every ton of dry starch produced, SME is considered as the primary pollutant from this processing. To make matters worse, the average Chemical Oxygen Demand (COD) in the SME stands at 8kg for every ton of effluent generated. High COD levels signifies a substantial presence of organic matter in the untreated SME. In the case of SME, the COD is primarily contributed by the presence of soluble sugars in the spent process water, fine fibres, and fine starch granules - making SME a carbohydrate-based wastewater.

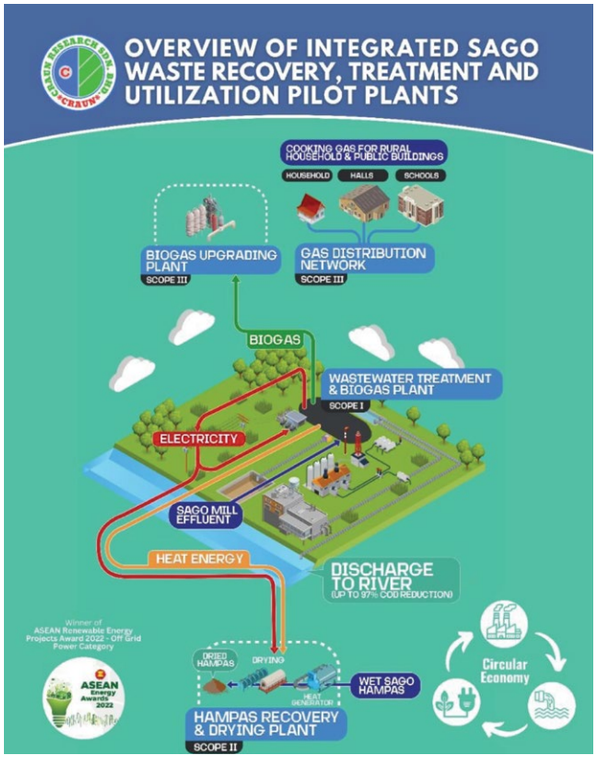


Picture 2: Simplified process flow diagram for Mukah Sago waste treatment pilot plant.

In the event that untreated SME are released into the river, the repercussions are intricately tied to the existing aquatic ecosystem. The influx of carbohydrate-rich SME prompts resident river microorganisms to naturally degrade the organic substances in the effluent. This underwater microbial community initiates a vibrant feast, consuming nutrients in the SME - much like individuals diving into a buffet. While breaking down organic matter, this microbial activity also avidly depletes oxygen from the water, leading to a decrease in dissolved oxygen levels. Insufficient dissolved oxygen poses a threat to aquatic life, as various species of fish and other aquatic organisms heavily depend on oxygen for survival. Over time, the continuous discharge of untreated SME into the river can result in oxygen deprivation for aquatic organisms and adversely impacting the

ecosystem. Therefore, it is imperative to treat SME before its discharge into the river or any natural water bodies to safeguard the delicate balance of aquatic environments and alleviate the environmental ramifications as a result of sago starch processing.

Thus, at the Mukah Sago Waste Treatment plant, a proactive approach is taken to address the environmental concerns associated with SME. Instead of allowing direct discharge of untreated SME into the river after starch processing, an intervention strategy is implemented. The SME generated from nearby sago mill is recovered and channeled to a covered anaerobic pond located within the waste treatment plant facility. As the name implies, it is in this pond the anaerobic digestion process to treat SME takes place. This process is rooted in the principle of fermentation, wherein microorganisms like yeast or bacteria break down organic substances such as starch and sugar in the absence of oxygen—akin to the way a cup of kombucha undergoes its transformative process. Much like kombucha ferments to produce a delightful beverage, the anaerobic pond functions as a giant fermenter, adept at transforming SME into treated water with reduced organic pollutants to be safely discharged to the river. Remarkably this pilot plant has the capability to reduce the COD content in the SME by more than 90%.



Picture 3: Overview of scope 1,2 and 3 of Sago Waste Recovery, Treatment and Utilization Pilot Plant.

However, the wonder does not end there. This anaerobic process presents a two-fold benefit by not only producing treated effluent but also generating valuable biogas (Picture 2, 3). The cover of the anaerobic pond traps gases, including methane - a byproduct that opens avenues for product innovation and value creation. For instance, the recovered biogas circles back to the plant itself, where it is stored and utilized as a clean energy source for electricity generation, as well as fuel for burners. Hot air generated from the burner will then be further utilized for drying of sago *hampas* (fibres). *Hampas* is the fibrous remnant from starch processing, and this goes without saying that it typically contains high moisture. Interestingly, dried *hampas* can be valorised as nutritious animal feed - another sustainable twist in this tale. In addition, following a series of carefully orchestrated processes, some of the raw biogas produced can also be further upgraded to have a higher energy content. This upgraded biogas becomes suitable for cooking or heating purposes in households, positively impacting the lives of local residents in the most heartwarming way.

In a nutshell, the Mukah Sago Waste Treatment Pilot Plant provides a model to other sago mills that are struggling with sago waste management. At the foremost, the plant also exemplified how sustainable development can be embodied within the Sarawak sago industry through technology and innovative ideas to recover, treat, utilize and value-add sago wastes. Apart from the obvious environmental benefit, the establishment of this pilot plant also reinforced the socioeconomic lifeline of the local community through job creation and clean energy generation. This project is expected to lead the sago industry towards the aspiration to fulfill the Sustainable Development Goals 7 for affordable and clean energy, set by the United Nations General Assembly in 2015.

THE HIDDEN TREASURE OF NATURE: THE JOURNEY OF SARAWAK'S UNIQUE LITSARA® ESSENTIAL OIL

Edited by
Melissa Chang May Fung
Sarawak Biodiversity Centre

In the heart of Sarawak's rainforest, a captivating scent drifts through the air, bringing out the fragrances of citronella or lemongrass. The source of this invigorating fragrance is from a tree, known locally as *Tenem* by the Lun Bawang or *Pahkak* by the Bidayuh. This aromatic journey in 2005 began with the late Mr Taie Puret, a forest guide and local medicinal plant expert from the Lun Bawang community. Mr Taie introduced the tiny berry-like fruits of the *Litsea cubeba* tree, which had been a fundamental part of the traditions of several ethnic groups in Sarawak for generations.

These vibrant berries, with lemony scent and minty taste, were more than just a spicy condiment to accompany rice; they were also cherished as a natural remedy, believed to ease stomach and backaches. The aroma they released was nothing short of enchanting. Belonging to the Lauraceae family, the *Litsea cubeba* flourishes in its natural habitat, emitting a strong and intense fragrance characterised by citrusy and lemony scent, attributed to compounds like D-limonene and citronellal.

Picture 1: Litsea cubeba fruits.

Picture 2: Litsea cubeba leaves.

The Sarawak Biodiversity Centre's (SBC) team, driven by a sense of curiosity and appreciation for the local cultures, documented the usage of this plant, scientifically known as *Litsea cubeba*, and preserved this precious Traditional Knowledge. SBC took several cuttings of the Litsea cubeba tree back to the Centre with a goal to study the secrets of this remarkable tree.

The SBC Traditional Knowledge (TK) documentation programme aims to safeguard indigenous communities' ancient wisdom, which has been handed down through the ages. This is achieved by recording and documenting their traditional knowledge digitally. This way, their valuable heritage is preserved, ensuring it will not be lost to the future generations.

Back at SBC, scientists analysed the chemistry of the *Litsea cubeba* plant meticulously. What they discovered left them exhilarated – the essential oil composition of Sarawak's *Litsea cubeba* was distinctively different from closely related Litsea plants found in the highlands of China and Taiwan, which were also used for medicinal purposes. This uniqueness prompted the SBC to register the local tree as "Sarawak Litsea," securing Intellectual Property protection for this botanical treasure.

But the discovery did not stop there. The research team also uncovered that Sarawak's *Litsea* oil possessed both antimicrobial and repellent properties. Additionally, its scent was described as invigorating and crisp. These revelations marked the inception of a remarkable journey that spanned over a decade, culminating in the creation of a range of delightfully-scented personal care products.

Picture 3: Lun Bawang community member, Mina Sudai, from Long Telingan, Lawas, with LitSara® products.

These exceptional products were introduced to the world under the brand name "LitSara®", a fusion of Litsea and Sarawak. The LitSara® product line included soaps, body wash, shampoo, conditioner, hand sanitiser, body oil and air fresheners. The journey of LitSara® essential oil from the heart of the jungle to the consumer market was nothing short of extraordinary. What set this endeavour apart was the commitment of SBC to ensure that all the benefits were equitably shared with the local communities. Combining science with the indigenous communities' knowledge, we create innovative products for everyday use. The products can be purchased from LitSara® website at www.litsara.com or at Shopee store via www.shopee.com.my/litsara.

This commitment aligned with global standards set by the 1992 Rio de Janeiro Convention on Biological Diversity (CBD) and the 2010 Nagoya Protocol. The Nagoya Protocol recognises rights of indigenous communities to manage and reap the benefits of the commercialisation of the biological resources in their area. Any new findings derived from their Traditional Knowledge are shared with the community, nurturing a sense of empowerment and pride.

Figure 4: Benefit Sharing Agreement Signing Ceremony for LitSara® Project conducted on 21st May 2022, signed between Sarawak Biodiversity Council Chairman, Datuk Amar Jaul Samion, with 6 communities, witnessed by Minister for Education, Innovation and Talent Development Sarawak Dato Sri Roland Sagah Wee Inn.

Access and Benefit Sharing (ABS) is a crucial aspect in CBD. It aligns with one of the three primary objectives of the Convention, which is consistent with the preservation and sustainable utilisation of biodiversity. SBC has formalised Benefit Sharing Agreements (BSA) with (6) six villages, including Kampung Kiding, Pa' Ukat, Pa' Lungan, Long Kerebangan, Long Telingan, and Long Rusu to harvest *Litsea cubeba* essential oil. Since its inception in 2017, LitSara® has significantly contributed to these communities by creating employment opportunities and additional income streams, ultimately enhancing their socio-economic well-being.

In addition to harvesting the Litsea essential oil, SBC also conducts regular workshops aimed at sharing new information on growing *Litsea* trees. They also conduct classes on essential oil extraction via distillation method, as well as soap-making to enable the locals to craft their own products from these precious oils.

Monetary gains materialise upon the commercialisation of products. In the case of LitSara® products, the SBC purchases the essential oils produced by the locals at a reasonable price, ensuring that the economic prosperity resulting from these products directly contributes to the welfare of the community. This fair-trade approach fosters economic stability and incentivises sustainable practices.

Today, six villages in Sarawak are involved in the sustainable production of LitSara® essential oil, with an annual production target of 100 litres. This endeavour has extended beyond the Lun Bawang villages, as the SBC expanded its reach to collaborate with the Kelabit and Iban communities once it became apparent that they also utilised the Litsea plant.

In summary, the journey of Sarawak *Litsea* essential oil is a testament to the harmonious relationship between nature, traditional knowledge, and modern science. It highlights the importance of preserving indigenous wisdom and sharing the benefits of biodiversity with local communities. This humble *Litsea cubeba* tree, with its scented tiny fruits, has indeed earned a well-deserved place among the premium ranks of essential oils. Its journey serves as a powerful example of how nature's treasures can be harnessed sustainably and ethically, leaving a positive impact on both the environment and the lives of those who have guarded its secrets for generations.

SUPPLEMENTARY EDUCATIONAL SECTION

Distillation Technology for Essential Oil Extraction

Distillation is a method used for essential oil extraction from plant sources. This process involves the use of steam or water to separate the volatile aromatic compounds from the plant material. The set up consists of a distillation vessel, a condenser, a collection flask, and a separatory funnel. The essential oil is separated from the water and collected in the separatory funnel. The plant material containing the aromatic compounds, such as flowers or leaves, is placed in the distillation vessel. The process begins by heating water in the distillation vessel. The heat generated from the boiling water causes plant's cell walls to break, releasing the essential oils carries the aromatic compounds from the plant material. In the condenser, the steam and vaporised compounds are cooled and condensed back into liquid form. This forms a mixture of water and essential oil. The essential oil floats on top of the water because it is less dense than water. Finally, the essential oil layer is then drained from the collection flask into a separatory funnel, where it is separated from any remaining water.

Picture 5: Lun Bawang community member, Asun @ Agong Bin Lawat, from Long Kerebangan, Lawas placing leaves of Litsea cubeba into the distillation vessel.

Picture 6: Asun @ Agong Bin Lawat draining water from the separatory funnel to separate the water and collect the essential oil that floats on the water.

Picture 7: Lun Bawang community member, Joe Padan, from Long Kerebangan, Lawas, observing the quality and amount of pure essential oil collected from *Litsea cubeba* leaves.

Trivia for children/students

D	G	A	R	A	O	U	R	I	O	K	S	L
I	L	C	F	R	U	I	T	A	X	M	I	A
S	H	A	I	W	N	N	A	E	I	T	N	Y
T	A	C	W	A	Y	A	R	N	S	L	V	A
I	R	B	H	A	O	M	G	E	I	A	I	S
L	O	S	U	N	S	I	A	N	K	H	G	A
L	M	I	A	I	A	C	T	O	O	A	O	S
A	A	U	O	T	U	O	O	M	T	L	R	E
T	T	S	S	B	P	A	C	I	A	I	A	A
I	I	A	E	R	A	N	L	L	N	T	T	L
O	C	B	I	A	G	V	O	D	A	N	I	G
N	A	A	S	A	R	A	W	A	K	H	N	H
O	F	D	E	N	S	I	T	Y	O	T	G	I

1. Scientific name of the plant used in LitSara® products.
2. A compound found in LitSara® essential oil which is similar to a major component in the oil of citrus fruit peels.
3. "LitSara®" is a fusion of the word *Litsea* and _____.
4. LitSara® scent was described as _____ and crisp.
5. A technology used for essential oil extraction.
6. SBC has formalised Benefit Sharing Agreements (BSA) with _____ villages.
7. Long Kerebangan is located in _____, Sarawak.
8. LitSara® oil can be extracted from the leaves and _____.
9. _____ compounds are usually found in flowers or leaves.
10. Oil floats on water because of _____.

Please refer to page 77 for solutions.

BRIGHTSPARX: FOSTERING INNOVATION AND EMPOWERING VISIONARIES

WHERE FUN MEETS LEARNING, AND IDEAS IGNITE

Felicia Chin, Eve Sanedi and Kelly Yeo
Sarawak Research and Development Council

In the world of STEM (Science, Technology, Engineering, and Mathematics), innovation is the driving force that propels us forward. It is the spark that ignites creativity and fuels progress. The BrightSparx program, initiated by the Sarawak Research and Development Council (SRDC), aims to introduce young students to the world of research. This program stands at the intersection of STEM principles, offering a dynamic platform for budding visionaries to transform their ideas into tangible reality.

BrightSparx Achievements: From Vision to Impact

The SRDC's BrightSparx fund allocates RM5,000 to each project. This program has sparked a range of trailblazing innovations, and SRDC has recently celebrated a series of outstanding projects that demonstrate inventive solutions in various fields. Here are some noteworthy examples:

Waste takes on a new life as a valuable resource. The SMK Batu Lintang School team has introduced an innovative approach to waste management, resulting in the creation of a bio dressing sourced from biomass. This not only elevates the quality of healthcare but also contributes to a sustainable future.

Meanwhile, SMK Sungai Tapang School has delved into the realm of health supplements, creating a plant-based brain health capsule using natural products. This effort reflects the school's dedication to stay in line with the increasing global preference for natural and sustainable approaches.

On the engineering front, St Joseph Private School introduced Oil Palm Shells (OPS) as a green alternative for concrete aggregates, a stride towards eco-conscious construction materials.

Lastly, SMK Semerah Padi school's project has gained recognition for their natural-based insect repellent product, "Citrus Medicass Repellent", employing natural ingredients like lime, 'selukai bark', and lemon grass to ward off household pests. The project demonstrates creativity and point towards a future that is both sustainable and innovative.

The BrightSparx Program: Unleashing the Potential

BrightSparx is more than just a program; it's a launchpad for imagination. It provides a platform for students with exceptional STEM-related ideas and proposals to receive the support, resources, and mentorship needed to bring their vision to life. Whether you are a primary or secondary school student, BrightSparx believes that every great idea deserves a chance to shine.

BrightSparx projects are driven by the students themselves, focusing on important matters within their local communities, ranging from environmental issues to the responsible use of resources. Engaging in BrightSparx projects not only fosters leadership and teamwork skills but also raises awareness, deepens understanding, and seeks solutions for pressing local problems.

A Fun Memory: The Science Carnival Experience with BrightSparx

Have you ever observed the process of microbes thriving on a slice of bread? Isn't it miraculous to experience the thrill of observing a sterling engine turning solely through the combustion of fire, witnessing the conversion of energy? These are the moments that leave us a lasting impression, sparking an enduring interest in exploration.

Incorporating the BrightSparx program, we had the pleasure of creating a lasting memory during the science carnival, STEM Trailblazer 2023. Envision the event as a lively carnival of scientific exploration, where sights and sounds come alive. Hands-on experiments, interactive displays, and engaging demonstrations captivate the imagination of both kids and adults.

The STEM Trailblazer events held at Curtin University, Miri and Swinburne University, Kuching was truly enlightening. These events, a collaborative effort between universities and with the invaluable support of the Sarawak government, strive to commemorate the impact of STEM on revolutionizing innovation, education, and industry.

Encouraging Future Innovators

The journey is far from over. BrightSparx is extending an open invitation to all those with a spark of creativity and a love for STEM. Share this article, ignite conversations, and encourage anyone with a brilliant STEM-related idea to take that bold step forward. Together, we can shape a future where innovation is not just a possibility, but a promise. The BrightSparx programme contributes to the 4th Sustainable Development Goal which is SDG 4 : Quality Education.

Picture 1: (above) Sarawak Research and Development Council team participating in the STEM Trailblazer event as an exhibitor at Curtin University, Miri and Swinburne University, Kuching.

INNOVATIONS TO ENHANCE MOBILITY AND AID HOME CAREGIVERS

Dr. John Tang and Louis Tang
Twin Catalyst Sdn. Bhd.

About 35–80% of nurses sustain back injuries from lifting patients. For caregivers with inadequate formal training, the percentage could increase. This typically leads to burnout and stress. Conversely, at any given point in time, there could be anywhere between 10 and 50 million bedridden people around the world.

In light of this, Twin Catalyst Sdn. Bhd., a Malaysian company based in Sibu, has received funding from the Sarawak Research & Development Council (SRDC) to develop and commercialize a new lifter wheelchair that promises to disrupt caring for people with disabilities. The innovative lifter wheelchair, called the Wondaleaf Hammock Wheelchair, is designed to help caregivers move bedridden patients without manually carrying them.

By combining the features of a wheelchair, forklift, and hammock, caregivers can move and transfer patients without having to manually lift them. A cloth will act as a pallet, while the wheelchair with two prongs acts like a forklift.

The patent-pending and award-winning Wondaleaf Hammock Wheelchair (Lexus Design Award Finalist 2022 and iAge Innovation Competition Gold Medalist) was entirely designed and made in Sibu, Sarawak. The staff at Twin Catalyst Sdn. Bhd. worked with local universities (University Technology Sarawak) and other local vendors to complete the design.

It is designed to:

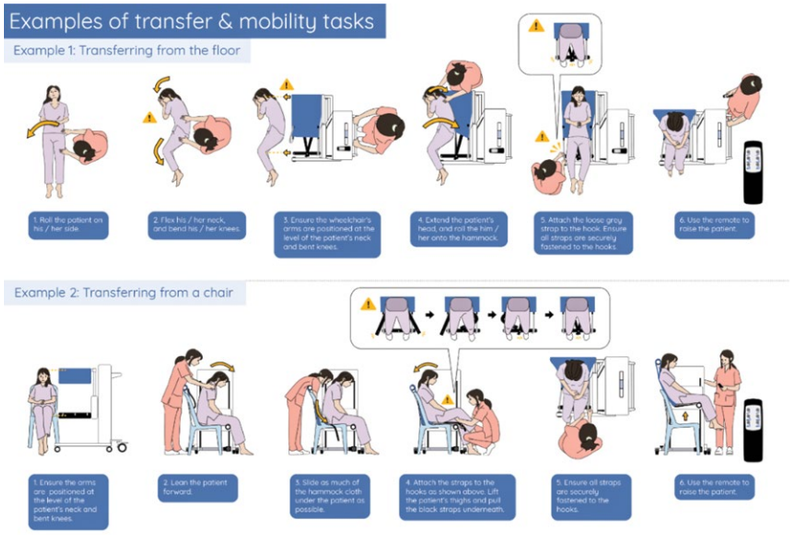
i. eliminate lifting;
ii. be battery-powered;
iii. enable single-person caregiving;
iv. transfer patients to and from any platform; and
v. reduce the stress of caregiving.

Despite receiving interest from buyers in the UAE, Singapore, Hong Kong, and Italy, the Wondaleaf Hammock Wheelchair is required to undergo clinical and bench testing to ensure it conforms to internationally recognized standards prior to sale. To that end, the SRDC, as part of its mission to enhance research standards and capabilities, funded the project to conduct clinical trials, perform testing per ISO and IEC standards, and commence sales.

According to the CEO of Twin Catalyst Sdn Bhd, Dr. John Tang Ing Ching, the funding provided by SRDC has been instrumental not just in helping the company develop the Wondaleaf Hammock Wheelchair but also in kickstarting the medical device manufacturing industry in Sarawak. “The wheelchair requires a lot of testing and workmanship; we can kickstart these industries here in Sarawak and help enhance more innovation in this space in the future”.

The Wondaleaf Hammock Wheelchair is currently in the testing phase, with plans to launch the product in 2024.

According to the General Manager of SRDC, Dr. Peter Morin Nissom, “the Wondaleaf Hammock Wheelchair represents just one example of the many innovative products and technologies being developed by Sarawakian companies with the support of the SRDC. From renewable energy solutions to the prevention of soil erosion, SRDC is playing a critical role in driving innovation and progress in Sarawak and beyond.”



SRDC’s support for companies like Twin Catalyst is a testament to the importance of investing in research and development and to the critical role that innovation can play in driving social and economic progress, especially in the Sarawak central region.

Looking ahead, it is clear that there will be many more challenges and opportunities to come and that the need for innovative solutions will only continue to grow. SRDC’s support for innovation and progress will be more important than ever.

This innovation is in line with two of the Sustainability Development Goals, which are SDG 3 : Good Health and Well-being and SDG 9 : Industry, Innovation, and Infrastructure.

USING IOT TO MONITOR WATER LEVEL AND PRESSURE

Brenda Alexander Anak Alaw[1] and Kennedy Anak Saba[2]
Sarawak Skills

Incidents of unscheduled disruptions are beyond the control of the water operator. It happens when there is equipment damage in the plant, and unexpected burst or leaking pipes. Therefore, there is a dire need for possible solutions to overcome this crisis. For this purpose, a suitable method is needed to monitor the water pressure of the pipeline, and to ensure that the water tank is filled. It must also be filtered so that the water is clean and safe.

Our objective is to design a sustainable water flow monitoring system using water pressure sensors. These sensors will generate signals to measure the water pressure in the pipe lining. A new approach was created to automatically implement water pressure meter readings to indicate the pressure value in the pipeline by sending the information to the user's smartphone and computer. Hence, it is easy to identify if the water line encounters problems.

The proposed smart monitoring approach differs from the existing commercial methodologies by using Internet of Things (IoT) hardware and smartphone applications. This allows both the water pressure meter readers and individual domestic/industrial users to use smartphones to take meter readings and carry out repairs in the event of a water line problem. This will make it easier for users to identify channel damage and water pressure used in the housing sectors.

In developing this project, several problems were identified:

I. Low water level in the storage tank;
II. Old pipes with accumulated dirt/rust; and
III. Difficulty in identifying leaks in pipelines.

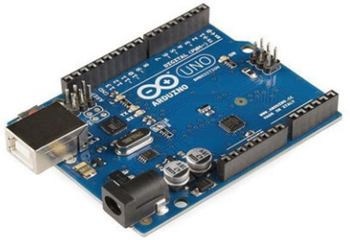
Based on the above, the following solutions were proposed:

I. The use of a water pump connected to the tank so that the pressure in the pipeline is stable;
II. The use of a water filter to maintain water quality and cleanliness; and
III. The use of water pressure sensors to monitor the water pressure value - the data will be monitored by using a smartphone.

There were five (5) phases in the development of this project, namely the design phase, the purchase phase, the development phase, the testing phase, and the evaluation phase. The planning phase consisted of the selection of suitable projects. The purchase phase involved selection and purchase of materials and necessary equipment used for the project. The development phase involved materials and equipment used for project development. This phase focused on the quality of materials and equipment during the development of the project. The development of this project will be illustrated by design sketches, hardware development and schematic electronic circuit wiring. The testing phase included testing the functionality of the product. This phase ensured that the developed product is fully functional according to the product's objectives. Finally, the evaluation phase involved detailed evaluation of the water pressure monitoring project and the automatic water level tank.

The project elements comprise coding, embedded system, mechanical system and Internet of Things. In this respect, the C++ language provides a mechanism for mixing code compiled by compatible C and C++ compilers in the same programme. Programmers can experience varying degrees of success when compiling that code to different platforms and compilers. It shows how to solve common problems that arise when simple errors may occur in a programme. To resolve errors that occur in the programming, the use of application is required to configure the coding by using the Oracle Developer Studio C and C++ compilers.

An embedded system is a microprocessor-based computer hardware system with software that is designed to perform a dedicated function, either as an independent system or as a part of a large system. At the core is an integrated circuit designed to carry out computation for real-time operations. Arduino Uno, a microcontroller board is based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It is a microcontroller to control the water level in the tank and the water pressure in the channel. This circuit will be connected to the water pump and the water pressure sensor.



Arduino Uno

A mechanical system is a system that manages the power of forces and movements to accomplish a task. For example, a water pump will pressurize the water to pass through the sensor so that the sensor can detect the movement of water on the pipe stem.

A water flow sensor monitors the water line and incorporates a pinwheel sensor to measure the amount of liquid that has passed through it. There is an integrated magnetic Hall Effect sensor that outputs an electrical pulse with every revolution. The Hall Effect sensor is sealed from the water pipe and allows the sensor to be used safely.

Water Flow Sensor

A water pump is a machine or mechanical equipment designed to lift liquid from a low level to a high level or to move liquid from a low-pressure area to a high-pressure area, serving as a booster in a piping network system. This application is common in heavy-duty equipment where high discharge pressure and low suction pressure are often required. The pump operates by drawing fluid from a certain depth due to the low pressure at the suction side, and then, propelled by the high pressure at the discharge side, it pushes the fluid to the desired height.

A water filter removes impurities by reducing water contamination through a fine physical barrier, a chemical process, or a biological process. Filters purify water

Water Pump

for various purposes, including providing agricultural irrigation, ensuring accessible drinking water, maintaining public and private aquariums, and facilitating the safe use of ponds and swimming pools.

A water tank is a container designed for storing water, serving various applications such as drinking water, irrigation in agriculture, fire suppression, farming (for both plants and livestock), chemical manufacturing, food preparation, and many other uses. Water tanks offer an efficient solution to help developing countries store clean water.

The internet of things (IOT) describes devices with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the internet or other communications network. The internet of things encompasses electronics, communication, and computer science engineering. The devices only need to be connected to a network, and to be individually addressable. For example, the measured sensor value will be displayed on the website's dashboard to demonstrate the water movement value. NodeMCU is an open-source firmware for which open-source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The term "NodeMCU" refers to the firmware rather than the associated development kits. It is used to control and monitor sensor values and displayed on smartphones. The microcontroller will connect to the cloud for data storage.

This project is an important step forward for users to monitor the stability of the water pressure, to get water without restriction, and to facilitate maintenance by monitoring the indicators via their smartphones. This project will also be useful for the housing sector by making it easier for users to identify pipeline problems.

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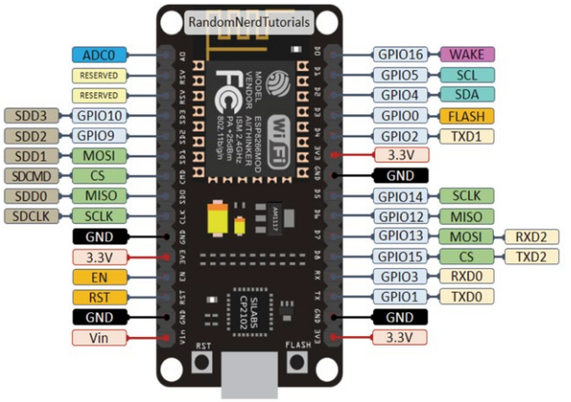
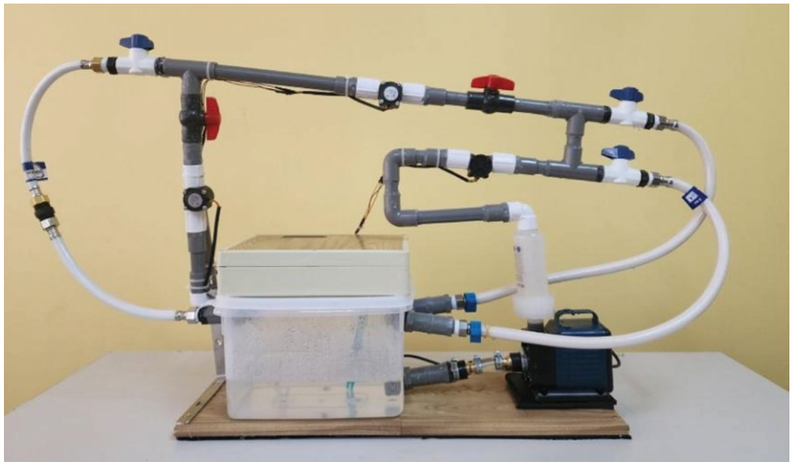


NodeMCU



Prototype: Using IoT to monitor water level and pressure.

Note:

1. During Borneo International Innovation & Invention Competition 2023, this student project (Electronic & Electrical Technology Programme) won the Silver Award.
2. This article is in line with Sustainable Development Goal No. 6: Clean Water and Sanitation.

TOWARDS HUMAN CAPITAL DEVELOPMENT FOR GREEN AND SUSTAINABLE FUTURE

Dr. Dayang Hanani binti Abang Ibrahim
Centre for Technology Excellence Sarawak

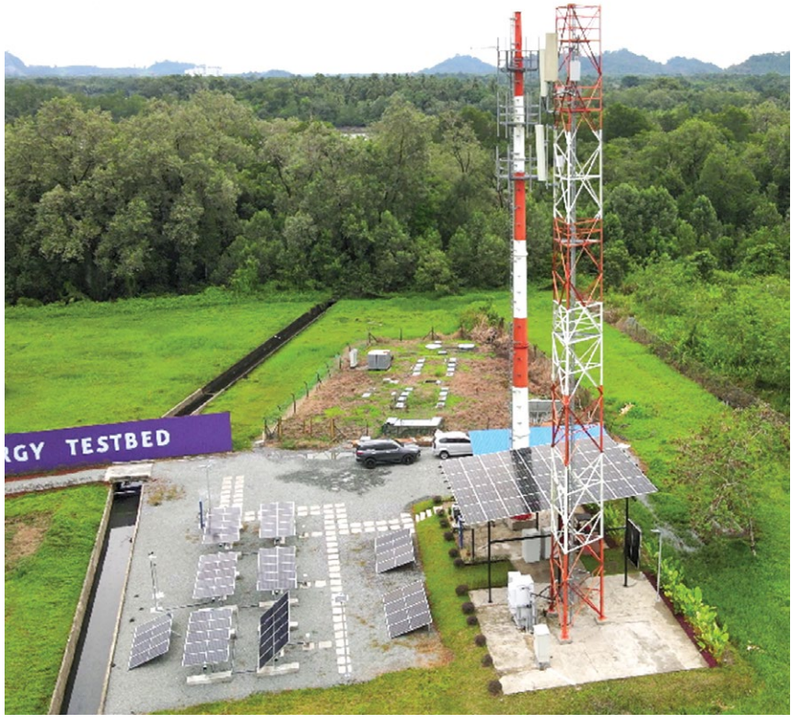
Centre for Technology Excellence Sarawak (CENTEXS), formerly known as Centre of Technical Excellence Sarawak was established on 1st October 2014. Since its inception in 2014, CENTEXS has been entrusted to meet the needs of industries by upskilling and reskilling of youth and industry employees. CENTEXS has widened its target group beyond school leavers and industry workers, but also to include University Graduates especially those who wish to improve further their competencies as some jobs without competencies are getting more competitive and difficult to get employment. Nowadays, Competency Based Training is also gaining popularity amongst University Graduates, CENTEXS has been an avenue for them to produce a well-grounded graduate for the nation's industry and service sectors.

CENTEXS is driven by Sarawak Economy Progression in a series of economic waves started from Oil and Gas, Renewable Energy, Pan Borneo Highway, Digital Economy, and a new wave towards the Hydrogen Economy, in line with Sarawak's

Post Covid-19 Development Strategy (PCDS 2030), and also with Malaysia Economy MADANI, Malaysia New Industry Malaysia Plan (NIMP 2030). Therefore, CENTEXS is aligning its training towards the High Growth High Value (HGHV) Industry. CENTEXS is always taking proactive approach to understanding and searching for industry needs and to helping them progress by supplying talent and training them to fulfill the needs of the State and Nation. CENTEXS has two main academies: Industry & ESG Academy (IESG), and Digital & Green Energy Academy (DGA).

In ensuring to provide the right skills set needed by the industry, we work together with strategic partners who are the leaders in the industry, thus the partners can provide guidance, share best practices and help kickstart the digital and industry transformation process. Therefore, the training that we provide is job-tailored by equipping our trainees with the precise skills and knowledge needed for the role, allowing them to seamlessly transition into their job, in other words 'plug and play'.

CENTEXS Strategic partners include Huawei, EON Reality, Keysight, Bosch Rexroth, Next Schlumberger (SLB), The Welding Institute (TWI), Solarvest and many others.



All the training programmes that we offer are cross-functionality for many industrial sectors. Embracing High Growth High Value (HGHV) advanced digital technology is very crucial to drive innovation, enhance productivity and create new opportunities for economic growth. Therefore, CENTEXS is also intensively working on Electric Vehicle (EV) Advanced technology and Green Energy technologies. This also includes artificial intelligence, big data analytics, IoT (Internet of Things), Android Mobile Application Development and others.

Apart from its training programmes, CENTEXS also conducted Testbeds and Industry projects. This is important to ensure all the programmes are always current and relevant to the industries. There are eleven (11) testbeds where all the testbeds involve technologies are: (1) Juma'ani Pavilion, (2) Solar, Wind & Hydrogen, (3) 5G & Starlink Satellite, (4) Construction Automation and etc. By implementing testbeds, we can take this as validation points for new technologies, processes, or solutions before full-scale implementation.

For every training programme that we plan to offer, we must deep dive ensuring our in-depth understanding of the Digital and Green Energy subject including the industry and technology applications, the right skill set, as well as the ecosystem required to enable seamless integration into the industry workforce.

In realising this, Digital and Green Energy Academy has seven (7) focus areas that include (i) Digital Hardware/ Telecommunication, (ii) Big Data, Data Analytics, Artificial Intelligence, (iii) Software, (iv) Immersive Technologies, (v) Internet of Things, Industry 4.0, Robotics, Automation, Microelectronics, (vi) Digital Marketing, (vii) Cloud & Data Centre Security and Blockchain, and (viii) Green Energy.

CENTEXS under Digital and Green Energy Academy is offering Certificate in Smart Solar Photovoltaic (PV), Certificate in Green Mobility and Storage, and Certificate in Green Hydrogen training programmes in collaboration with Huawei and Solarvest. Under the Certificate in Smart Solar Photovoltaic (PV), trainees learn the design and sizing of solar PV systems, PV components, and the calculation of solar irradiation. For the Certificate in Green Mobility and Storage programme, trainees learn about the basics and trends of Electric Vehicles (EV), charging technologies, and battery storage. CENTEXS also provides e-scooters that use swappable batteries for teaching aid.

In the Green Hydrogen programme, trainees discover more about the basics of Hydrogen, hydrogen production and its value chain, fuel cells and electrolyser components, and their applications. The trainees will also learn how to produce Green Hydrogen through electrolysis from water and solar energy. University graduates with a bachelor's degree in engineering or science are eligible for these training programmes. We have successfully rolled out our first batch of students in the previous July 2023 intake, with 10 university graduates from UNIMAS.

CENTEXS is also offering a Certificate in Environmental, Social and Governance (ESG) for Enterprise, that focuses on building knowledge on sustainability challenges for reaching net zero and meeting the Sustainable Development Goals (SDG).

A Pathway to a Sustainable Future: CENTEXS towards human capital development for Green Energy transition

The Digital and Green Energy Academy at CENTEXS Kuching is more than an institution; a pathway to a sustainable future. By linking digital technology with green energy solutions, the academy empowers trainees to be leaders in the transition to a greener, more sustainable world.

CENTEXS has eleven (11) testbeds, however, in this article we are focusing on the CENTEXS Solar, Wind and Hydrogen Testbed, which is aligned with Sarawak's aspiration in renewable energy. Based on the needs from the Energy industry on required skilled manpower, we are currently offering foundation training programmes on electric and hydrogen, and soon towards high-skilled advanced training programmes.

Solar, Wind and Hydrogen Testbed

The testbed includes two components:

- Firstly, on the energy generated from the Solar Photovoltaic (PV) system. The solar PV rooftop is set up in CENTEXS where the learners can experience and learn from the proven technologies in the Energy industry. Grid-connected and ground-mounted smart Artificial Intelligence (AI) solar PV systems are also set up to provide learners with an understanding of where this can be applied in various scenarios in the solar market; residential, commercial industrial, and utility. The combined solar testbed built on the rooftop and at the ground has a total installed capacity of 425kwp, and 804 solar panels, which is the biggest rooftop solar system in Sarawak. The solar testbed is integrated with a battery storage system to simulate on-off-grid operation.
- Secondly, the hydrogen system that operates in hybrid mode either on or off the grid. It can be fully powered by an on-site solar system to generate green hydrogen to power up the 5G telco system by hydrogen fuel cell. The wind testbed is in progress. In CENTEXS, we are also experiencing the capability of Electric Vehicles with KIA EV6 and E-scooters.

These testbeds furthermore facilitate everyone especially the industries, a better understanding of the challenges, solutions and requirements involved in deploying solar and battery energy storage systems in green hydrogen production, ultimately promoting the scalability of green hydrogen technology in Sarawak and the region. On a larger scale, these testbeds initiative is an innovation platform with a real working environment to showcase the technology, conduct research and training, and accelerate workforce and industry transformation. Therefore, these testbeds are crucial for the development of training programmes to always stay current and relevant.

Our commitment to upskilling and reskilling does not stop here, it extends to commercialisation by any interested parties, as one of our strategies to bring proven and tested technologies into the market for the industries. This includes Hydrogen and EV Valley, Residentials and Commercials, and Power Plants. As the market grows, the need for highly specialised and skilled manpower is increasing. Therefore, CENTEXS is ever ready to meet the demands of industry where our training continuously evolving more in-depth into advanced training programmes. We envisioned those digital technologies are set to make green energy systems to be more connected, intelligent, efficient, reliable, and most importantly sustainable.

In conclusion, skilled workforce and talent development are vital for economic growth. They enhance productivity, foster innovation, attract investment, promote global competitiveness, reduce unemployment and increase resilience to economic changes. By investing development of human capital, Sarawak is able to create a strong foundation for sustainable economic growth and prosperity.

FROM FOOD SCRAPS TO ECO-ENZYME MARVELS: A SUSTAINABLE MULTIPURPOSE ORGANIC LIQUID

Sie Yon Lau*, Evelyn Chiong Tung and Chiong Shiong Ting
Department of Chemical and Energy Engineering, Faculty of Science, Curtin University Malaysia
*Corresponding Author

BACKGROUND

Food waste is a global issue, with a substantial portion arising from kitchen waste and food scraps (Picture 1). According to the United Nations Food and Agriculture Organization (FAO), approximately one-third of all food produced for human consumption, equivalent to about 1.3 billion tons, is lost or wasted globally every year. A significant share of this waste comes from households. Malaysia faces a notable challenge with kitchen waste and food scraps. The excessive food waste disposal is a common issue in urban and rural areas. As of 2018, reports indicate that food waste in Malaysia has reached alarming levels. The food discarded in the country is sufficient to feed around 12 million people daily. As per the findings of Mohammad Diah Wahari, the Deputy Chief Executive Officer at the Solid Waste Management and Public Cleansing Corporation (SWCorp), Malaysians dispose of a staggering 16,688 tonnes of food waste daily. Unfortunately, a significant portion of this food waste is deposited in landfills, reflecting the heavy reliance of Malaysians on these sites, where 95% of the discarded food ends up (Malaysian Food Waste, 2018).

By 2025, the cost of treating food waste per household is expected to increase from RM60-RM150 to RM160-RM400. In addition, household waste, which consists of 33% of inert materials and 48% of organic waste, also contributed to food waste disposal. The significant volume of food production places immense strain on the Earth's natural resources, including land and water, resulting in increased greenhouse gas emissions. This is primarily due to the disposal of food in landfills, where it decomposes and generates methane, a greenhouse gas with even greater

Picture 1: Waste generated during the daily preparation of meals in the kitchen.

potency than carbon dioxide. Eco-enzymes can serve as a viable option for the biological conversion of organic waste into these eco-friendly enzymes when aiming to decrease food wastage. The fermentation process in eco-enzyme production indirectly helps mitigate waste (Verma, 2019). Cost-effective methods with rapid production cycles on a large scale should be devised to address the organic waste generated by both society and individual households to keep pace with the escalating industrial waste.

One of the capabilities of the eco-enzyme is to discompose the insoluble organic compound into the soluble organic compounds that can be known as homemade vinegar. There are several enzymes extracted from organic waste such as protease, amylase, lipases are used to decompose or degrade large molecules into smaller compounds such as protein, carbohydrates and fats. The fermented eco-enzyme can be used as a cleaning agent, antifungal, antibacterial and insecticidal agent. By altering the organic waste into the eco-enzyme, it helps reduce the saturation of the landfills provided an alternative way to transform the organic waste into a value-added product. Moreover, in replacing the landfills as a prior waste management method, eco-enzyme also contributes to protecting both the environment and human health, minimizing the waste dumped to the open sites (Muliarta, 2021).

What is Eco-Enzyme?

Eco-enzyme is a biologically derived, eco-friendly liquid created through a fermentation process that involves organic waste materials. It is a versatile and sustainable solution with applications in various fields, including cleaning, agriculture, and wastewater treatment. The study concerning the eco-enzyme drew the attention of the researchers when they found that of the total waste disposal, 60% were organic waste. Thus, this acknowledgment had raised the society's attraction as the fermented food waste possibly produces unpleasant odor and toxic gasses such as methane gas (Vama and Cherekar, 2020).

Generally, eco-enzyme is produced through mixing the yeast (microbes) with sugar as the nutrient substrate for the microorganism to grow and decompose the organic waste such as fruit and vegetable peels, thus, to produce the eco-enzyme (Nazim and Meera 2017). Most kitchen wastes comprised of fruit and vegetable peels are commonly used in fermenting the eco-enzyme where both fruit and vegetable peels consist of high organic acid levels that are suitable in eco-enzyme manufacturing. The eco-enzyme production can be influential toward the environment and economy. One of the eco-enzymes that is produced is acetic acid (H3COOH) and because of the presence of acetic acid, it consists of disinfectant property that can kill the germs, viruses, and bacteria. Besides that, several enzymes can be found in eco-enzyme such as protease, amylase and lipase that can degrade protein, starch, grease, and oil (Vama & Cherekar, 2020).

Based on the studies done by Rasit and her teams, the eco-enzyme produced from orange and tomato peels have excellent disinfectant properties that can be used in enhancing the aerobic digestion process to treat the aquaculture sludge (Rasit, Fern, and Azlina 2019). Moreover, nitrate, phosphorus and carbon trioxide are also the elements that can be produced by eco-enzyme which are good in use as a natural fertilizer and have been used in the wastewater treatment to purify the wastewater. By substituting the fertilizer as eco-enzyme which is chemical free instead of the chemical fertilizer that can help in natural cycles such as soil treatment (Teknologi, 2020). In the view from economics with the presence of the eco-enzyme which can help in reducing the organic waste and transforming the waste to value-added products such as the fertilizer and cleaning agent such as dish detergent or insectifuge. The disinfectants that are produced from eco-enzyme are cheaper and have greater disinfectant properties compared to the marketed disinfectants. Eco-enzyme can generate the profit from the waste instead of dumping all the organic waste to the open sites which may cause environmental and health issues (Novianti and Nengah Muliarta, 2021).

At Curtin Malaysia, Associate Professor John Lau and his research team have devised an enhanced variation of Effective Microorganisms (EM) for the production of fermented eco-enzymes. This improved EM blend is created by fine-tuning the proportions of beneficial bacteria, yeast, and fermenting fungi, resulting in significantly reduced fermentation times. Dr. John Lau emphasizes that microorganisms are the primary source of enzymes found in nature, playing a pivotal role in ecological equilibrium. EM comprises naturally occurring beneficial microorganisms that aid in enhancing and harmonizing soil properties, both chemically and physically. Additionally, it serves as an inoculant, enriching the microbial diversity within soil ecosystems (Joshi et al., 2019). The EM blend encompasses a range of bacteria, including photosynthesizing bacteria, lactic acid bacteria, yeasts, actinomycetes, and fermenting fungi, each possessing distinct characteristics detailed in Table 1.

Table 1: Components of EM and their function

Microorganism types	Species	Functions
Photosynthetic bacteria	• Rhodopseudomon palustris • Rhodobacter spaeroides	• Amino acids, amino nucleic as production • Bind nitrogen from air • Converting the toxic gases
Yeasts	• Saccharomyces • Candida utilis	• For the growth of the plant and promote fermentation • Produces bioactive substances • Substrate for other EM
Lactic acid bacteria	• Lactobacillus plantarum • L. Casei • Streptococcus lactis	• Increase the rate of decomposition and fermentation • Reduce and decrease the pathogens
Actinomycetes	• Streptomyces albus • S. griseus	• Produce and antibacterial matter
Fermenting fungi	• Aspengillus oryzae • Mucor hiemalis	• Contribute in decompose organic matter • Control odours • Synthesize amino acids and glucose from carbohydrates.

Procedures for Making an Organic Eco-Enzyme

Creating an organic eco-enzyme using Effective Microorganisms (EM) involves a series of uncomplicated steps. EM is a blend of beneficial microorganisms critical for the fermentation process. First, the organic waste, which can include fruit waste, vegetable peels, leftover food scraps, and other biodegradable materials, is finely chopped into small pieces. Reducing the waste to smaller fragments increases the surface area, promoting microbial activity and expediting fermentation.

The next step is the layering of the organic waste and EM in a clean, airtight container. The quantity of EM employed correlates with the amount of organic waste used, with a typical starting ratio of 1:1 (organic waste to EM). To facilitate fermentation, the container is securely sealed in an airtight manner, creating an anaerobic environment as depicted in Figure 2(a). This sealing process prevents the intrusion of unwanted air and microbes.

Subsequently, the sealed container is stored in a cool, dark location, shielded from direct sunlight for a duration of 2-3 weeks, allowing the fermentation process to unfold. Upon completion of the fermentation period, the liquid is meticulously filtered to separate the liquid eco-enzyme from any solid waste residues, as demonstrated in Figure 2(b).

Picture 2: (a) The organic waste fermentation process carried out at Curtin Malaysia; (b) Fermented enzyme liquid collected from container.

Potential Usage of Eco-enzyme

The processed eco-enzyme derived from organic materials could serve as a natural and environmentally friendly cleaning and disinfecting product. It offers an alternative to chemical-based cleansers, which may potentially cause skin irritation (pogored, 2023). Additionally, eco-enzymes produced from vegetable and fruit peels contain high levels

of organic acids, making them suitable for treating metal-based effluents. This is of particular importance as the rapid industrialization has led to a significant increase in the generation of heavy metals and organic waste (M. Hemalatha and P. Visantini 2020). According to Janarthanan and Mani (2020), various types of citrus fruit peels used in eco-enzyme preparation have applications in wastewater treatment and bioremediation, contributing to pollution reduction. Furthermore, the deodorizing property of eco-enzymes aids in reducing water contamination (Janarthanan & Mani, 2020).

Furthermore, in the realm of food production, eco-enzymes have potential applications in enhancing the taste, consistency, appearance, nutritional value, and longevity of processed foods (Sindhu et al. 2018). Eco-enzymes derived from fruit waste can yield pectinase, a valuable enzyme with commercial and industrial uses. Typically, pectinase is employed to break down complex carbohydrates like pectin, a component found in the cell walls of fruits and vegetables. By breaking down these cell walls, it facilitates the digestion of food. Additionally, the pectin-breaking properties of pectinase are beneficial in juice production, as they reduce the presence of sediment in the final product. Consequently, eco-enzymes are frequently incorporated into manufacturing processes, including canning, baking, and the production of alcoholic beverages (Nurlatifah, Agustine, and Puspasari 2022).

Sustainability Development Goals

Research on fruit-waste fermented enzymes plays a vital role in contributing to the United Nations Sustainable Development Goals (SDGs), particularly in the following areas:

SDGs	Explanation
	Enzymes derived from fruit waste can be used as biofertilizers in agriculture. These enzymes help improve soil health and nutrient availability, enhancing crop yields and contributing to food security.
	By reducing the need for chemical fertilizers and pesticides, fruit-waste fermented enzymes promote the production of healthier and more natural food, reducing health risks associated with pesticide residues.
	The use of eco-friendly enzymes from fruit waste reduces waste generation and promotes recycling and responsible resource management.

	When waste is disposed of in landfills, the solid components of food waste or the liquid waste may saturate the landfills, leading to potential contamination. This, in turn, increases the risk of water pollution as soil with acidic or alkaline properties could be carried into nearby rivers or seas, impacting aquatic life. Therefore, addressing waste through the conversion into beneficial enzymes offers a solution to the water pollution problem.
	In Malaysia, a significant portion of waste is managed through the landfill method. To address the growing issue of food waste, the exploration of additional landfill sites becomes necessary, impacting wildlife habitats indirectly. Furthermore, the noxious odors emanating from these landfills pose a threat to both local wildlife and residents.

In summary, research on fruit-waste fermented enzymes aligns with several United Nations Sustainable Development Goals by promoting sustainable agriculture, reducing waste and chemical usage, and fostering innovation and collaboration for a more sustainable and equitable future.

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CULTIVATING AWARENESS OF CYBERBULLYING THROUGH DIGITAL INTERVENTION

Lim Willone[1], Lau Bee Theng[1] and Fakir M Amirul Islam[2]

[1]Swinburne University of Technology Sarawak Campus, [2]Swinburne University of Technology

Global Connectivity and Impacts of Cyberbully

The rapid advancement of information and communication technology has been propelled by the Industrial Revolution 4.0. This progress has transformed the internet into a global computer network, enabling swift and effortless connectivity for sharing information worldwide. However, this transformative development has inadvertently given rise to concerning behaviours associated with internet usage, notably cyberbullying [1]. Cyberbullying, an insidious modern-day scourge, transcends geographical borders and has emerged as a pervasive threat to individuals globally. The ubiquity of cyberbullying is evidenced by alarming statistics, with studies conducted by organizations such as the World Health Organization and UNICEF reporting that approximately one-third of young individuals globally have encountered some form of cyberbullying [2].

The ramifications of cyberbullying extend beyond digital spaces, exerting significant impacts on mental health and social well-being. Extensive research corroborates the correlation between cyberbullying and adverse psychological outcomes, including heightened levels of anxiety, depression, low self-esteem, and, in severe cases, suicidal ideation among affected individuals [3]-[5]. Globally, the common occurrence of cyber-victimization ranges from 14.0% to 58.0%, and cyber-offenders range from 6% to 46% [6]. Spain exhibited the highest incidence of cyberbullying victimization at 57.5%, followed by Malaysia at 52.2%, Israel at 45.0%, and China at 44.5%. Conversely, Canada and South Korea reported the lowest victimization rates at 14.0% and 14.6%, respectively. In the United States of America, cyberbullying victimization rates ranged from 15.5% to 31.4%, while Israel showed a range between 30% and 45%. In China, the rates varied between 6.0% and 46.3%, and the country recorded the

highest prevalence of cyberbullying perpetration at 46.3%. Studies in Canada and South Korea indicated the lowest prevalence of cyberbullying perpetration, scoring at 8.0% and 6.3%, respectively [6]. Although initially not as prevalent as some nations, the problem has surged recently. In a 2018 assessment of 28 countries, Malaysia emerged as the sixth-worst globally for cyberbullying [7]. Subsequently, a global statistic two years later revealed Malaysia's staggering cyberbullying rate at 71% [8]. Presently, Malaysia stands as the highest in Asia for reported cases of cyberbullying [6]. Cyberbullying has reached an alarming rate in Malaysia and has made its mark within the digital space of Sarawak [9].

Despite multiple efforts aimed at controlling the cyberbullying incident, there are no signs of the problem being brought under control. Cyber Security Malaysia reported 266 cases of cyberbullying in 2018, a figure similar to the 260 cases recorded in 2019. However, the situation took a concerning turn in 2020, with reported incidents escalating dramatically to 596. However, there was a slight decrease in 2021, totalling 417 incidents [10]. This issue is exacerbated by the inadequate intervention measures aimed at curbing cyberbullying in Malaysia. Existing studies primarily concentrate on interventions tailored for young children, leading to a limited comprehensive understanding and definitive conclusions on effectively mitigating cyberbullying among other age groups, resulting in a significant knowledge gap in this domain [11], [12].

Digital Intervention in Combating Cyberbully

With the advancement of technology, researchers should steer towards digital intervention to tackle this issue. The practicability of serious digital games has been brought forward and shows a promising outcome in European countries [13]. The efficacy of serious digital games in their dynamic approach to tackling cyberbullying. These games engage users actively, providing a safe environment to understand, respond to, and prevent cyberbullying. Players develop critical thinking, empathy, and behavioural strategies through interactive scenarios to address cyberbullying effectively. The games facilitate experiential learning, fostering a deeper understanding of the issue while promoting positive online behaviours.

Additionally, they reach a wide audience, promote collaborative learning, and enable data collection for evaluating interventions. Overall, serious digital games serve as valuable tools in educating and empowering individuals to combat cyberbullying and foster a safer online community. Hence, the pervasiveness of cyberbullying underscores the importance of implementing efficient digital serious game interventions aimed at assisting young individuals to develop effective coping mechanisms in response to cyberbullying [14].

Perceptions and Experiences of Cyberbully

Considering the pressing need for effective interventions against cyberbullying, the overall research aims to investigate, design, develop, and evaluate the effectiveness of a digital serious game intervention that improves awareness, coping strategies, and the management of anxiety and depression for cyberbullying among youth. There are three planned phases: pre-intervention, intervention, and post-intervention.

The article discusses the pre-intervention study conducted to explore perceptions and experiences related to cyberbullying among youth within the Malaysian context. To date, the pre-intervention assessment has been completed with the youth in Malaysia who had encountered cyberbullying incidents and those who had not. The following tables present the detailed statistics derived from the study on perceptions and experiences of cyberbullying.

Table 1: Factors associated with cyberbullying (with the scale where 'NEVER' corresponds to 1, 'ALWAYS' to 5)

		Cyberbullying	Cognitive appraisal	Problem-solving	Social distancing	Cognitive distancing	Depression	Anxiety	Stress
Gender	Male	-1.002	.21	-.16	-.21	.15	-.38	-.50	-.33
	Female	-.815	.22	.15	.07	-.22	-.41	-.44	-.29
	Prefer not to say	-.009	-.24	.49	-.58	.30	-.39	-.09	-.05
Education level	Primary School	.	.	.	.	.	.	.	.
	Secondary School	-.697	.13	-.20	.22	-.25	-.51	-1.02	-.86
	Diploma	-.609	.30	.17	.37	.20	.46	.28	.17
	Undergraduate degree	-.872	.20	-.01	-.16	-.04	-.43	-.40	-.24
	Postgraduate degree	-.975	.20	.44	.27	-.26	-.41	-.58	-.42
Employment status	Employed full time	-1.082	.27	-.09	-.31	.06	-.08	-.57	-.14
	Employed part-time	-1.468	.67	-.76	.52	.14	-.72	-.49	-.21
	Seeking opportunities	-2.059	.49	.32	-.15	-.40	-.81	-1.03	-.84
	Student	-.729	.14	.13	-.04	-.10	-.40	-.40	-.30
	Others	.	.	.	.	.	.	.	.

Table 1: Continued (with the scale where 'NEVER' corresponds to 1, 'ALWAYS' to 5)

		Cyberbullying	Cognitive appraisal	Problem-solving	Social distancing	Cognitive distancing	Depression	Anxiety	Stress
Household monthly income	Under RM 2 000	-1.358	.49	.23	-.02	-.21	-.59	-.77	-.50
	RM 2 000 - RM 4 000	-.783	.18	-.11	-.30	-.14	-.31	-.35	-.05
	RM 4 000 - RM 6 000	-.671	.28	.04	.22	-.13	-.41	.03	-.03
	Above RM 6 000	-.355	-.06	.10	.50	.11	-.45	-.27	-.13
	Prefer not to say	-.864	.06	.14	-.02	.07	-.37	-.71	-.70
Time spent with families	Less than 2 hours	-.946	.27	.09	.16	-.18	-.42	-.61	-.56
	2 - 4 hours	-.826	.23	-.12	-.28	-.07	-.42	-.56	-.37
	4 - 6 hours	-.672	.19	-.08	.04	-.03	-.64	-.42	-.11
	More than 6 hours	-1.002	.14	.33	.02	-.05	-.19	-.25	-.19
Social media accounts own	Instagram	-1.061	.32	.02	-.13	-.20	-.40	-.40	-.30
	Facebook	-.521	.04	.06	-.07	.06	-.35	-.34	-.06
	TikTok	-.541	-.02	-.02	-.05	.06	-.17	-.56	-.51
	Twitter	-.971	.20	.20	.38	.07	-.96	-.93	-.60
	Others	-1.542	.68	1.16	.95	.36	.49	-.09	.20
Time spent on social media	Less than 4 hours	-.801	.08	-.07	-.28	-.03	-.48	-.55	-.35
	4 - 6 hours	-.757	.34	.05	.27	-.07	-.25	-.34	-.21
	6 - 8 hours	-1.473	.15	.20	-.29	-.39	-.63	-.76	-.53
	More than 8 hours	-.537	.11	.15	-.13	.18	-.39	-.21	-.18

Table 1 presents an overview of participants' awareness, experience, and behavior related to cyberbullying. This table highlights the statistical significance of various factors associated with cyberbullying. Particularly, the data demonstrates that a notable segment of participants possesses prior awareness of cyberbullying, suggesting a level of digital proficiency and comprehension within the surveyed cohort. Interestingly, a pattern emerges regarding gender aspects. The results reveal that males exhibited a mean score of 1.002, indicating a slightly lower reported experience than females (0.815). This suggests that, on average, females reported higher experiences of cyberbullying than their male counterparts.

Additionally, a positive correlation was observed between education level and problem-solving skills. Specifically, higher education levels were associated with higher mean scores in problem-solving, with postgraduate students scoring 0.44. However, the relationship between education and depression and anxiety is less clear, with no consistent trend observed. Those who reported spending more time with their families tend to have lower mean scores for depression and anxiety. This finding suggests that family support and closeness may have a protective effect against these mental health issues associated with cyberbullying.

Table 2: Awareness and experience of cyberbullying (in percentage)

		I know about cyberbullying	I have experienced cyberbullying	I have seen someone getting cyberbullied	I have cyberbullied someone
Gender	Male	91.5	46.5	72.1	32.6
	Female	94.1	56.3	64.6	22.9
	Prefer not to say	100	50	0	0
Education Level	Primary	0	0	0	0
	Secondary	100	12.5	100	25
	Diploma	100	42.9	71.4	42.9
	Undergraduate	94.4	58.2	59.7	28.4
	Postgraduate	78.6	45.5	81.8	9.1
Employment status	Employed full time	90.9	20	90	10
	Employed part-time	100	60	80	40
	Seeking opportunities	33.3	0	0	0
	Student	95	55.3	63.2	28.9
	Others	100	100	100	0
Household monthly income	Under RM 2 000	89.5	47.1	76.5	17.6
	RM 2 000 - RM 4 000	90	59.3	48.1	40.7
	RM 4 000 - RM 6 000	100	50	64.3	28.6
	Above RM 6 000	100	55.6	77.8	22.2
	Prefer not to say	92.9	46.2	76.9	19.2
Time spent with family members	Less than 2 hours	96.2	44	76	32
	2 - 4 hours	96.3	38.5	69.2	19.2
	4 - 6 hours	95.5	57.1	38.1	23.8
	More than 6 hours	84	71.4	81	33.3

Table 2: Continued (in percentage)

		I know about cyberbullying	I have experienced cyberbullying	I have seen someone getting cyberbullied	I have cyberbullied someone
Social media use	Instagram	98	48	72	32
	Facebook	84	57.1	57.1	23.8
	TikTok	91.7	63.6	54.5	18.2
	Twitter	88.9	62.5	75	25
	Others	100	0	66.7	0
Social media use daily	Less than 4 hours	91.7	39.4	66.7	21.2
	4 - 6 hours	94.1	56.3	75	31.3
	6 - 8 hours	100	62.5	62.5	25
	More than 8 hours	85.7	58.3	50	33.3

Table 2 provides insights into the relationship among various psychological factors, cyberbullying, and demographic variables within the study's participant cohort. The analysis reveals that 47% of male participants and 56% of female participants experienced some level of cyberbullying. Interestingly, 94% of females showed awareness of cyberbullying, slightly higher than males at 92%. However, a higher percentage of males, 33%, compared to 23% of females, indicated engaging in bullying behaviour. Moreover, the subgroup of undergraduates reported the highest incidence of cyberbullying experiences, with 58% of this demographic reporting such encounters.

Conclusions and Future Work

Global connectivity has accelerated cyberbullying, a pervasive threat impacting mental health worldwide. The surge in cases, notably in Malaysia, emphasizes the urgent need for effective interventions. This calls for collaborative efforts from researchers, policymakers, educators, and society to create a safer digital environment.

This article presents the findings on factors, awareness and experience of cyberbullying, including family dynamics and psychological factors. Targeted interventions, education, and support systems are crucial in equipping young individuals with coping mechanisms against cyberbullying.

Thus, future work will include the intervention phase conducted with the serious game (Picture 1), an interactive intervention tool to increase coping strategies within the intervention group. We will explore how the proposed serious digital game, CyberStory can help foster a safer online community.

Subsequently, the post-intervention assessments will be administered to the intervention group after the intervention period, while the non-intervention group will be retained as a comparative reference. The subsequent future works include analyzing data from both intervention and control groups and evaluating the effectiveness and impact of the serious game intervention on the enhancement of coping strategies in cyberbullying.

Picture 1: Samples of scenarios and feedback in CyberStory

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SARAWAK SUSTAINABILITY RESOURCES FOR ENGINEERED TIMBER PRODUCTS

Ts Mohamad Saiful Sulaiman
Lecturer | Head of CeWEP, University of Technology Sarawak

Sarawak, Malaysia, boasts abundant timber resources, predominantly hardwoods like Belian, Keranji, Merbau, Resak, Meranti, Kapur, and Keruing, as well as fast-growing planted species including Acacia, Eucalyptus, Batai and others. These resources have been the cornerstone of the state's economy. Recent years have seen a shift towards sustainable timber management practices, with the Sarawak Timber Industry Development Corporation (STIDC) and Sarawak Forestry Corporation (SFC) leading the way. Certification efforts, such as recognition from the Forest Stewardship Council (FSC), underscore the commitment to sustainable logging. However, challenges mar this progress. Illegal logging continues to threaten Sarawak's forests, resulting in deforestation, biodiversity loss, and environmental harm. Additionally, land allocation conflicts between agriculture, infrastructure development, and conservation efforts lead to the fragmentation of natural habitats. Sustainability efforts include reforestation programs to restore damaged or deforested areas while enhancing timber resources. Biodiversity conservation remains a focus, preserving the diverse flora and fauna species within the state. Furthermore, community involvement is vital for sustainable resource management, ensuring both conservation and livelihood support. In sum, Sarawak grapples with the complex and ongoing challenge of balancing economic interests with environmental preservation in its timber industry. Despite the strides made toward sustainability, illegal logging and land conflicts persist. Sustainable management and community engagement are crucial to maintaining the ecological and economic well-being of Sarawak's natural resources.

Initial steps have been taken to foster awareness about wood-engineered products. Starting at the academic level, the University of Technology Sarawak (UTS) looking forward to establishing a research center namely the Centre of Excellence in Wood Engineered Products (CeWEP). CeWEP was established to boost the involvement of the local timber industry, specifically in Sarawak, Malaysia. The

objective is to shift the focus from producing raw materials (upstream products) to finished products, thereby enhancing the profitability of the industry. Sarawak is renowned for its abundant natural resources, particularly timber, yet the emphasis has traditionally been on upstream products such as sawn timber, plywood, veneer, and particleboards. The potential for downstream products like furniture, engineered products, and wood charcoal which offers higher profits, remains largely untapped. In line with the Sarawak Corridor of Renewable Energy (SCORE) initiative, the timber-based industry has been designated as a priority sector, alongside oil and gas, marine engineering, tourism, and aquaculture. The strategy involves transitioning from basic timber production to the manufacturing of high-value components and finished goods for export. CeWEP's role is not only centered on processing wood into high-quality engineered wood products with modern designs but also places importance on lesser-known and local wood species, addressing biodiversity concerns. This initiative aims to drive the development of Sarawak's timber product industry towards value-added, sustainable, and environmentally responsible practices.

In order of downstream products, engineered wood is a versatile and environmentally friendly building material that offers numerous advantages over traditional solid wood and other construction materials. It is manufactured from various wood types, including recycled wood, hardwoods, planted wood, and bamboo. The process is in line with the recommendations of the 15th SDG which is to promote sustainable management of forest products. Engineered wood finds applications in furniture, cabinetry, and as a construction material for walls, roofs, and floors.

Cassava waste fiber products fabricated in UTS Laboratory. It has a high potential for house interior design and applications.

One of its key benefits is its superior strength and stability, making it less susceptible to warping, cracking, and shrinking compared to solid wood. This durability stems from the process of bonding wood strands, veneers, or fibers using adhesives, ensuring consistent strength and dimensional stability. Engineered wood's reduced propensity to twist or warp enhances its long-term performance.

Furthermore, engineered wood products are highly adaptable and available in a wide range of dimensions, forms, and arrangements to meet specific design and construction requirements. This flexibility allows for the creation of innovative architectural designs and complex structures, with products like glue-laminated timber providing architectural versatility.

Environmental considerations make engineered wood an appealing choice as well. It minimizes the impact on natural resources by utilizing smaller, fast-growing trees and incorporating wood industry by-products. The manufacturing process can also utilize adhesives with low volatile organic compound emissions, improving indoor air quality. Moreover, engineered wood reduces waste by being manufactured in large panels or beams.

The cross-laminated parquet (Eco-CLP) has been produced in the UTS laboratory. The products fabricated from a combination of Nypa frond fiber and Bio epoxy are strongly affected by their strength and application especially.

Cost-effectiveness is another advantage of engineered wood, as it can be made from smaller, more affordable trees. Its greater dimensional stability reduces maintenance expenses over time, and large panels eliminate the need for intricate joinery or assembly. Certain engineered wood products, such as fire-rated plywood and fire-resistant particleboard, provide enhanced fire resistance, meeting specific safety regulations. However, the benefits of engineered wood can vary depending on the product and its intended application, so consulting industry professionals and adhering to relevant standards and guidelines is essential when using it in construction projects. In summary, engineered wood is a sustainable, durable, and versatile building material

that offers numerous advantages for modern construction and design. Once again, it was aligned with the 9th SDG which is to promote inclusive and sustainable industry, innovation, and infrastructure products.

Milestones of Wood-Engineered Products Growth in Malaysia

The development of engineered wood products in Malaysia traces back to the mid-20th century when the nation sought alternatives to solid wood for construction and furniture. While specific timelines and milestones may vary, a general history of these products in Malaysia is as follows. In the 1950s, Malaysia embraced plywood as one of the earliest forms of engineered wood. Plywood, created by bonding thin veneer layers of wood with adhesive, gained popularity, primarily driven by the construction sector's need for building materials. It became a significant import to cater to the surging demand for construction supplies. During the 1960s and 1970s, particleboard emerged as another engineered wood product. It is produced by compressing wood particles or chips with resin under heat and pressure. This innovation provided an alternative to solid wood in furniture manufacturing and interior applications. Laminated veneer lumber (LVL) gained prominence in the 1990s. LVL involves bonding veneer sheets with adhesives to create robust and dimensionally stable structural members. LVL found applications in load-bearing elements in construction, such as beams and columns. In the early 2000s, glue-laminated timber, or glulam, gained popularity in Malaysia. Glulam involves bonding layers of solid wood to create larger, stronger, and visually appealing structural elements. It found architectural and structural uses in curved beams and arches.

Cross-laminated timber (CLT), a relatively new engineered wood product, has gained global interest. CLT panels are formed by stacking and gluing multiple layers of wood at right angles, known for their strength and sustainability. The specific adoption of CLT in Malaysia may differ. The adoption of engineered wood products in Malaysia has been driven by factors such as raw material availability, advancements in manufacturing technologies, and the desire for sustainable and cost-effective construction solutions. Malaysian manufacturers have invested in production facilities and research to improve the quality and variety of engineered wood products available locally. It is one way to achieve the Sarawak Government goal which is to provide over one million new jobs by 2030, thereby improving the standard of living for the people of Sarawak.

Engineered wood products offer significant advantages, including strength, sustainability, cost-effectiveness, and consistent quality. These qualities make them a valuable choice for modern construction. Engineered wood is poised to grow in popularity due to its strength, flexibility, durability, and sustainability,

especially in house designs. Roof framing requires precise design and compliance with construction regulations, ensuring safety. When selecting insulation, climate, local codes, and construction type should be considered, with proper installation being vital. Interior finishes should reflect style, durability, and maintenance needs. Nonetheless, engineered wood houses offer lower costs, enhanced durability, energy efficiency, sustainability, and safety. They provide an ideal option for eco-friendly and enduring homes.

The cross-laminated parquet (Eco-CLP) has been produced in the UTS laboratory. The products fabricated from a combination of Nypa frond fiber and Bio epoxy are strongly affected by their strength and application especially.

RETROSPECTIVE ON SAGO PALM MISIMPRESSION WITH ADVANCED BIOTECHNOLOGICAL APPROACH

Dr. Muhammad Norhelmi Ahmad
i-CATS University College

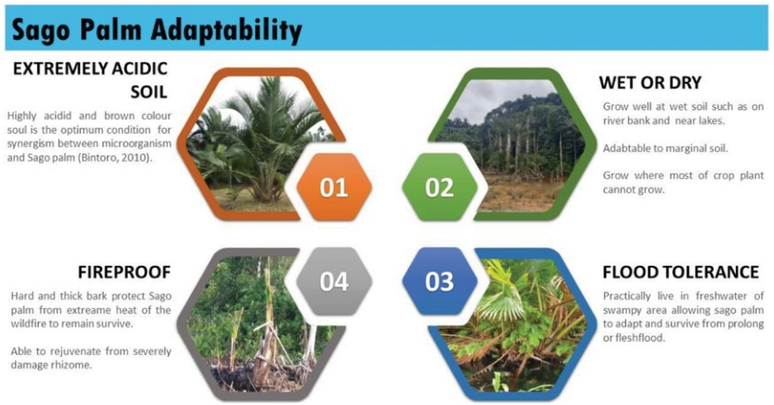
Long before rice was consumed as the staple food by the indigenous ethnicities in Sarawak, Sago was the main source of food providing starch as a basic ingredient to make a wide variety of delicacies together with creamy sago worm as a nutritious source of protein. Despite only being for food, Sago palm also plays a significant role in the customary of the native tribe such as the Melanau ethnic.

The Major Challenge and Misimpression in Sago Plantation

Due to the extensively long maturation period, sago palm tends to be misimpressed. Sago palm commonly requires 8-12 years to be ideally harvestable for starch extraction. Somehow, many are not aware of the potential of sago plantations without understanding the lifecycle of that ancient crop. Sago palm is a perennial plant which grows in clusters producing suckers as one of the reproductive mechanisms. Hence, once the mother palm is harvested the next generation or successional palm from the same cluster can be harvested in a shorter time. This cycle can last for centuries without replanting and minimal maintenance of the Sago farm. Furthermore, within the maturation period, conventionally there is no profitable commodity that can be obtained from sago plantations. In addition, inefficient and unsystematic farm management of traditional plantation practices reduces the productivity of the sago palm. Due to this condition, sago farmers desperately substitute sago palm for cash crops. Since 2010, Sarawak has lost 47% of its sago plantation area reducing 30% of the production capacity. If this trend continues, Sarawak will lose its credential as the biggest sago starch exporter in the world.

Key to Sustainable Food Security

Extreme climate changes have triggered the world to experience severe defects in agricultural productivity leading to a major shortage of global food supply and instability of food prices. Hence, the cultivation of food crops that are able to adapt to the effects of climate change is the key to maintaining the sustainability of food security and preventing the rise of world hunger. Sago palm possessed the ideal characteristic to become a crucial contributor to achieving Sustainable Development Goal 2: Zero Hunger as proposed by the United Nations.



Application of Industrial Biotechnology in Developing Novel Sago-Based Product

The implementation of technology in agriculture has driven the industry into modernisation in improving efficiency and productivity and, most importantly, diversifying the product and application to fulfil the requirements of multiple industries. Sago palm used to be known only as a source of food but with technology, sago became a versatile feedstock to produce a wide variety of non-food products. The exploration of developing value-added products from Sago palm will not affect the production of starch for food due to the focus on utilizing its biomass.

1.0 Fermentable Carbon Feedstock

The industrial scale of Sago starch extraction produces a massive amount of residual fibre known as Sago *hampas*. For every ton of starch produced, about 580 Kg of Sago *hampas* were discarded from the mill and flushed into the nearest river. The Sago *hampas* still contain about 60% residual starch embedded in the hollow fibre of the

Picture 1: Sago *hampas* accumulated outside of the mill before being discarded into the river.

hampas that cannot be recovered by using the mechanical respiring method. However, using the enzymatic hydrolysis approach manages to break the starch into glucose and simply can be retrieved from the hampas through multiple solid-liquid separation methods. Glucose is a crucial component in the fermentation process that acts as the energy source to fuel the growth of the selected microorganism. The formulated glucose solution can be utilized as a fermentable substrate to produce a wide variety of high-value chemical substitutes or for the cultivation of good microorganisms.

Picture 2: Bioethanol produced from Sago *hampas* substrate.

2.0 Sustainable Organic Fertilizer

The solid residue after enzymatic hydrolysis of Sago *hampas* still possessed a traceable amount of glucose that can be beneficial for microbial growth in multiple applications such as the production of compost. The presence of glucose as simple sugar can accelerate microbial growth during the composting process. The conventional co-composting method will involve animal excreta as the source of nitrogen and degrading microflora, agricultural waste as a source of organic matter and molasses as the source of carbon as feedstock for the microorganism.

By using the Sago solid residue, the co-composting method can be executed more efficiently than the conventional method due to the presence of free sugar void the supplementation of molasses as a source of carbon. The porous structure allows the Sago fibre to absorb and possesses strong water holding capacity so it can be an eligible sole growing medium to plant semi-aquatic crops such as 'Kangkung' (*Ipomoea aquatica*). It also can be used to plant paddy, especially in urban areas where land is limited and highly acidic.

Picture 3: 3 weeks old Kangkung grown solely in Sago *Hampas* Compost.

3.0 Prebiotic and Organic Acid

Researchers discover an elegant solution to the devastation of the extensively long time for the Sago palm to be harvestable with the utilisation of Sago frond. Conventionally, the Sago fronds are just being discarded on the farm after the trunks were harvested and some were used to make roofs and handcraft products. Dried Sago frond can ignite wildfire during drought season and not favourable as a natural fertilizer due to low nitrogen content and takes time to degrade. In the meantime, pruning the Sago frond from the growing palm is commonly practised by the farmer to reduce competition among the palms in the same cluster to promote the growth of the mother trunk. Hence, the Sago frond massively accumulated and became a waste of biomass that can be used as raw material to produce high-value products.

Picture 4: Dried Sago frond discarded on farm can trigger wildfire.

Picture 5: SaFrond Prebiotic Drink derived from Sago Frond.

To utilize Sago frond, it requires the application of advanced bioprocess technology since it possesses complex lignocellulosic components that make it difficult to be degraded. Again, the enzymatic hydrolysis process was used to convert the complex structure to a substitute chemical. Cellobiose is the product of metabolizing sago frond fibre with specific enzymes. Unlike glucose, cellobiose is extremely indigestible by humans without aid from digestive microflora. Hence, cellobiose act as a prebiotic component that promotes the growth of good bacteria in human to improve the efficiency of the digestive system and protect the body from pathogenic microorganism.

Picture 6: SaFrond L-lactic acid based hand sanitizer is alcohol free provides selective antibacterial properties that only affect mostly pathogenic bacteria and allow good bacteria such as lactic acid bacteria to remain viable to keep skin tissue safe and healthy.

The L-lactic acid also serves as exfoliant to remove dead cells that commonly accumulate in the skin pore which cannot be removed by ordinary skincare product. The treatment with L-lactic acid will allow the skin to rejuvenate provide an antiaging effect.

Underneath the strong and flexi external structure of the Sago frond, there is a spongy texture of the pith inside of the rachis (middle part of the frond), hiding sweet and tasty sap that can simply be extracted using a roller presser machine. The Sago frond sap contains free sugar made up of mainly glucose and xylose as well as residual starch. The coexistence of crucial minerals such as nitrogen, magnesium, manganese, copper and zinc are complementary to the application of the Sago frond sap as fermentation media to produce high-value chemical substitutes such as L-lactic acid which only can be produced naturally via fermentation of lactic acid bacteria.

L-lactic acid is an organic short-chain fatty acid which is considered a high-value ingredient in producing cosmetic and pharmaceutical products. The L-lactic acid acts as an exfoliant and moisturizer in cosmetic products to remove dead cells and maintain the moisture of the skin. In medicine, L-lactic acid is used as a pH regulator and antibacterial agent.

The Sago frond sap is a two-for-one fermentation media which is not only reliable for producing high-value chemical substances but also can cultivate probiotic bacteria that can be repurposed into functional food and feed.

3.0 Animal Feed

Malaysia is a country that is deeply dependent on imported food, especially on meat and dairy products. Over the years, multiple policies and enterprises were established to stimulate the Self Sufficient Level (SSL) of meat by shrinking the deficit between domestic meat production and consumption. However, none of them exhibits a

significant impact on the accessibility to the local meat and affordability index of meat products in the market. Until animal feed was identified as the key factor in achieving a sustainable livestock production industry. Feed cost covers 70% of the total cost for the production of livestock. Unfortunately, Malaysia also highly depends on imported raw material to produce animal feed such as maize and wheat. Global crises such as climate change and war cause unstable supply and price of animal feed leading to the fluctuating price of meat products in Malaysia. The utilisation of local crops as raw material to produce animal feed is a feasible solution to reduce dependency on imported food and feed.

The residual fibre obtained after the extraction of Sago frond sap was used as the sole raw material to produce animal feed for ruminants in the form of silage. The probiotic recovered from the fermentation of L-lactic acid bacteria was repurposed as an effective microorganism to improve the quality and shelf life of the silage. The feeding of Sago frond silage shows the feasibility to be serving as a long-term feeding regiment in promoting the growth performance of ruminants without compromising animal welfare.

Picture 7: A goat enjoying Sago frond silage.

In conclusion, the Sago palm is a blessing ancient crop that must be preserved and acknowledged as a key to achieving sustainable food security.

The article tackles Sustainable Development Goal (SDG) 2: Zero Hunger and SDG 12: Responsible Consumption and Production.

SDGs	Explanation
	In this article we highlight the potential of the Sago palm to be a sustainable source of food, while also highlighting the importance of cultivating food crops that can adapt to climate change. In the local context, this article shows that Sago palm helps Sarawak in achieving Zero Hunger and helps ensure global food security.
	This article explores how industrial biotechnology can be applied to develop novel Sago-based products, thus demonstrating how technology can efficiently utilize various parts of the Sago palm to produce fermentable carbon feedstock, sustainable organic fertilizer, and prebiotic and organic acid. Moreover, the article highlights how innovative biotechnological approaches can transform the Sago palm from a traditional food source into a versatile feedstock with multiple applications. This, in turn, promotes sustainability and addresses challenges related to food security and agricultural practices.

ACT-SING-BLEND: ELEVATING READING PROFICIENCY AMONG MALAYSIAN YOUNG ESL LEARNERS

Pui Kuet Poh
Institut Pendidikan Guru Kampus Tun Abdul Razak

INTRODUCTION

The Malaysian primary English language curriculum emphasises on the development of learners' reading skills for comprehension and enjoyment (Ministry of Education, 2022). To support this objective, the English language curriculum is designed to establish a strong foundation in learners' basic literacy skills. For example, fun activities were integrated into phonemic awareness lessons to provide young learners with letter-sound correspondence exercises in a non-restrictive environment.

As a Malaysian primary English as a Second Language (ESL) teacher, the researcher aimed to uphold the country's aspirations and progressively develop his young learners' reading skills. Consequently, at the beginning of the school year, a reading diagnostic test was conducted with the learners to assess their existing reading proficiency, in terms of letter-sound correspondences. However, the researcher encountered a problem in which the majority of his learners were still unable to differentiate individual phonemes, blend and segment them, making it difficult for the learners to read the words given to them. Besides, the researcher also found that the test items in the diagnostic test did not assess learners' reading proficiency but primarily evaluated learners' mastery of vocabulary.

Thus, to address the issues mentioned, the Act-Sing-Blend (ASB) approach was introduced as an intervention to improve young learners' mastery of letter-sound correspondences, while the Reading Proficiency Test (RPT) was used to determine whether the learners have acquired these skills. In this study, two research objectives were formulated:

1. To assess the effectiveness of the ASB approach in improving the mastery of letter-sound correspondences among young Malaysian ESL learners.

2. To investigate the effectiveness of the RPT in assessing the reading proficiency of young Malaysian ESL learners.

Based on the research objectives, the following research questions (RQ) were formulated:

1. What is the level of mastery of letter-sound correspondences among young Malaysian ESL learners before and after implementing the ASB approach?
2. Is there any significant difference between the level of mastery of letter-sound correspondences among young Malaysian ESL learners before and after implementing the ASB approach?
3. How does the RPT assess the reading proficiency of young Malaysian ESL learners?

The interventions introduced were adapted from the Total physical response (TPR) method and Krashen's (1982) Affective filter hypothesis. According to Rokhayati (2017), the TPR method employed actions and bodily movements to illustrate the words presented to learners, which could help enhance learners' memory about the words presented (Rokhayati. 2017). Another relevant theory was the Affective Filter Hypothesis. According to Krashen, affective filter is an imaginary mental block that could influence the development of second language in learners, particularly learners could acquire the language input presented to them more effectively when their affective filter is lowered.

The Study

This study employed a mixed-method approach to collect data from both qualitative and quantitative paradigms (Creswell, 2014). The researcher invited 22 Year 1 English language learners (i.e., aged 7) who were studying in a national-type (SJKC) school in Limbang, Sarawak. The learners were purposively chosen as they represented a subset of Malaysian young ESL learners and they also exhibited a very low level of reading proficiency.

Besides, the study was conducted for a period of six weeks. Prior to conducting the study, informed consents from learners' guardians were obtained. A reading proficiency test (RPT) was used as both the pretest and posttest of this study to assess the learners' mastery of letter-sound correspondences (Figure 1). The RPT was divided into three sections, each assessing a different aspect of the learners' reading proficiency. Section A evaluated the learners' ability to discriminate between phonemes. Section B examined the learners' ability to blend individual phonemes into monosyllabic words, while Section C assessed a combination of skills.

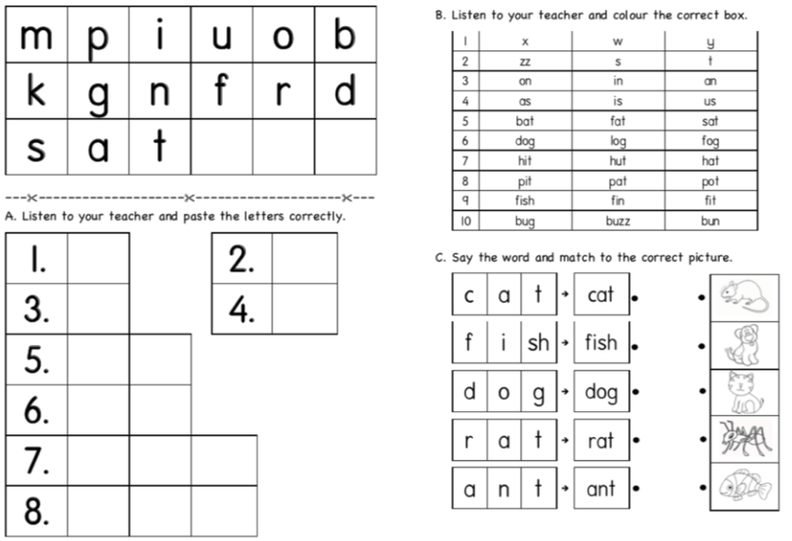


Figure 1: Reading proficiency test.

Furthermore, the Act-Sing-Blend approach was carried out during a total of 12 English language lessons in four consecutive weeks. Each lesson was structured into three main segments, namely Act (A), Sing (S) and Blend (B). Field notes were used to record the researcher's reflections and insights throughout the process of implementation.

In the Act stage, the researcher introduced various phonemes using actions adapted from Jolly Phonics, a method in teaching young learners using alphabetical codes (Lloyd, 2007). For example, when teaching the /s/ phoneme, the researcher mimicked the action of a snake slithering and produced the hissing sound (Figure 2).

Figure 2: Action for phoneme /s/.

Subsequently, the researcher provided practice in the Sing stage. The researcher chose a familiar children's song, entitled 'There's a farmer had a dog', for learners to practise the targeted phoneme. With the teachers' guidance, the learners sang the song while performing the actions (Figure 3).

Figure 3: Learners practised the phonemes with songs.

In the Blend stage, a learner was called to the researcher's desk at a time, while the other learners engaged in their reinforcement exercises. The selected learner received several phonemes and was instructed to perform the corresponding actions and sounds. Subsequently, the learner was asked to place the phonemes on the arm and blend them into a word (Figure 4).

Figure 4: Learner demonstrated blending the phonemes into words.

The same RPT was administered to the learners as the posttest after 12 English lessons (Figure 5). The learners used about 35 minutes to complete the test. The test papers were collected, and the scores were calculated and tabulated.

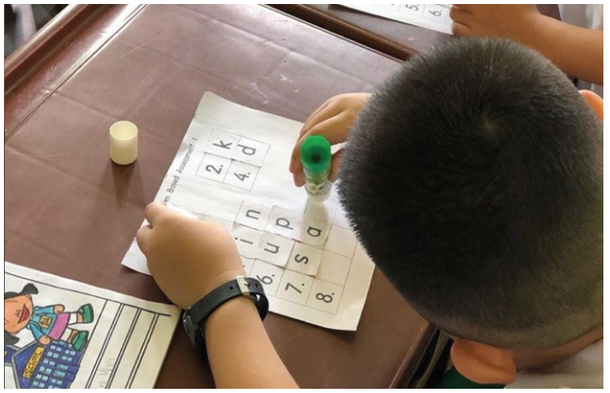


Figure 5: Learners were completing the RPT (posttest).

Findings and Discussions

In this section, the findings are presented in response to the research questions outlined.

RQ1: What is the level of mastery of letter-sound correspondences among young Malaysian ESL learners before and after implementing the ASB approach?

Table 1 displays the learners' RPT scores prior and after the intervention. It was found that 21 out of 22 learners scored less than 50% before the intervention was introduced. L19 achieved the highest score of 19 (M=0.56), while L3 scored the lowest score of 3 (M=0.09). After the intervention, it was observed that L1 scored full marks (M=1), whereas L4 obtained the lowest score of 17 (M=0.5). Moreover, all learners in this study showed improvement in their RPT scores from the pretest to the posttest.

Table 1: Learners' test scores before and after the intervention.

Learner	Before (out of 34 marks)	After (out of 34 marks)
L1	15	34
L2	9	28
L3	7	22
L4	3	17
L5	10	24
L6	8	33

Table 1: Learners' test scores before and after the intervention *(continued)*

Learner	Before (out of 34 marks)	After (out of 34 marks)
L7	8	29
L8	6	31
L9	9	32
L10	6	26
L11	5	25
L12	10	32
L13	9	32
L14	6	32
L15	3	31
L16	11	33
L17	9	30
L18	15	29
L19	19	33
L20	7	32
L21	10	30
L22	8	30

RQ2: Is there any significant difference between the level of mastery of letter-sound correspondences among young Malaysian learners before and after implementing the ASB approach?

The RPT mean scores before (M=8.8) and after (M=29.3) implementing the ASB approach was compared in a line graph and presented in Figure 6.

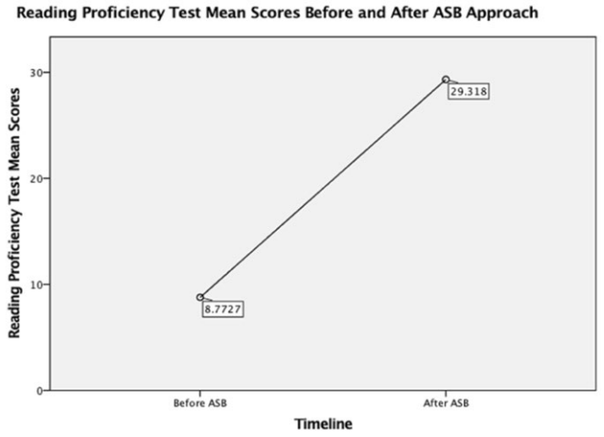


Figure 6: RPT mean scores before and after ASB approach.

A dependent sample t-test was conducted on the learners' RPT scores before and after the intervention to identify if there was any significant difference between both sets of data. The SPSS output generated t(21)=-22.913, p<.001. Therefore, the null hypothesis (i.e., there is no significant difference between the means for pretest and posttest) was rejected since the p-value is less than .05. In other words, the mean of learners' RPT scores after the intervention was significantly higher than their RPT scores before the intervention.

RQ3: How does the RPT assess the reading proficiency of young Malaysian learners?

In the field notes, the researcher indicated that the RPT assessed various aspects of the learners' reading proficiency. For example, the researcher observed that learners needed to demonstrate discrimination skills to differentiate the "phonics action for /o/ sound and /a/ sound". Besides, learners were required to show blending and segmenting skills when they tried to combine or separate the words into individual phonemes. Furthermore, comprehension skills were also observed when learners matched words to the corresponding pictures. Besides, the RPT also facilitated a more focused observation of learner behaviours. For example, the researcher observed that learners "could not choose the correct letter card" to be pasted in Section A of the RPT.

This section discusses the findings obtained and presents them according to the RQ. Generally, all the learners improved in their reading proficiency, as evidenced from the RPT scores after intervention. The improvement could be due to the effect of the Act in ASB approach in memorising the actions and subsequently linked to recognising phonemes. This aligned with the TPR method, whereby actions and bodily movements were used to strengthen the learners' memory of the presented words (Rokhayati, 2017). Apart from that, the Sing in ASB method might also help to engage learners in the learning of letter-sound correspondences. As the use of 'There's a farmer had a dog' song, which was catchy and fun for the learners, may have lowered their anxiety level and facilitated their learning.

Besides, the researcher's field notes also indicated that the learners employed a variety of reading skills when completing the RPT. This suggests that the RPT could assess various aspects of learners' reading proficiency, such as to discriminate, segment and blend individual phonemes.

CONCLUSION

This study investigated the effectiveness of the ASB approach in improving the learners' mastery of letter-sound correspondences, while RPT was used to determine whether the learners have acquired the mentioned skills. The findings

from the study indicated that there was an increase in the RPT scores from pretest to the posttest, while the difference between the scores were statistically significant. Besides, RPT was also found to assess different aspects of learners' reading proficiency. Therefore, it could be suggested that ASB approach offers fun, technology-integrated and learner-centred learning to improve the learners' mastery of letter-sound correspondences, while RPT provides a holistic assessment of learners' reading proficiency. Future studies could include a non-equivalent group to compare the findings between groups after the intervention. Besides, interviews could also be carried out with learners to obtain in-depth understanding regarding the ASB approach. Overall, the study tackles Sustainable Development Goal (SDG) 4 - Quality Education.

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YOUTUBE VIDEO LINK OF ASB APPROACH

ANSWER

D	G	A	R	A	O	U	R	I	O	K	S	L
I	L	C	F	R	U	I	T	A	X	M	I	A
S	H	A	I	W	N	N	A	E	I	T	N	Y
T	A	C	W	A	Y	A	R	N	S	L	V	A
I	R	B	H	A	O	M	G	E	I	A	I	S
L	O	S	U	N	S	I	A	N	K	H	G	A
L	M	I	A	I	A	C	T	O	O	A	O	S
A	A	U	O	T	U	O	O	M	T	L	R	E
T	T	S	S	B	P	A	C	I	A	I	A	A
I	I	A	E	R	A	N	L	L	N	T	T	L
O	C	B	I	A	G	V	O	D	A	N	I	G
N	A	A	S	A	R	A	W	A	K	H	N	H
O	F	D	E	N	S	I	T	Y	O	T	G	I

1. Scientific name of the plant used for LitSara® products. – *Litsea cubeba*
2. A compound found in LitSara® essential oil which is also a major component in the oil of citrus fruit peels. - *D-limonene*
3. "LitSara®" is a fusion of Litsea and Sarawak.
4. LitSara® scent was described as *invigorating* and crisp.
5. A technology used for essential oil extraction. – *Distillation*
6. SBC has formalised Benefit Sharing Agreements (BSA) with *six* villages.
7. Long Kerebangan is located at *Lawas,* Sarawak.
8. LitSara® oil can be extracted from the leaves and *fruit*.
9. *Aromatic* compounds are usually found in flowers or leaves.
10. Oil floats on water because of *density*.

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