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Article

Waste to Chemical: A New Green Chemistry Concept for Malaysia Post Covid-19

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Abstract: This paper is primarily focusing on alternative chemical production to aid the recovery of the world economy, besides improving the educational and environmental sectors after the Coronavirus pandemic (Covid-19). The remarkable impacts of Covid-19 are the increased usage of hand sanitisers, masks and the need of Covid-19 vaccine has become the basic necessity. The manufacture of these essential materials requires fossil fuels (ethene) as a solvent in their production. However, energy from the burning of fossil fuels causes negative impacts on the environment such as global warming and pollution. In certain market segments, chemical companies are currently facing supply shortages. In response to the current issues, our team aims to review a concept in achieving a better future post Covid-19. By deepening Science, Technology, Engineering and Mathematics (STEM) knowledge in education, we had addressed to new ideas, that is Waste to Chemical (WTC) to produce energy from waste instead of fossil fuel. This WTC transform excess biomass to energy, fuel, and other useful chemicals. From the literature review, this new process is less costly compared to the conventional process because it only make use of cheap and raw materials. Furthermore, this process can reduce the biomass waste and lessen the dependency on fossil fuels in chemical industry. We hypothesized that the WTC method can become an innovation process that can solve environment and economic crisis besides reduce the dependency on the non-renewable fossil fuels. The WTC is also can be regenerated, eco-friendly and requires minimal energy consumption. The outcome from this paper can educate society with Green Chemistry concept and implement critical engineering mind to overcome the real-time environmental issues.

Keyword: *Alternative Chemical Production, Education, Green Chemistry, STEM, Waste to Chemical (WTC).*

1. Introduction

The world has been affected by a type of virus that is killing people on a large scale and the virus was named SARS-CoV2 by the World Health Organization (WHO). Another malady coronavirus that has caused a worldwide pandemic which significantly has changed human life in numerous parts. During the pandemic, the use of personal protection equipment (PPE) such as masks, gloves, and sanitisers has been part of our daily life. The WHO has requested a 40% escalation of disposable PPE production to slow the spread of coronavirus disease (Sarawut Sangkham, 2020). In response, 116 million single-use face masks had been produced each day in China, which is 12 times higher than the usual quantities. Based on the research conducted by Sarawut Sangkham, the estimated number of face masks used in Asia during Covid-19 pandemic was 2,228,170,832 (Sarawut Sangkham, 2020).

The production of these PPEs requires large quantity of ethanol as solvent in the manufacturing processes. To produce ethanol, fossil energy such as petroleum, coal and natural gas are needed. The production of ethanol is, however, lead to environmental pollutions as substantial amounts of CO_2 is released to the atmosphere. This has significantly contributed to the global warming.

The increasing concern here is the threat to energy security, climate change, global warming, environmental degradation, and the depletion of fossil fuels due to fossil fuel over-usage. This has propelled the need to shift towards more sustainable energy usage. Hence, we propose a safer alternative method of producing ethanol using the Green Chemistry concept. Ethanol production using fermentation utilises only 25% of the carbon from sugars and starches which is then released as CO_2 into the atmosphere (Shobhana Ramtekea & Bharat Lal Sahu, 2020). Ethanol production via the fermentation process is thus, more environmentally friendly compared to the use of fossil fuel. As such, the use of Green Chemistry as an alternative design for the chemical processes can reduce and eliminate the release of harmful substances to the environment. In this paper, we explained how to synthesis ethanol using fermentation of biowaste instead of using fossil fuel.

2. Carbon accumulation by conventional method

We are currently witnessing an ongoing hike in fossil fuels consumption. Based on the data obtained from Our World in Data (2020) based on BP Statistical Review of World Energy (2019), the United States of America is the world's largest consumer of fossil fuels (66,525 MWh) followed by Australia (64,592 MWh), Germany (33,836 MWh), the United Kingdom (25,528 MWh), South Africa (24,437 MWh), China (23,373 MWh), Europe (44,188 MWh) and India (6,303 MWh). The largest consumers use ten times more fossil energy than the smallest consumers.

Fossil fuels, including coal, oil and natural gas are the major source of energy in the world. Fossil fuel formation happens from the decomposition of organic matter in the earth crust over millions of years. The trade of fossil fuels has developed the U.S. economy since the last century. The increased use of fossil fuels especially in the industry has however, tremendously led to a negative impact on the environment and human health. For example, the United States greenhouse gas contribution is driven by massive use of fossil fuels. In manufacturing industries that substantially increased the earth's temperature. As reported in the BBC News (2020), the Death Valley National Park in California, has recorded a temperature of 54.4°C becoming the hottest place in the world. This has been verified by the US National Weather Service (National Weather Service,2020). The high usage of fossil fuel resulted in global warming that can bring changes and disruptions to climate cycles, habitats and may eventually result in droughts and floods. Floods caused by extreme weather increase the risk of drinking water and the spread of water borne diseases.

The spread of Covid-19 is forecasted to increase

the use of fossil fuels. If humans continue to use fossil fuels at the current rate, the CO_2 gas in the atmosphere is expected to increase by six-fold. This may eventually contribute to global warming and increase the risk of death from stroke, heart disease, lung cancer, and respiratory illness. Therefore, the use of fossil fuels needed to control so that sustainable environmental and human health can be reserved.

Figure 1 summarizes some of the significant threats when using fossil fuels in chemical industries. First and foremost, the fossil fuels are changing our climate. The amount of carbon found in fossil fuels is more than enough to warm the plant to a dangerous level. Moreover, according to Rogelj et. al., (2019), it is estimated that our carbon budget is remaining 12 to 15 years old from now. The carbon budget is the amount of carbon that allows the industries to emit carbon without going over 1.5 degrees. Going beyond this threshold will incur severe health issues including premature death and asthma. We can expect that over the 12 years if we are still to use fossil fuel as our main raw material in manufacturing ethanol, our world will be doomed to doomsday. On top of that, the fossil fuel is also expected to run out storage in 2060. Nunez (2019) has stated that currently, fossil fuels are the world's energy supply at 80%. Globally, oil demand is assumed to rise by an average of 2.2 percentage a year from 2018 to 2021. Moreover, the depletion of fossil fuels led to an increased petroleum price. Thus, we need alternative and renewable energy to replace the dependency on fossil fuels.

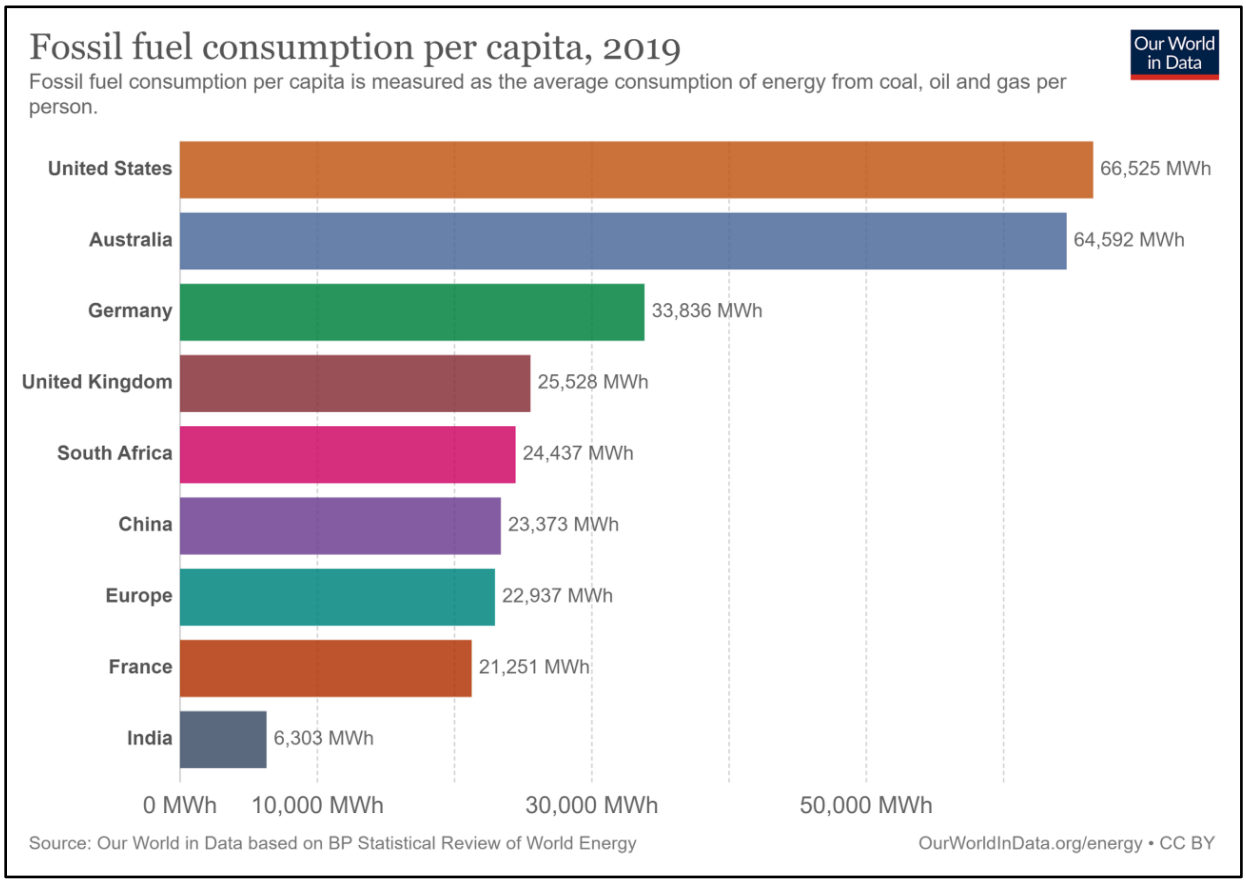

Figure 1: Fossil fuel consumption per capita in 2019
Source: Our world in Data, retrieved from: https://ourworldindata.org/fossil-fuels

3. New discovery Waste-To-Chemical (WTC)

To promote a sustainable environment and economy, the industrial sector must adopt renewable energy. Thus, the policymakers must devise policies that shift more use of alternative renewable energy. One way is by choosing to introduce a safer and environmentally friendly method called the Waste-to Chemical (WTC) process.

The WTC refers to a renewable energy process that can transform wastes and residues into energy. The wastes and residues sources could be biomass or materials that have been thrown away, such as wastepaper, grass cuttings and wood chipping. In the WTC process, ethanol (fossil fuels) is produced by fermentation (Busic & et.al., 2018). *Zymomonas mobilis*, *K. oxytoca* and *E. coli* are the bacteria used to convert the waste biomass to ethanol (Yang & Zhang, 2016). This method is preferred as it is an alternative way to pass out the fossil fuel in the production of ethanol and it is known as bio-ethanol technology.

For a better insight into the process, there are three steps altogether, pre-treatment, extraction of fermentable sugars and fermentation. The pre-treatment process is where the preparation of feedstock into smaller sizes (this increases the surface to volume ratio) for sugars extraction. Next, the extraction process that transforms various sugars polymer chains into simple fermentable sugars (Busic & et.al, 2018). The last step is the fermentation process where the fermentable sugars are converted into cellular energy and whereby, ethanol and CO_2 are produced as metabolic waste. Furthermore, this process is conducted without the presence of oxygen (anaerobic process) using yeast, *Saccharomyces cerevisiae*. The theoretical yield of bioethanol is 0.51 g per one gram of glucose consumed during fermentation.

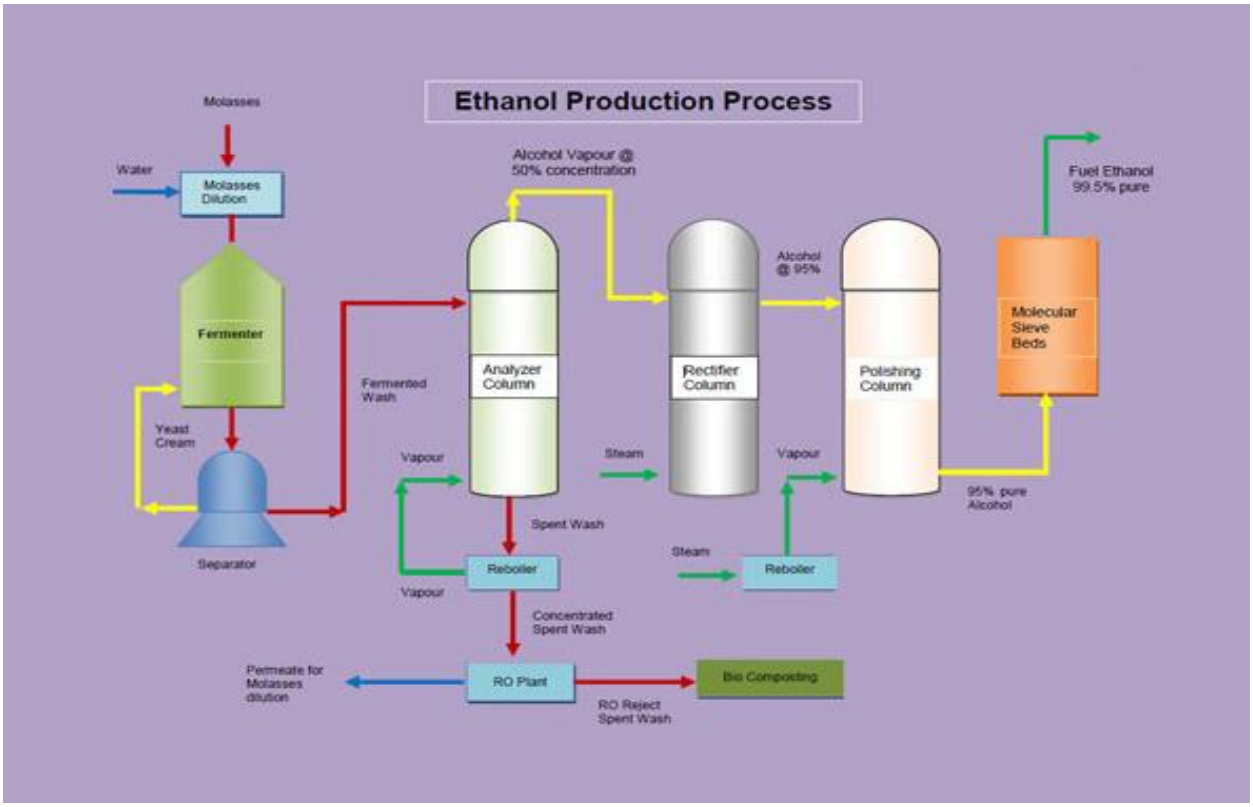

Figure 2: Prototype for ethanol production process
The illustration was adopted from:
https://www.exportersindia.com/product-detail/project-report-for-bio-ethanol-manufacturing-4843895.htm

The production of biofuels is significantly safer than fossil fuels especially in offsetting the greenhouse effect. It is undeniable that CO_2 still emitted during the fermentation process but as the biomass was obtained from plants (corn and sugarcane), the CO_2 released during this process is the same (quantity) as it is being absorbed by the plant (Hanaki & et. al., 2018). The biofuel linked carbon cycle friendly thus, it can reduce the harmful greenhouse effect, but not the fossil fuels.

From safety perspective, it is dangerous to yield fossil fuels and its product as it involves a risky drilling, mining, and crude oil extractions. In contrast, bioethanol is safe as the raw materials comes from waste materials such plant biomass. Moreover, it can easily break down into organic substances compared to the fossil fuel.

Interestingly, research shows that bioethanol can be produced by green alga, *Scenedesmus obliquus*. Microalgae not only use inorganic nutrients (such as nitrogen and phosphorus) for their growth, but also contribute to produce oxygen that will be utilized by other aerobic bacteria. Besides, algae also frequently used in the bioindustry for removing metals and xenobiotic substances from the water surface. Moreover, *S. obliquous* algae can accumulate carbohydrates in their biomass and these sugars can be extracted to produce fermentable sugar for bioethanol production (Ragaa & et.al., 2016). Thus, the biological method can be used to overcome both waste pollution and water pollution.

4. Waste-To-Chemical (WTC) awareness in schools

Uncontrolled dumping of garbage in Malaysia is one of the reasons contributing to environmental pollution, especially to water and soil. The impact on the environment due to poor waste management is enormous. Therefore, awareness on the importance of recycling and reusing to reduce waste must be instilled in all, especially in school students. In schools, teachers play an important role by creating awareness in the younger generations using STEM subjects such as biology, chemistry, and physic. For instants, the teachers can teach how household waste such as spent vegetables and fruits can be used to generate renewable energy. This approach is fairly practiced in Sekolah Kebangsaan Bendang Pa'yong, Tumpat, Kelantan. The 3R (Reduce, Reuse and Recycle) programme which was incorporated into the STEM syllabus and in collaboration with Universiti Sains Malaysia (USM) has yielded great success. The programme's objective was to integrate knowledge, attitude, and practices on 3R among the school students.

Armenia for example has a very limited and irregular waste management practice that had led to environmental pollution in the past. To overcome this problem, various programmes have been held, for example, programmes organized by the Urban Foundation for Sustainable Development (UFSD) and supported by SGP to help and reduce environmental pollution in that country. Designated places have been proposed to send and dispose of garbage properly. Therefore, the authorities have taken an alternative route from the programme by sending waste to the chemical industry to produce bioethanol.

To reduce pollution, it is undeniable that early education on environmental management is important for children. Therefore, many initiatives can be taken to introduce early education on environment management such as promoting the recycling and reusing concept to the community. For example, teachers can promote the concept of a recycling plan to students by creating a recycling schedule in each class where tasks such as separating garbage into 3R-labelled bins can be done. This will train the students to apply good practices in waste management. Teachers can also introduce the topics on bioethanol and teach them how to produce them from household wastes. Furthermore, these recycling activities encourage students to recycle and invent useful products such as bioethanol.

5. Developing a Bioethanol Model Based on Project Based Learning (PBL) Criteria

To strengthen the concept of WTC among students, we suggest STEM teachers to integrate WTC into their teaching activity. This can indirectly be assimilated during the science class. In chemistry class, for instance, students can be asked to build a prototype for bioethanol productions. This idea is consistent with the requirement of the Ministry of Education (MOE) for teachers to implement Project-Based Learning (PBL) where learning becomes more enjoyable for the students. This can, furthermore, help the students to recognise the concept that they had learnt in the classroom. As the first step, students must be able to identify the (research) problem, "How to convert waste product (examples excess food) into ethanol?" This can lead to prototype designing as shown in Figure 2. Next, students need to analyse the problem, such as identifying the steps on how the machine works and predict the materials needed to build the model. To look over the issue, students must acquire and deepen their knowledge in WTC by reading journals, newspapers or seeking help from their teachers. Then, students must be given a time approximately 2 weeks to complete this project. This enables the students to work on strategy and time. During the progress of the project, students must be monitored and supervised by teachers and ensured the work is done as group work. Lastly, students must present their work and teachers must be able to give feedbacks on what needed to be improved. By following these suggestions, students critical thinking skills, creativity, and communication skills can be improved.

6. Conclusion

The remarkable impacts of Covid-19 are the excessive demand for the supply of hand sanitisers, vaccines and masks. The manufactures of these essential materials require fossil fuels (ethene) as a solvent to produce their product. However, energy from the burning of fossil fuels causes negative impacts on the environment such as global warming and pollution. An innovative and safer route in producing solvents such as ethanol has been discussed in this paper. The Waste-to-Chemical (WTC) concept can be the answer for the increasing concern over issues related to energy security, climate change, global warming, environmental degradation and the depletion of fossil fuels. From the academic perspective, we propose a safer alternative production of ethanol using the Green Chemistry concept. We strongly stand that this concept must be incorporated in school education with priority to create awareness among the teachers and students. This proof of concept worked well when Project-Based Learning (PBL) was tested among the school students, and it had significantly enhanced and strengthen the student's knowledge. The prototype for bioethanol production must be thought as part of PBL in chemistry lessons in school.

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