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ASPHYDROXEL: ASPHALT CARBON DIOXIDE CAPTURE BY SYNTHESIS OF POTASSIUM HYDROXIDE FOR UTILIZATION OF PALM OIL BUNCH ASH WASTE

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ABSTRACT

Environmental pollution is the most common problem faced by Indonesia, for example, industrial waste. The country of Indonesia once occupied the first position in Southeast Asia, as a country with the worst air quality. In addition, Indonesia is the largest producer of crude palm oil (CPO) and palm oil plantations in the world. The industry produces the most solid waste in the form of empty palm oil bunches and requires a large area to store it. In order to reduce the storage area needed, empty palm oil bunches are burned to ashes or palm oil fuel ash (POFA). Therefore, we have the idea of absorbing CO_2 gas and utilizing POFA as a mixture of concrete and asphalt, by converting it into a potassium chloride compound. Then, the electrolysis process is carried out toproduce potassium hydroxide compounds. The potassium hydroxide compound will later be mixed with asphalt to produce Asphydroxel asphalt, which absorbs carbon dioxide. In implementing Asphydroxel, several parties are involved, such as oil palm smallholders, palm oil mills, asphalt company research teams, asphalt companies, and the government. It is predicte that this idea will prevent the buildup of bunch ash waste and air pollution which cause climatechange.

Keywords: *Asphydroxel*, *Asphalt, Potassium Hydroxide, POFA.*

1. INTRODUCTION

Indonesia is a country with the worst air quality in Southeast Asia. This air pollution is caused by emissions from motor vehicles, power plants, and industrial waste. Motor vehicle emissions are the largest contribution to the concentration of NO_2 and CO_2 in the air, which is more than 50% [1]. Several epidemiological studies have concluded that the incidence (prevalence) of respiratory diseases such as acute or chronic throat diseases is closely related to urban air pollution levels [2].

Environmental pollution is a problem most often faced by Indonesia, for example industrial waste. Indonesia is the largest producer of Crude Palm Oil (CPO) and palm oil plantations in the world [3]. The industry produces the most solid waste in the form of empty palm oil bunches and requires large areas of land to store them. To reduce the required storage area, empty palm fruit bunches are burned to ash or Palm Oil Fuel Ash (POFA). However, because the area of oil palm plantations continues to increase every year, the ash from palm oil waste also continues to increase. In 2007 there was an increase in land area to 6.6 million ha and CPO production reached 17.3 million tonnes so that the waste produced by palm oil bunches also increased [4].

Therefore, we came up with the idea of absorbing CO_2 gas and utilizing POFA as a mixture of concrete and asphalt, by converting it into a compound of potassium chloride. Then, electrolysis process is carried out to produce potassium hydroxide compound. The potassium hydroxide compound will later be mixed with asphalt to produce asphalt carbon dioxide absorbent (Asphydroxel). It is hoped that this idea will be able to prevent the buildup of bunch ash waste and air pollution which cause climate change.

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2. METHODOLOGY

The method used in this study is general problem identification, understanding problems, literature review, development of ideas, and journal preparation.

Figure 1. Research Methodology Flowchart

1. General Problem Identification

Looking for information about existing problems in general. With this information, researchers can choose more specific problem topics to study and find solutions.

2. Understanding Problems

Understand more deeply about the topic of the problem to be researched by discussing and reviewing the literature. This method will make it easier for researchers to find appropriate and effective solutions to existing problems.

3. Literature Review

Collect literature related to the problem to be studied. This literature review can help researchers to get new ideas, narrow the scope of the problem, get to know the problem more deeply, and find solutions to existing problems.

4. Development of Ideas

Develop ideas that have been obtained from literature review by way of discussion. Discussions can be carried out with directly related parties or parties who have previously researched the same problem. From this discussion, researchers get a variety of perspectives from each party. This point of view will trigger the emergence of new innovations to develop previous research or create new research.

5. Journal Preparation

After getting new ideas or innovations, researchers put them in the journal. Writing in this journal aims to make this innovation known to the general public. It is hoped that by writing this journal, people can care more about existing problems and can try to research more about the solutions presented and provide other, more effective solutions.

3. RESULT AND DISCUSSION

3.1 Current Condition

Pollution or air pollution is one of the unresolved problems in Indonesia. In big cities or in industrial areas, air pollution is usually higher so that the air quality gets worse. Air pollution is usually found in big cities or industrial areas which causes air quality to deteriorate. In 2018, air pollution causes 7,000,000 cases of death worldwide making it the biggest health threat in the world [5]. In 2018, air pollution throughout Southeast Asia was almost double the level of pollution recommended by WHO (World Health Organization), which resulted in approximately 424,000 people dying each year due to diseases caused by air pollution [6].

Table 1. Worst air quality ranking in Southeast Asia

No	Country	Persentatiton
1	Indonesia	34,3
2	Vietnam	25,9
3	Myanmar	24,7
4	Laos	21,5

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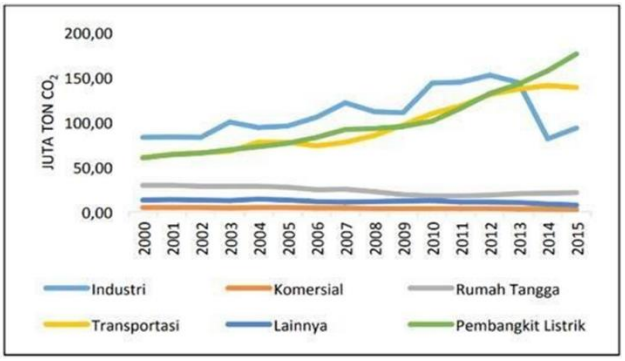
No	Country	Persentatiton
5	Thailand	20,2
6	Cambodia	19,8
7	Malaysia	19,4
8	Philippines	15,6
9	Singapore	13,8

Source: www.iqair.com, 2018

In 2021, Indonesia ranks 17th in the world and 1st in Southeast Asia, the country with the worst air quality. The city of Jakarta is the area with the worst air quality in Indonesia with DKI Jakarta air pollution level seven times higher than the WHO threshold. Apart from DKI Jakarta, cities that are among the cities with the most population in Indonesia also have poor air qualitym namely Bandung and Semarang [7].

Air pollution in Indonesia is caused by motor vehicle emissions, industrial activity emissions, forest fires, open burning, burning for land clearing, greenhouse gases, and others [7]. In 2020, the number of motorized vehicles in Indonesia will reach 136,137,451 units and will increase every year [1]. These vehicles emit emissions in the form of lead/lead (Pb), suspended particuar matter (SPM), nitrogen oxides (NOx), sulfur oxides (SO_2), hydrocarbons (HC), carbon monoxide (CO), and photochemical oxides (Ox). In addition, there are other exhaust emissions in the form of carbon dioxide (CO_2) and water vapor (H_2O) which come from complete combustion [8].



Source: esdm.go.id, 2016

Figure 2. Sectoral GHG emissions

Greenhouse gases (GHG) are gases in the atmosphere which function to absorb infrared radiation and determine the temperature of the atmosphere. Greenhouse gases in the atmosphere include carbon dioxide (CO_2), nitrogen dioxide (N_2O), methane (CH_4), and freon (SF_6, HFC and PFC) [9]. Of these greenhouse gases, the amount most produced is CO_2. Greenhouse gases (GHG) come from several sectors such as industry, commerce, energy, households, transportation, power generation, and others. The sector that produces the most CO_2 gas is the power generation sector with 175.62 million tons of CO_2, the transportation sector with 137.94 million tons of CO_2 and the industrial sector with 93.22 million tons of CO_2 [10].

Apart from motor vehicle emissions and greenhouse gases, forest burning, and open burning also contribute to exacerbating air pollution in Indonesia. Most of the burning is done for land clearing, especially in Riau province to turn forests into agricultural land [7]. According to Siti Nurbaya Bakar, Minister of Environment and Forestry, which was covered by medcom.id in 2019, the government has made various efforts to deal with air pollution. These efforts include making regulations that violate forest burning for land clearing, building parks and urban forests, organizing car-free days, making pedestrian pathways, building a network of air quality monitoring systems or e-Quality Monitoring Systems, as well as monitoring to meet emission quality standards. continuous and integrated emission

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reporting for industry [11]. However, these efforts have not been able to overcome air pollution in Indonesia due to the fact that in 2021 Indonesia will be the country with the worst air quality in Southeast Asia.

Apart from contributing a large amount of greenhouse gases, the industrial sector also contributes a large amount of waste to Indonesia. The waste can be in the form of solid waste or liquid waste. One industry that produces a lot of solid waste is the palm oil industry. Indonesia has more than 12.3 million hectares of oil palm plantations spread across 22 provinces and produced more than 34.47 million tons of palm oil in 2017 [12]. With this plantation area, Indonesia has many industries that use palm oil as raw material to produce crude palm oil (CPO). The waste generated from palm oil for every 1 ton of processed palm oil is 23% or 230 kg of empty palm fruit bunches, 6.5% or 65 kg of shells, 13% or 130 kg of coir, and 50% liquid waste [13].

One of the wastes that becomes an obstacle for factories that process palm oil is empty fruit bunches. This waste has a large volume so that the factory requires a large area and large transportation costs to dispose of this waste. This is an obstacle because every year production increases so that there will be more and more waste. To overcome this, empty palm oil fruit bunches will be burned in an incinerator (kiln) to produce palm oil bunch ash [14]. However, this certainly does not solve the problem because with an increase in production, more and more ash is produced from the combustion process.

To overcome this, oil palm bunch ash is used as fertilizer and bioethanol [13]. However, based on data from the Central Statistics Agency (CSA) in 2015, only about 10% of oil palm bunch ash is used as fertilizer because it contains high potassium, most factories only spread the empty palm fruit ashes in empty areas. Oil palm bunch ash waste contains high organic matter. The nutrients contained in the ash of the only palm oil bunches, namely K2O, are 35-47% [14]. With this content, it is very unfortunate if the palm oil bunch ash waste is not utilized properly.

3.2 Proposed Ideas

The idea put forward is to synthesize potassium from palm oil bunch ash waste and convert it into potassium chloride compound. Then, electrolysis process is carried out to produce potassium hydroxide compound. The potassium hydroxide compound will later be mixed with asphalt to produce asphalt which can absorb carbon dioxide. Oil palm bunch ash waste contains high organic matter. The nutrients contained in oil palm bunch ash are K_2O of 35-47%; P_2O of 3.5%; MgO of 6-9.5%; CaO of 4-6% and micronutrients [14].

Potassium content is taken in the form of KCl or potassium chloride. This is done because if K_2O is directly reacted with water to form KOH, there will be a violent reaction between K_2O and water. Therefore, the K_2O contained in the palm oil bunch ash is converted to KCl first. The conversion process consists of extraction, purification or separation processes, reaction processes, and crystallization [15]. The extraction process is carried out by dissolving the ash using water and mixing it until it is homogeneous. After that, the heating process is carried out and the extracted potassium is separated from the solvent by evaporation. After that, potassium in the form of K_2O is reacted with HCl to form KCl with the following reaction:

$$K_2O_{(aq)} + 2\ HCl_{(aq)} \rightarrow 2\ KCl_{(aq)} + H_2O_{(l)} \qquad (1)$$

To separate KCl from the solution, a crystallization process is carried out and then filtration is carried out so that the KCl crystals are separated from the water.

After obtaining KCl, to convert KCl into potassium hydroxide (KOH) through an electrolysis process, a KCl solution is made by dissolving KCl in water at 60°C [16]. The electrolysis process is carried out by feeding KCl solution to the electrolysis cell and entering the cathode (positive pole). At the cathode, KCl will decompose into potassium (K^+) and chlorine gas (Cl^-). The accumulation of chlorine gas will form chlorine gas (Cl_2) which will be released as a by-product. Potassium (K^+) will be fed to the anode

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and react with water (H_2O) to form potassium hydroxide (KOH) and release hydrogen gas (H_2). The reaction that occurs is as follows:

$$2KCl_{(Aq)} + 2\ H_2O_{(l)} \rightarrow 2KOH_{(Aq)} + H_{2(g)} + Cl_{2(g)} \qquad (2)$$

This reaction will produce a KOH solution with a concentration of around 40 – 45%. In order to form a more concentrated solution, evaporation, crystallization and filtration processes are carried out. The evaporation process is carried out using an evaporator to concentrate the KOH solution to 61%, then a crystallization process is carried out to crystallize the KOH. In order for the KOH crystals to separate from the KCl solution, a filtration process is carried out. The three processes were carried out repeatedly to obtain KOH crystals with a minimum level of 90% based on the literature [16].

Asphalt can be obtained through the residue of the petroleum distillation process. Fossil fuels produce carbon dioxide emissions when burned which can cause climate change. In addition, carbon dioxide can be produced naturally in the environment such as humans inhaling oxygen and releasing CO_2. If excessive carbon dioxide is produced, it can exacerbate climate change. Asphalt mixed with potassium hydroxide (KOH) at high temperatures (>600°C), can be converted into porous carbon with a surface area of: 2,780 m^2/gram. The asphalt can capture 21 mmol g^{-1} or 93% CO_2 by weight at 30 bar and 25°C [17].

The asphalt is prepared by heating at 400°C to remove volatile components and unnecessary organic molecules. Furthermore, the asphalt is heated again at 900°C with added potassium hydroxide (KOH) for about 20 minutes so that it will produce porous asphalt [18]. These tiny pores in asphalt will increase its surface area so that more CO_2 will be absorbed. With this process, asphalt will be converted into carbon storage.

Asphydroxel is an environmentally friendly asphalt because it can utilize palm oil bunch ash waste, palm oil bunch ash waste will have usable value, reduce excess carbon dioxide in the air we breathe, and prevent global warming which can cause climate change.

3.3 Parties Assisting Implementation

In order for the purpose of the Asphydroxel idea to be implemented, the Penta-Helix concept is used, with the active coordination of 5 main components, namely:

1. Oil Palm Farmers

Oil palm farmers as suppliers of raw materials for palm oil which will later be processed by palm oil factories into products made from palm oil.

2. Palm Oil Factory

The palm oil mill as a supplier of palm oil bunch ash waste, to be processed into potassium hydroxide compound.

3. Asphalt Company Research Team

The research team for the asphalt company is conducting trials and researching ideas in order to obtain the composition and design of asphalt according to the standards.

4. Asphalt Company

As a raw material processor which can then be implemented on asphalt roads.

5. Government

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The role of the government is to facilitate permitting the development of asphalt innovations, to provide support in the form of allocating funds for the development of asphalt research, and to open up opportunities to create innovations for the nation's children.

3.4 Strategic Steps to Realize Ideas

The steps that need to be planned so that the idea can be realized namely:

1. Conduct research and trials so that a product prototype is obtained that can be implemented.
2. Inform ideas to asphalt companies based on the results of research conducted so that ideas can be realized.
3. Establish cooperation between raw material suppliers, raw material processors, and the government so that this asphalt innovation can be carried out.

4. CONCLUSSION

Asphydroxel is an innovation that captures CO_2 from palm oil bunch ash. Asphydroxel is produced by synthesizing potassium from palm oil bunch ash waste and converting it into potassium chloride compound. Then, electrolysis process is carried out to produce potassium hydroxide compound. The potassium hydroxide compound will later be mixed with asphalt to produce asphalt which can absorb carbon dioxide. Potassium content is taken in the form of KCl or potassium chloride, this potassium is taken through extraction, purification or separation processes, reaction processes, and crystallization. After obtaining KCl, to convert KCl into potassium hydroxide (KOH) through an electrolysis process, then evaporation, crystallization, and filtration processes are carried out in order to obtain KOH crystals with a minimum content of 90%. The KOH crystals will later be mixed into asphalt at high temperature for approximately 20 minutes so that it will produce porous asphalt. These tiny pores in asphalt will increase its surface area so that more CO_2 will be absorbed. With this process, asphalt will be converted into carbon storage. Asphydroxel is an environmentally friendly asphalt because it can utilize palm oil bunch ash waste, palm oil bunch ash waste will have usable value, reduce excess carbon dioxide in the air we breathe, and prevent global warming which can cause climate change.

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