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A Review on oil Palm Waste as Precursor for Activated Carbon on Arsenic, Zinc, Manganese, Aluminium and Copper Removal

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Abstract: Activated carbon is recognized as a potential adsorbent for many application due to its inexpensive cost, improved pores and excellent adsorption capabilities. At the moment, the growing availability of oil palm wastes is causing a slew of environmental issues. As a result, these agro wastes have the potential to be used as low-cost precursors for the manufacture of activated carbon. The generation of activated carbon from oil palm biomass is discussed in detail in this critical review.On the synthesis of activated carbons from oil palm biomass, the impacts of various process parameters on the pyrolysis stage, features, and effects of physical and chemical activating conditions are explored. This review is focus on removal heavy metal such arsenic, copper, aluminium and zinc. Heavy metal in wastewater from industrial activities will effected human, animal and plant. Throughout this research paper, strong emphasis is given to activated carbon made from oil palm waste will produce good activated carbon. This review paper was used Scopus to find prior studyrelated to this study and extract the document to the software (VOSviewer) to get thevisualization. Overall, this review article aids researchers in moving on with their investigations into a simple and cost-effective method for producing oil palm waste- based activated carbon with high physiochemical characteristics and adsorption capacity.

Keywords: Oil Palm Waste, Heavy Metal, Activated Carbon, Scopus,VOS Viewer

1. Introduction

The growth in urbanization and industrialization technology has contributed to an increase in percentage of waste accumulation worldwide. One of the challenge is the wastewater with heavy metals bearing that finally discharge to the receiving water source. Heavy metals are elements found in a periodic table with metallic properties and a density of 5 g/cm3 [1].

The rising of heavy metal concentration in the water is mainly due to pollution discharges from industrial manufacturing [2]. The industrial revolution of the nineteenth century inserted several synthetic chemicals and heavy metal pollutants to the aquatic environment [3].

Heavy metal accumulation works against human bodies by consuming source of water with metals

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[3]. Besides that, these heavy metal that in wastewater are not biodegradable and their presence can causes bioaccumulation in living species and may lead to health issues to animal and human such as cancer, kidney failure, metabolic acidosis, oral ulcer, renal failure and damage in for [4]. The heavy metal removal from wastewater is necessary because of the severity of the problems caused by heavy metal contamination [4]. Therefore, there is a need to study on heavy metals removal from wastewater.

There are numerous methods to remove heavy metals from wastewater such as ion-exchange membrane filtration, adsorption, chemical precipitation, and coagulation and flocculation [1]. Among the methods involved, the adsorption process has been shown to be the most feasible and efficient approach for the remediation of mercury removal [5]. Activated carbon (AC) is well known as a purification method for drinking water and wastewater treatment for its ability for the elimination harmful elements like heavy metals via filtration system [6].

In recent years, several plant materials or agriculture waste with high absorptivity have been tested in removal heavy metal. These are include oil palm agro waste such as fibre, palm shell, empty fruit bunch , oil palm mesocarp , oil palm leaves and oil palm frond. The aim of this review is to acknowledge in deep the potential of oil palm waste as activated carbon for removing heavy metal such as copper, arsenic, zinc, aluminium and manganese that contains in the wastewater.[7].

2. Literature Review

2.1 Heavy metal

Heavy metals are any hazardous metals or metalloids with a relatively high atomic mass or density that are non-biodegradable, which means they cannot be eliminated by natural processes. Arsenic, cadmium, copper, lead, manganese, mercury, nickel, and zinc are examples of heavy metal elements. This heavy metal area superiority found in industrial effluent and wastewater [8]. Table 2 presents the sources of heavy metal.

Currently, one of pollution that threats surroundings is heavy metal pollution. Heavy metals can beingested by living organism due to their high solubility in the aquatic sediments, once the heavy metalsreach the food chain, substantial amounts of heavy metal can accumulate in the human body [9]. In theindustrial waste water, cadmium (Cd), chromium (Cr), copper (Cu), plumage (Pb), iron (Fe), zinc (Zn)and manganese (Mn) are the most common heavy metals found [9]. Via the discharge of waste water sources, these hazardous heavy metals can bedspread and it is possible to penetrate the delivery pipingsystem before it hits the water tap [9]. The pollution of heavy metals has put significant burden on authorities and government

Therefore, in an effort to curb the problem of heavy metals pollution standard and regulations been developed. Two requirements for effluent discharge are set out in the Environmental Quality Act (EQA) 1974: Standard A for upstream discharge and Standard B for downstream discharge of any input of raw water as indicated in Table 1.

Table 1: Discharge of Industrial Effluent of Standards A and B (EQA, 1974) Parameter

		Standard	
	Unit	**A**	**B**
Arsenic	mg/L	0.05	0.10
Copper	mg/L	0.20	1.0
Manganese	mg/L	0.20	1.0
Zinc	mg/L	2.0	2.0
Aluminum	mg/L	10	15
Selenium	mg/L	0.02	0.5

Different methods suchlike membrane filtration, ion exchange, chemical precipitation, coagulation and adsorption can remove heavy metals in industrial wastewater [10]. However, according to Shirbate [10], adsorption is well-established process regarded as the most adaptable with a quick operation system forthe removal of heavy metals. The most frequently use and efficient technique for the low-cost and chemically feasible adsorbent over recent decades is the adsorption process [11].

Table 2: Source of heavy metal (Mahmood, 2019)

Heavy metal	Source of industry
Copper	Mineral processing, chemical manufacturing processes employing copper salts or copper catalyst, mining, metal-process pickling bath and plating baths and electroplating
Zinc	Metal processing, steelworks, fibre manufacture and electroplating
Aluminium	Industries of fertilizer, mining, tannery, metal plating, batteries.
Manganese	Dry-cell battery manufacture, steel alloy, glassand ceramics, hemical manufacture, ink and dye works and paint and varnish.
Arsenic	Dye manufacture, mining, smelting, pesticide manufacture, organic and inorganic Manufacture and petroleum refining.

2.2 Heavy metal effect

Heavy metals occur naturally in low amounts in the earth's crust, but they have become concentrated as a result of industrial operations. Heavy metals created by industrial operations, such as cadmium, lead, chromium, arsenic, mercury, copper, and nickel, contribute to pollution in the environment [12]. Due to their toxicity and cancerous, heavy metals with a density more than 5 g/cm3 constitute a significant threat to the environment ecosystem [13]. Heavy metal ions are non-biodegradable chemicals that havea long time in the environment and tend to build up in the food chain which cause significant health issues, plant growth and animal habits [13].

2.3 Process in activated carbon (AC) preparation

There are two process in activated carbon (AC) which is activation and carbonization. Before the activation procedure, pre-treatment of all precursors is necessary. In this procedure, the precursor is soaked and washed with distilled water and heated at 110oCthroughout 24 hours in order to eliminate dirt or contaminants on the surface area [6]. The dry precursor can then be proceed for AC production.Production of AC involves two main methods is Physical activation and Chemical activation. Figure 2.1 shows a process of activated carbon manufacturing. In Table 3 shows the previous research on activated carbon production based on chemical activation.

Table 3: Previous Research on Activated Carbon Production based on chemical activation

Study	Type of Activation	Type of Waste	Activation Agent	Impregnation Condition %/ratio	Activation Temperature
[14]	Chemical	Palm kernel shell	Potassium hydroxide	1:1, 1:1.5 and 1:2	500-900 °C
[15]	Chemical	Palm kernel shell	Potassium hydroxide	1:1	500, 600 and 700°C
[16]	Chemical	Empty fruit bunch fiber	Potassium hydroxide Hydrochloric acid	1:1	800°C

[17]	Chemical	Oil Palm frond	Sodium hydroxide Hydrochloric acid Potassium Chromate	-	-
[18]	physical	Palm kernel shell	-	-	800°C
[19]	physical	Empty fruit bunch Palm kernel shell	-	-	900°C

2.4 Oil palm waste as activated carbon

Recently, attempts have been made to employ inexpensive and readily accessible agricultural wastes as activated carbon to remove heavy metals from wastewater, suchlike coconut shell, orange peel, rice husk, peanut husk, and sawdust. At the moment, the growing amount of oil palm waste is causing a slew of environmental issues. As a result, these oil palm wastes can be used as low-cost precursors for the production of activated carbon [20]. Palm wastes are said to be advantageous as precursors for the synthesis of activated carbon because of their high carbon composition [20]. According to the literaturereview, the carbon percentage in palm waste ranged from 43 to 47%, with ash accounting for less than 1% [20]. Table 4 shows the previous research of oil palm waste-based absorbent for heavy metal removal.

Table 4: Literature studies of oil palm waste-based absorbent for heavy metalremoval

Part oil palm waste	Reference
Oil palm frond (OPF)	[17]
Palm kernel shell	[14]
Empty fruit bunch	[18], [10], [16]

2.5 Chemical composition of oil palm waste

Oil palm is a lignocellulosic substance that is high in carbohydrates such as starch and sugar. Hemicellulose, cellulose, and lignin are the three major structural components of lignocellulosic substances. In general, the three major components have high molecular weights and provide a lot of bulk, whereas the extractives have tiny molecular sizes and are scarce [22]. Adsorbents from various parts of oil palm biomass show a varied shape according to its content (Table 5) as they were usedto increase the adsorption process by activating carbon. Anhydrous- sugar, aldehyde, hydroxyl, furan, acetic acid, and carbonaceous chars are all low molecular weight compounds produced by biomass witha higher cellulose content [23].

Table 5: Basic composition percentage of oil palm waste

Parts of oil palm biomass	extractives	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Ref
Frond	-	35	36	29	[24]
Trunk	14.50	50.21	72.60	20.15	[21]
Leaves/mesocarpfiber	-	45	48	27	[25]
Empty fruit bunch	16	25	28	27	[26]
Shell	-	28	22	44	[27]

The surface area pores development on the surface, as well as surface functional groups, regulate the adsorption characteristics of activated carbons. Mesopores, as opposed to micropores and macropores,are thought to be better for adsorption [22].

3. Methodology

3.1 Introduction

The purpose of this review paper was to conduct a comprehensive review of the literature on the subject of oil palm oil as activated carbon. Literature data were collected using systematic review. This systematic review is conducted by searching for articles on reputable websites and then picking articlesbased on keywords related to the study's title. Figure 1 describe is a research framework in this study.

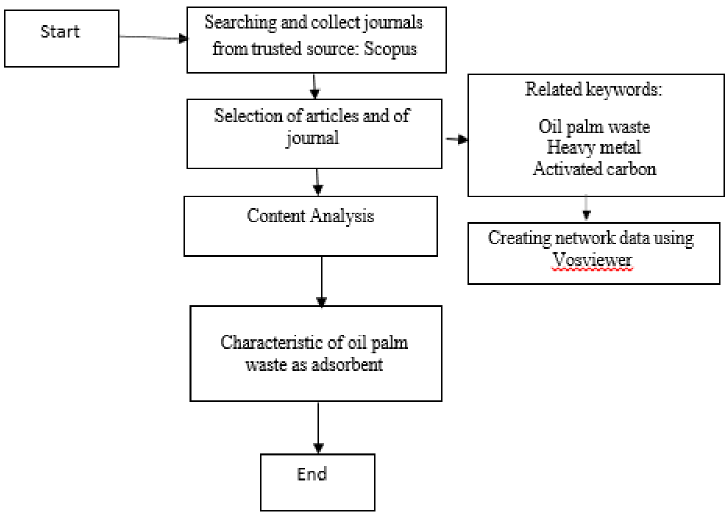

Figure 1: Summary of review process

3.2 Information sources and search methods

In this systematic review, specified keywords were used to conduct a Scopus search. Scopus was chosen for this study because Scholars have identified it as having a high level of singularity [28] and as the database with better data coverage [29].Figure 2 shows the logo of Scopus.

Figure 2: Scopus's logo

The specified search words are as follows: TITLE-ABS-KEY ("palm oil" OR "oil palm" OR "elaeis guineensis" AND "removal" AND "heavy metals"). The delimitation of the unit of analysis is the basis of any review process. The unit in this study is a single research or review publication. As a consequence, the search was restricted to "Article," "Article in Press," and "Review." This project contains all experimental articles published in peer-reviewed English journals between 2015 and 2020.The research was confined to the years 2015 until 2021. The Scopus search found 75 items. The next stage was to critically assess these findings in order to pick articles that focused on activated carbon produced from oil palm waste for removal heavy metal in wastewater. In fact, only those exclusively dealing with oil palm waste as an adsorbent were evaluated further in this research based on the analysisof query results.

3.2 VOSviewer

We used the VOSviewer program, a bibliographic data-based map, to do a Co- occurrence analysison words. Ludo Waltman and Nees Jan van Eck van (2010) developed this free software at Leiden University to create maps to depict bibliometric network data using the visualization of similarities (VOS) methodology. The frequency of publications in which two or more keywords appear together is used to determine the relatedness of the keywords. With the entire counting method, author keywords served as a unit of analysis. We needed a minimum of three occurrences of each keyword in order to construct a clear and representative network map. All the document that found in the Scopus will be extract into the VOSviewer to get the bibliographic data. Figure 3 shows the visualization that obtain from VOS viewer software.

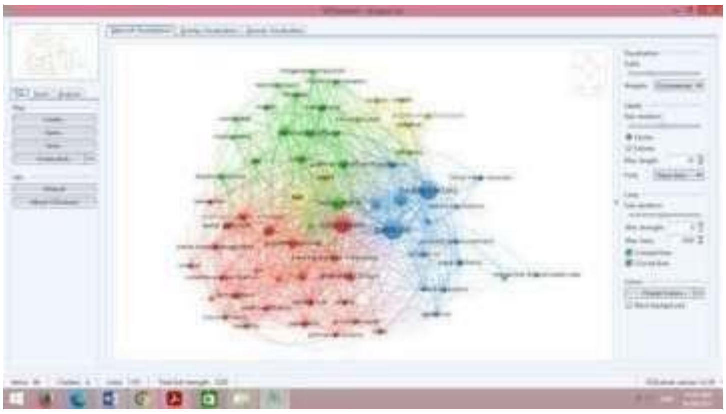

Figure 3: Network visualization

4. Results and Discussion

4.1 Data mapping

Figure 4, 5 and 6 were obtained from the Scopus. Figure 4 shows the experimental study and review paper on oil palm biomass as activated carbon publish per year. The graph present that many researcher started interested on this study. The highest year paper publish about oil palm biomass as adsorbent was in year 2020. Figure 5 shows that Malaysia and is the country with the most research onoil palm biomass.

This is because, Malaysia and Indonesia are the countries that manufacture the hugeamount of oil palm waste. The least country to do research on this is Bangladesh. Figure 6 display thatthe most type of research is article with 62.7%. Conference paper is 20% and conference review is 9.3 while review is only 5.3%.

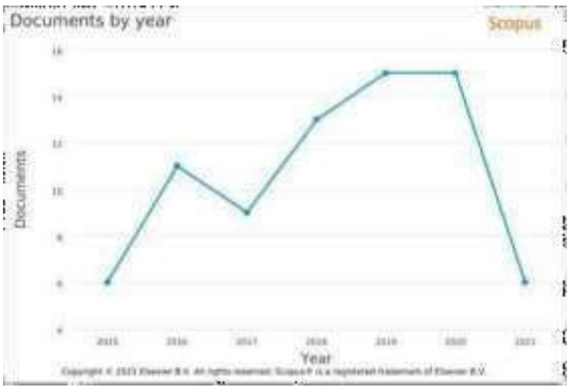

Figure 4: Evolution of publish studies on oil palm biomass as activated carbon per year

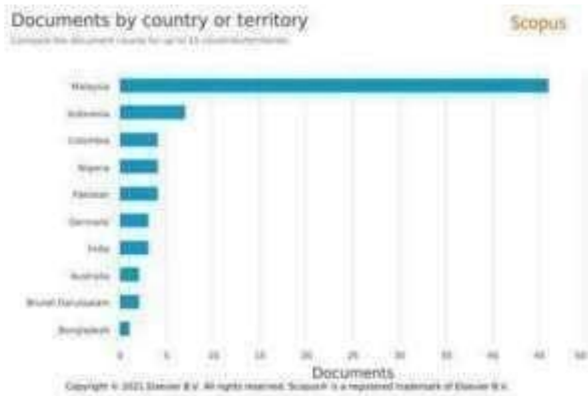

Figure 5: Country produce a paper about oil palmbiomass

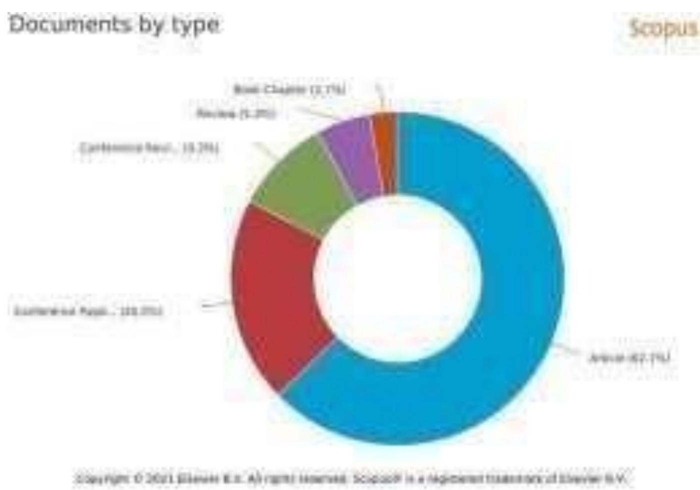

Figure 6: Type of research on oil palm biomass asactivated carbon

5. Conclusion

Oil palm waste has shown to be a viable alternative adsorbent for various pollutant types that is crucial to the long-term sustainability of the palm oil industry. Surplus oil palm biomass in the country is suitable for conversion into porous carbon value added such as empty grapes, shells, palm mesocarp fibre, and fronds. Recent research indicate that the activated carbons of oil palm biomass are often utilized in several industrial applications, including wastewater heavy metal removal, methane absorption, CO2 adsorption and many more applications.

The use of physicochemical techniques to modify the surface of oil palm waste-based adsorbents leads to a new way for improving pollutant absorption from wastewater. As a result, the method of choice might be tailored to the analyses of interest. It was also discovered that various activation treatments are required for different parts of oil palm waste in order to achieve optimal removal of specific contaminants. For physical activation high temperatures was required for all sections of oil palm bio-waste for the adsorption of organic contaminants. In short, continued and improved use of oil palm waste as a starting material for activated carbon production is required. A technique is created that allows the production and exploration of "green" adsorbents with good physiochemical and sorption capabilities.

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