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Surface Performance of Biochar from Young Coconut Shells (*Cocos Nucifera*) for Cd^{2+} Ion Adsorption

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***Abstract*— Using agricultural waste such as young coconut shells could reduce environmental pollution and support the zero-waste principle. This study aims to prepare and analyze biochar from young coconut shells and determine adsorption ability. The biochar was prepared by pyrolysis with varying temperatures, 400ºC, 500ºC, and 600ºC, and the resulting yield was 41.21%, 32.65%, and 29.79%, respectively. The biochar produced has met the Indonesian National Standard SNI 06-3730-1995 for moisture, ash, and the content of the amount of bound carbon in the biochar. Pore morphological characteristics and biochar elements were analyzed by Scanning Electron Microscopy-Energy Disperse Spectrophotometry (SEM) -EDS at 300x, 1000x, 3000x, and 10000x magnification. The pore size was 50 μm, 10 μm, 5 μm, and 1 μm with predominantly mass of element C 78.63%, atom C 85.18%. Atomic Absorption Spectrophotometry (AAS) measured the concentration of cadmium ions adsorbed using two variables; pH variable and biochar weigh variable. The absorption capacity in the pH variation indicates an increase in pH will increase the concentration of cadmium ions adsorbed, while the weight variation shows the fluctuated trend after 500 mg. The study showed an optimum biochar weight of 500 mg adsorbed 99.99% of cadmium ion. The pore size and the resulting carbon content, and the adsorption power of cadmium ions indicate that the biochar from young coconut shells has the potential to be developed industrially into activated carbon, which can be used as an adsorbent for industrial and domestic wastewater.**

***Keywords*— Biochar; young coconut shells; cadmium; SEM-EDS; AAS.**

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I. INTRODUCTION

Biochar created from rural squander can be considered a potential source for renewable vitality due to its maintainability, positive effect on the environment, and cost-efficiency. Coconut or Cocos nucifera is a plant with a tall, straight stem with large fruit. Coconut plants are one of the leading commodities of Central Sulawesi-Indonesia, with a production value of 189 661 tons in 2019 [1]. The main products of coconut trees are coconut fruit which is consists of husk and shell. Old coconut fruit is generally used as copra or squeezed for coconut milk. Coconut flesh is the main component that can be processed into various derivative products. Coconut fruit produces a shell and husk in the processing process, considered leftover squander. Coconut shell waste, either from coconut fruit handling businesses or family utilization, is essentially tossed absent. Even though it is classified as organic waste, coconut shell waste is not easily broken down by microorganisms due to its rigid nature. Also, coconut shells are quite large in weight and size. This condition has resulted in frequent accumulation of coconut shell waste disposal.

Meanwhile, young coconut is widely consumed as a drink without any processing. Coconut husk and shells are typically used as daily fuel, and they are straightforward to find in areas where young coconut traders are involved. Young coconut shells (7-10 months) can also be used as a raw material in crafting works, briquettes, and gardening items and can become income-generating [2]. For the activated charcoal industry, the types of shells that meet the quality requirements are old (11-12 months) because the wood is complex and has a low moisture content so that in the charcoal process, the ripening will take place nicely and evenly [2]. Although not industrial, young coconut shells have also been made into activated carbon used as an enrofloxacin adsorbent with an absorption capacity of 97.58% [3]. In the art field, young coconut shells have also been made as an acoustic material with high aesthetic value [4].

Efforts to utilize old coconut shell waste that has been undertaken today include processing it as biochar [5]-[7]. Several methods have been used to increase coconut shells' economic value, such as biodiesel with nano additives [8], for the synthesis of nanoparticle and antibacterial [9], as a raw material in concrete [10], as the outer layer of helmet [11], and formed as souvenirs, bags, etc. However, young coconut shell is widely used as a substitute for firewood and charcoal with high conductivity [12]. Simultaneously, a range of biochar from a wide range of organic waste has been used as the impurity's adsorbent in water, wastewater, and lake water [13], [14]. Several natural materials waste that has been made into biochar, such as *kepok* banana peel [15], red fruit [16], lettuce rice fields [17], durian bark [18], nutmeg shell [19], rambutan peel [20], rice husk and banana residue [21], and olive mill solid waste [22]. They have been applied as metal ion adsorbents of Cadmium, Lead, Copper, and Iron. The adsorption process occurs by the use of porous materials, which are biochar. The manufacture of adsorbent from young coconut shell waste is also used to reduce environmental pollution and support zero-waste.

Biochar has a large enough carbon binding function [23]. Biomass generally consists of cellulose, hemicellulose, and lignin. The study results stated that materials containing cellulose, hemicellulose, and lignin could treat hazardous heavy metal wastes because they have good absorption capabilities [24]. Young coconut shell contains 46.10% cellulose, 28.25% lignin, and 25.65% hemicellulose. [25]. Due to the significant biomass content, young coconut shells can be made into biochar, used as a metal adsorbent.

Biochar comes from biomass heating in a state of constrained oxygen or without oxygen, produced by using high-temperature organic waste as raw material. Biochar can be included in the soil to progress soil function and diminish biomass emanations, breaking down greenhouse gases. Biochar properties are affected by the sort of crude fabric, pore absorption, surface region, chemical properties of the biochar surface and are also influenced by the activation used [26]. The activation stage is carried out by soaking the biochar using active ingredients such as $ZnCl_2$, KOH, and H_3PO_4. H_3PO_4 as the enactment specialist gave the leading comes about when compared to KOH and ZnCl2 [27]. The activator is a dehydrator that can diminish the remaining OH and CO from the carbonized carbon. This study made biochar from young coconut shells, which were used as an adsorbent for cadmium ions. The adsorption power of biochar was measured by an Atomic Absorption Spectrophotometer (AAS). SEM-EDS analyzed the biochar to measure the pore size and determine the product's impurity metals.

II. Materials and Method

The raw materials utilized in this research were young coconut shells taken directly from the waste of young coconut drink sellers, furnace (Barnstead Thermolyze), digital balance (adventurer Ohaus), shaker (gemmy orbit shaker model VRN-480), filter paper (Whatman 42), flask, porcelain cup, measuring pipette, dropper pipette, desiccator, $CdCl_2$ solution, buffer solution, Scanning Electron Microscope (SEM, JSM 63660 LA)-Energy Dispersive X-ray Spectroscopy (EDS), and Atomic Adsorption Spectrophotometer (AAS, GBC 932 AA).

The research procedure was carried out by adopting the method in previous studies [15], starting with preparing raw materials, which is dried young coconut shells, then made into biochar by pyrolysis process in a furnace. The resulting biochar was measured for its moisture content and ash content. Samples with moisture content and ash content that complied with SNI 06-3730-1995 were analyzed for pore morphology and carbon content by SEM-EDS. Biochar with the best surface quality and high carbon content will be used to adsorbent to adsorb cadmium ions. Before measuring its adsorption on cadmium ions, the optimum pH and optimum weight of biochar are calculated. The research method is described as a flowchart in Figure 1.

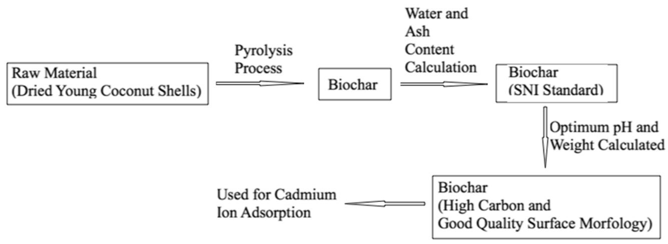

Fig. 1 Research Procedure flowchart

A. Biochar Preparation

The sample was washed to remove impurities, cut into little pieces, and dried for five days beneath coordinate daylight. 200 gr dried specimens were then burned (pyrolysis) for 4 hours in a furnace. The variation of temperature 400ºC, 500ºC, and 600ºC was applied, after which the samples were cooled at room temperature for 24 hours. Biochar mashed with grout and pestle. After that, biochar was sifted to a 70-mesh.

B. Water Measurement

Biochar (1 gr) was placed in a weighed porcelain dish (W1), then dried in an oven with temperature 105ºC for 3 hours, then chilled in a desiccator. The moisture content of biochar determines by weighed the samples (W2).

C. Ash Content Measurement

1 gr biochar was placed into a weighed porcelain dish (W1). The plate was then put into the furnace, and the temperature was set to 800ºC. The sample was left for 3 hours, then cooled in a desiccator and measured until it reached consistent weight (W2). Ash content was then calculated.

D. Pore Morphology and Elemental Composition Analysis

The biochar made is then characterized by its pore morphology using Scanning Electron Microscopy (SEM), while the biochar composition is analyzed by Energy Disperse Spectrophotometry (EDS). Filtering Electron Microscopy (SEM) could be a test handle that looks at a test with an electron pillar to create a magnified picture for investigation. The strategy is additionally known as SEM investigation and SEM microscopy and is utilized exceptionally viably in microanalysis and disappointment examination of strong inorganic substances. Electron microscopy is running at tall amplifications, creates high-resolution pictures, and precisely measures tiny highlights and objects. Energy-dispersive X-ray spectroscopy (EDS) is an expository procedure that empowers the chemical characterization/elemental examination of materials. A test energized by a vitality source (such as the electron pillar of an electron magnifying instrument) disseminates a few of the retained vitality by launching a core-shell electron. A better vitality outer-shell electron at that point continues to fill it put, discharging the contrast in energy as an X-ray that encompasses a characteristic range based on its molecule of the root. This permits the compositional examination of a given test volume that energizes the vitality source. The crests' position within the range distinguishes the component, though the flag's concentration compares to the attention of the element.

E. Determination of the Optimum pH

The 100 ppm (5 mL) Cadmium ion solution was placed into a 200 ml flask, then 45 mL of buffer solution pH 4.0 to 8.0. were added to the stirring mixture. Then 0.5 grams of biochar was added, and the flask was then covered with aluminum foil. The combination was placed on the shaker for 2 hours. After that, it was sifted with Whatman 42 filter paper. The resulted solution was collected then the adsorption capacity was measured using an Atomic Absorption Spectrophotometer (AAS) with a flame from ethylene air at a wavelength of 228.8 nm.

F. Determination of the Optimum Weight

Biochar was weighed 300, 400, 500, 600, and 700 mg, respectively, then blended with 100 ppm (5 mL) Cadmium ion solution at optimum pH in the previous step. 45 mL of buffer solution was added to the mixture. Then the flask was sealed with aluminum tin. The solution was left on a shaker for 2 hours. After that, it was separated with Whatman 42 filter paper. The resulted solution was collected then measured its adsorption using an Atomic Absorption Spectrophotometer (AAS) with a flame from ethylene air at a wavelength of 228.8 nm.

G. Adsorption Calculation

Adsorption percentage (adsorption efficiency) calculated using the equation $Cb = Ci-Ceq$ and $\% Cd = Cb / Ci \times 100\%$; where, Cb is the adsorbed cadmium ion concentration (mg / L); Ci is the starting concentration of the solution (mg / L); and Ceq is the final concentration of solution (mg / L) [28].

III. Results and Discussion

The biochar yield decreased significantly with increasing pyrolysis temperature (Table 1). At temperature 400ºC the product was 82.42 gr, followed by 500ºC with the work of 65.30 gr, and then 600ºC; the result was 59.58 gr. Study on biochar preparation from old coconut shells, it is known that the shrinkage of mass and heating value is directly proportional to the high temperature of the charcoal; the higher the temperature of the charcoal, the higher the shrinkage of material mass and the greater the calorific value [29]. At temperatures, 350ºC-400ºC organic elements such as N, S, O, and H evaporate. However, element C is still stable so that there is an increase in a specific temperature range, while at temperatures of 450ºC-500ºC, element C also disappears. The fixed temperature is indicated by the presence of ash formed in the resulting biochar [30].

The coconut shell's combustion process, which consists of very complex carbohydrates, will cause a series of reactions, namely thermal decomposition, and generate heat due to the decay of various molecular structures. At 275ºC, the lingo cellulose in the coconut shell begins to release H_2O and CO_2 gas; besides, it also forms charcoal and methane. The carbonization temperature will significantly affect the charcoal produced so that the correct temperature determination will determine the charcoal's quality [31].

TABLE I
CHARACTERIZATION OF BIOCHAR

Pyrolysis Temperature	Yield (%)	Content of Water (%)	Content of Ash (%)
400 ºC	41.21	5.89	7.65
500 ºC	32.65	4.86	8.76
600 ºC	29.79	3.51	9.34

A. Water Content

Determination of water content aims to determine the hygroscopic properties of biochar. Table 1 shows that the biochar's water content is relatively small and has rescued the standards of quality biochar based on the National Standard of Indonesia No. 06-3730-1995, which is a maximum of 15%. The number indicates that the sample's water content has vaporized during heating and diminishes with the expanding heating temperature. Build upon the results produced, biochar has hygroscopic properties, which could adsorb various gases or fluids [15].

B. Ash Content

Determination of the content of ash aims to resolve the range of metal oxide in carbon. These metal oxides are minerals in the crude sample, such as clay, silica, calcium, and others, that do not evaporate during the pyrolysis process. Table 1 indicates that the ash content of biochar has met the National Standard of Indonesia (SNI), which is a maximum of 10%. The content of ash will increase with increasing pyrolysis temperature. The ash content in biochar can influence its adsorption capacity since it could clog the surface in biochar to cover the pore's active site [32]. The higher fiery debris substance leads to higher tidy emanation and influences the combustion productivity; additionally, the lower the dynamic remains substance, the way better the quality of the biochar [33].

C. Pore Morphological Characteristics and Elemental Composition

Scanning electronic microscopy (SEM) analysis was carried out to see the biochar's microstructure originating from young coconut shells. Although the three products met the quality requirements of coconut shell charcoal according to SNI 06-3730-1995 for moisture and ash content, the biochar from the pyrolysis process temperature of 500ºC was chosen for further study. The choice of the temperature of 500ºC refers to previous researchers who found that the ash content did not pass the SNI standards in preparing biochar from coconut shells, which was 21.30% with a pyrolysis temperature of 400-450ºC [34]. Biochar was produced using a modified volume furnace, unlike the furnace used in this study, namely the Barnstead Thermolyze furnace.

SEM employments a central pillar of high-energy electrons to create an assortment of signals at the surface of strong examples. The signals that infer from electron-sample intelligence uncover data around the test, counting exterior morphology (surface), chemical composition, crystalline structure, and introduction of materials making up the test. Information is collected over a chosen region of the surface of the test, and a 2-dimensional picture is made that appears spatial assortment in these properties. Regions extending from around 1 cm to 5 microns in width can be imaged in a checking mode utilizing routine SEM methods (magnification 20X to around 30,000X, spatial designation of 50-100 nm).

The advanced definition of amplification is the proportion between two estimations, which infers those two objects are required for an adjusted esteem assessment. The primary object is the sample. The moment may be a picture of it. However, the fact is that the test will not alter its measure; the image can be printed in a boundless number of distinctive sizes. Magnification could be a relative number, and it is of no practical utilize within the logical field. After magnification, the equation remains a dubious portrayal and does not consider the determination. This implies that scaling the same picture to a greater screen will cause the magnification number to alter. The field of pore characterizes the measure of the include to be imaged. This esteem regularly ranges between a few millimeters to a few microns and some nanometers.

When the electron test two-dimensionally filters the example surface, an SEM picture shows up on the screen of the show unit. On the off chance that the filter width of the electron test is changed, the magnification of the shown SEM picture is additionally changed. Since the measure of the screen is unaltered, diminishing the check width increments the magnification while expanding the filter width diminishes the magnification. The pore morphology of the biochar surface made at 500ºC was differentiated using a Scanning Electron Microscope (SEM) tool magnification 300 times, 1000 times, 3000 times, and 10000 times.

The magnification is 300 times (Fig. 2), the pore size is 50 µm. In contrast, for the 1000 times magnification (Fig. 3), the pore size is 10 µm, and the magnification is 3000x (Fig. 4) the pore size of the biochar surface is 5 µm, and the magnification is 10000x (Fig. 5) the pore size of the biochar surface is 1 µm. This pore size indicates that the biochar from young coconut shells has the ability as an adsorbent. The microstructure of the biochar with a magnification of 10000 times showed relatively porous proportions. Single visible pore hole. The pore structure and surface area of biochar can benefit soil health and provide nutrients for plants because of its capacity to adsorb dissolved organic compounds, gases, and inorganic nutrients [35]. The carbonization process influences the morphology of the pore structure. The sulphonating process did not follow the carbonation process of young coconut shells at 500ºC for 4 hours. Unlike what was done in the morphological study of the carbon structure of corn cobs carbonated at 400ºC for 1 hour and the size of 60 nm, mesh produced random pores with pore diameters of 3 µm - 10 µm [36].

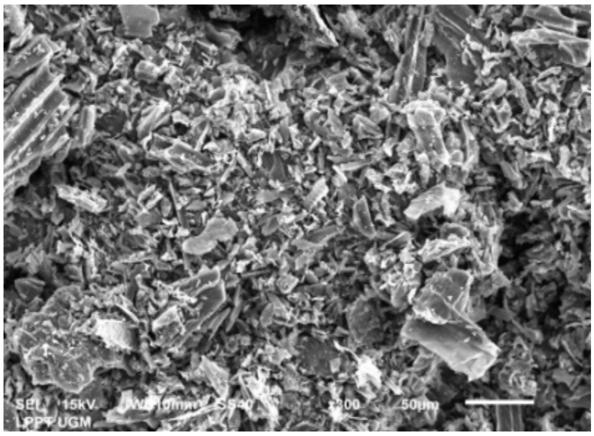
Fig. 2 Pore morphology at a magnification of 300x

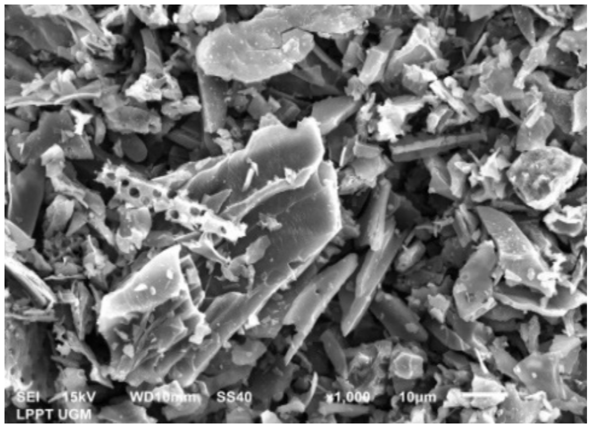
Fig. 3 Pore morphology at a magnification of 1000x

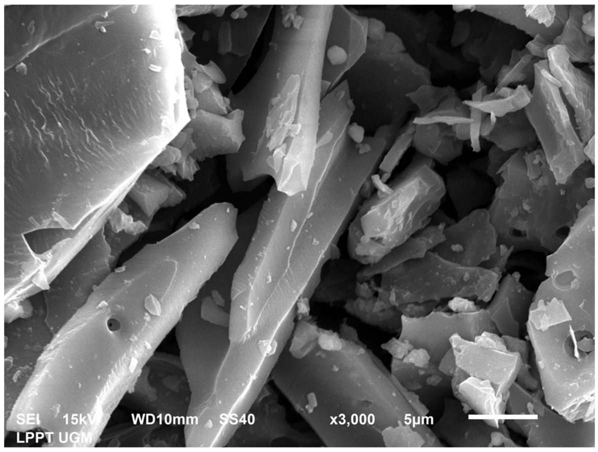

Fig. 4 Pore morphology at a magnification of 1000x

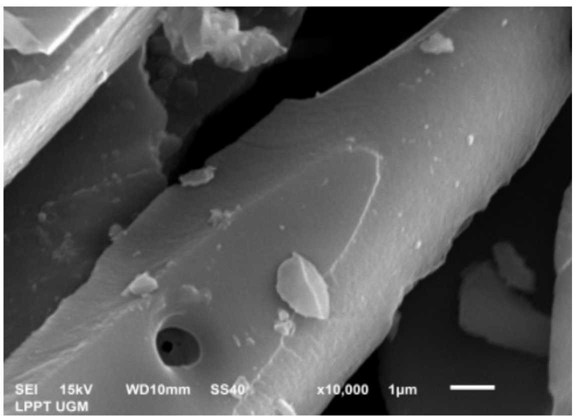

Fig. 5 Pore morphology at a magnification of 10000

Pore size has been estimated on shale, which may be a sedimentary shake shaped by compression of powdered sediment and soil-measured mineral molecules [37]. The examination utilized an open-source picture preparing computer program (ImageJ). SEM picture investigation is fundamental as shale properties can be straightforwardly watched, and critical points of interest concerning offbeat store conditions are superior caught on. SEM pictures are collected efficiently over a zone of arbitrary areas inside, a cleaned thin section. After the pictures' division into pores and grains point by point, data on pore volumes and pore sizes are collected. The methodology for picture collection is dependent upon the nature of the test and its pore framework. The SEM amplification is set agreeing to the extent in pore measure we are endeavoring to characterize. Depending upon the tests, we may collect pictures from irregular, non-contiguous areas over the test range or frequently disseminated, covering areas. Pore sizes and zones are measured, and the comes about prepared to supply add up to pore regions and pore measure dissemination information [38].

The elemental analysis results using EDS (Fig. 6) showed that the significant constituent average was dominated by carbon. However, there were still elements that were found such as oxygen of 15.87%, sodium 0.56%, magnesium 0.34%, chlorine 0.31%, potassium 1.32%, and copper 0.97%. While the atom percentage of carbon was 85.18%, oxygen 12.91%, sodium 0.31%, magnesium 0.18%, chlorine 0.11%, potassium 1.10%, and copper 0.20%. The results of element analysis (Table 2) conducted with EDS showed that biochar from young coconut shells could be used as an adsorbent because it has a high mass (78.63%) and atoms (85.18%).

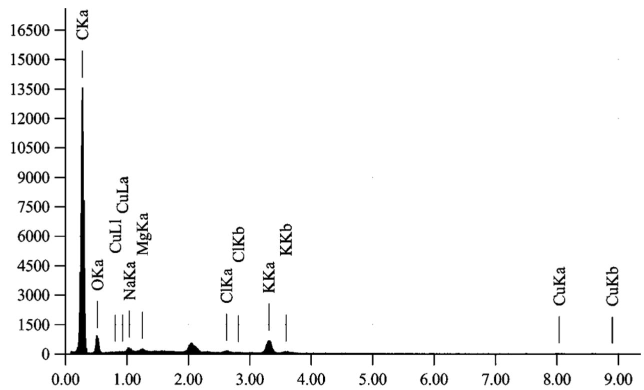

Fig. 6 Elemental Analysis of Biochar by EDS

TABLE II
THE ELEMENTS COMPOSITION OF BIOCHAR ANALYZED BY EDS

Elements	Mass (%)	Atom (%)
C	78.63	85.18
O	15.87	12.91
Na	0.56	0.31
Mg	0.34	0.18
Cl	0.31	0.11
K	3.32	1.10
Cu	0.97	0.20

Compositional data, down to the nuclear level, can be obtained with an EDS locator's expansion to an electron magnifying instrument. As the electron test is filtered over the trial, characteristic X-rays are transmitted and measured; each recorded EDS range is mapped to a particular position on the test. The quality of the comes about depends on the flag quality and the cleanliness of the content. Flag quality depends intensely on a significant signal-to-noise proportion, especially for following component location and dosage minimization (which permits for speedier recording and artifact-free comes about). Cleanliness will affect the number of spurious crests seen; this is often due to the materials that make up the electron column [39].

D. Effect of Biochar pH on Cadmium Ion Adsorption

The degree of acidity is a factor that significantly influences the adsorption process of metal ions in the solution because the presence of H^+ ions in the solution will compete with the cations to bind to the active site. Besides, pH will also affect the ion species present to simulate the ion interaction with the active adsorbent site [40]. The optimum pH in research on cadmium ion adsorption by biochar from young coconut shells was determined at various pH 4.0; 5.0; 6.0; 7.0, and 8.0. This pH variation aims to determine the optimum pH of the adsorption of cadmium ion solution by biochar.

In Fig. 7, it can be seen that the pH influences the adsorption of cadmium ions. At pH 4.0 to pH 8.0, there is an increase in cadmium ions' adsorption, which is relatively high with an adsorption percentage from 93.80% to 99.65% with an adsorbent weight of 500 mg.

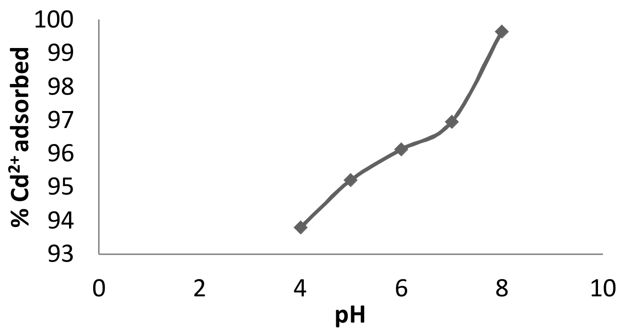

Fig. 7 The curve of the relationship between pH and percentage of cadmium adsorbed by biochar

The low adsorption that occurs at pH 4 and 5 is due to a few conceivable outcomes. To begin with, at low pH, there is a competition between H^+ and Cd^{2+} to associated with utilitarian bunches on the surface of biochar; moment, at low pH, the utilitarian bunches on the surface of biochar are encircled by H^+ ions to prevent the contact between cadmium ions and structural groups on the face of biochar. Third, the biochar body is positively charged so that there is an electrostatic rejection of the Cd^{2+} ion [28]. Whereas at pH 6 to 8, the adsorption that occurs is very large, 96.13% to 99.65%. The reason is that the number of H^+ ions begin to decrease, making the biochar surface tend to ionize by releasing H^+ ions, and the biochar surface becomes negative [41].

On the adsorption process, the low absorption of Cd^{2+} by biochar at a lower pH is due to the base's protonation (functional) group of the absorbent material. The active site has a positive tendency. The impact of the interaction between the hydrogen ion and the dynamic location is decreased or lost. Conversely, an increase in pH resulted in a busy area, increasing absorption capacity [42].

Referring to the data, it can be perceived that the ideal pH in biochar has not been obtained. That is because the maximum absorption peak point has not been received, but the absorption pattern of biochar continues to increase as the solution's pH value increases. Optimization of pH has been carried out in the biorefinery process of cocoa pods to extract pectin. The result showed that the pH had a fundamental impact on the render of cellulose, the content of pectin, and the content of methoxyl [43].

E. Effect of Biochar Weight on Cadmium Ion Adsorption

In this research, biochar acts as an adsorbent, where the adsorbent is a parameter that significantly influences the adsorption procedure of Cd^{2+} ions in dilution. The significant tare of biochar shows the figure of adsorbent molecules that can adsorb heavy metal particles at a specific concentration. Designation of the ideal weight of biochar for adsorption of Cd^{2+} ion was carried out at variations in the importance of the adsorbent, 300, 400, 500,600, and 700 mg addition of a buffer of pH 8. In this study, the contact time has not been varied; only a single contact time is 2 hours. Previous studies' variation in contact time showed that the difference in the quantity of cadmium ion taken up by biochar of durian bark was not significantly different [18].

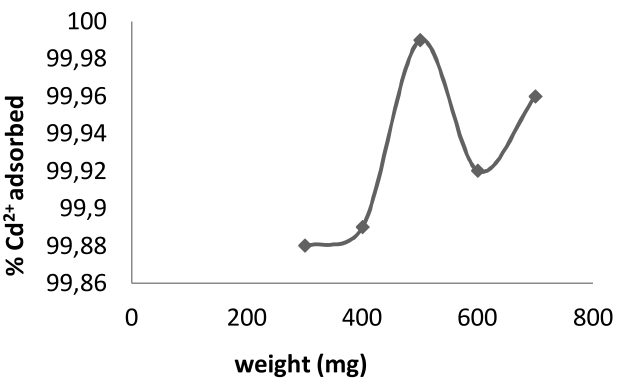

Fig. 8 The curve of the Relationship Between Biochar Weigh (mg) and percentage cadmium ion adsorbed

Fig. 8 shows that 300-500 mg adsorbent weight increases the percentage of adsorbed Cd^{2+} ions. However, at the adsorbent weight of 600 mg and 700 mg, the adsorption is relatively decreased due to the weak interaction between biochar and Cd^{2+} ion.

The results can be explained that the increase in the weight of biochar is relative to the rise in the number of molecules and the board region of the biochar. The more biochar, the higher the adsorption's active site, the adsorption efficiency increases. In contrast, the absorption capability diminishes with the increment within the adsorbent [20]. The adsorption capacity would decrease as the amount of adsorbent used increases [44]. The adsorption efficiency at 600 mg and 700 mg adsorbent tended to decline. This is since the biochar has completely adsorbed the cadmium particles in the mixture. It can too happen since the adsorbent surface is, as of now, soaked with cadmium particles. The increment in adsorbent weight moderately directly not influences the increment in metal particle take-up by the adsorbent [45].

Based on this information, it can be the view that the excellent adsorption of Cd^{2+} ions proceed at 500 mg by weight of biochar with an absorption proportion of 99.99%.

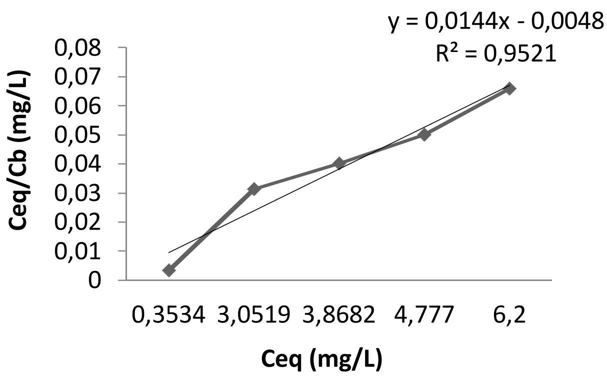

Fig. 9 Langmuir Dimensionality Arc for Cd^{2+} Ion adsorption based on Biochar pH

In this research, the Langmuir adsorption isotherm condition is applied to the adsorption energy of cadmium ions by biochar. Langmuir adsorption isotherm may be a demonstrate approach, both balance and adsorption energy. This show is based on a few presumptions: the adsorbent surface is homogeneous, so the adsorption vitality is steady throughout. Each substance is adsorbed at a suitable area on the adsorbent side, and each part of the body can only accommodate one molecule or atom [46].

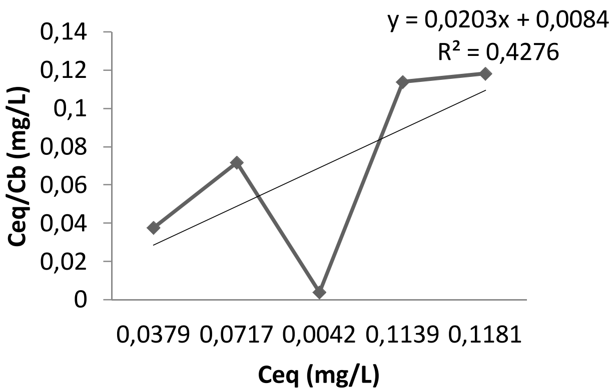

Fig. 10 Langmuir Dimensionality Arc for Cadmium Ion adsorption Based on Biochar Weight

The adsorption isotherm model for apiece adsorbent mass is decided by looking at the coefficient of determination (R2) in the adsorption regression of y on x. The most considerable relationship coefficient esteem shows that the adsorption handle utilizing the adsorbate is by the assumptions typical. The greater the correlation coefficient value, the significant correlation between the amount of adsorbed and the adsorbate mass [45].

The data in Fig. 9, namely the linearization graph of biochar to adsorb the cadmium particles at different pH solutions, found a relationship coefficient R2 = 0.9521 absorption affinity (k) of 0.00006 a maximal adsorption capability (am) of 69.44 mg / g. This implies that in every 0.00006 grams or 0.06 mg of biochar from a young coconut shell, it can adsorb cadmium ions by 69.44 mg/g. Meanwhile, in Fig. 10, which is the graph of the linearization of biochar on the different adsorbent weight, the relationship coefficient R2 = 0.4276 absorption affinity (k) is 0.00017 maximum adsorption capacity (am) is 49.26 mg/g. It is stated that every 0.00017 grams or 0.17 mg of biochar can absorb cadmium ions by 49.26 mg /g.

Based on the description above, it is revealed that the adsorption capacity proceeds to decrease as the quantity of adsorbent used increases. In variations in the solution's pH, only 500 mg adsorbent with an adsorption capacity of 69.44 mg/g. For variations in the adsorbent weight, the adsorption capacity decreased to 49.26 mg/g because the adsorbent was very large, namely 300 mg to 700 mg. This informs that the biochar undergoes desorption, which is the activity of discharging the absorbed ions. The adsorbent is saturated because everything is bound to metal ions in solution and the metal ion equilibrium is the same as the concentration of biochar [15].

IV. CONCLUSION

The biochar derived from young coconut shells was prepared at pyrolysis temperatures of 400ºC, 500ºC, and 600ºC for 4 hours, resulted in 41.21%, 32.65%, and 29.79% yields of biochar, respectively. The moisture content was 5.89%, 4.86%, and 3.51%, while ash content was 7.65%, 8.76%, and 9.34%. The pore morphological characteristics and the biochar elemental composition for a temperature of 500ºC were analyzed with Scanning Electron microscopy-Energy Disperse Spectrophotometry (SEM)-EDS at magnifications of 300x 1000x, 3000x, and 10000x with C elements dominated by 78.63%. The concentration of cadmium ions adsorbed by the biochar at a temperature of 500°C was measured by Atomic Absorption Spectrophotometry (AAS). Adsorption of cadmium ions at various pH solutions, namely pH 4 to 8, indicates that increasing the pH value will increase the concentration of adsorbed cadmium ions. Meanwhile, the adsorbent weight variation shows the optimum weight of 500 mg with a percentage of 99.99% cadmium ion adsorbed.

The process of making biochar greatly influences the product's surface (pore) condition. The pyrolysis temperature and the type of furnace used also affect the quality of the biochar. A furnace modification can be done to see the difference in biochar produced. Biochar activation also affects pore size. In this study, the biochar has not been activated yet. The biochar activation process will be carried out chemically and physically in further research, hence producing the activated carbon. Activated carbon is a form of charcoal that has been started with open pores morphology. Its absorption power is high—activated carbon functions as a filter to purify water, gas purification, beverage industry, pharmaceuticals, catalysts, and other uses. Analysis of biochar's pore morphology produced at temperatures of 400ºC and 600ºC needs to be done and its adsorption power to metal ions measured. Because coconut fruit waste consists of pulp, shell, and belt, it is essential to carry out further research to make activated biochar from old and young coconut husk and test its adsorption power against other heavy metals such as mercury (Hg), arsenic (As), copper (Cu), iron (Fe), Nickel (Ni), and lead (Pb). It is also necessary to make biochar from various agricultural wastes to find alternative porous substances as adsorbents. Activated charcoal is an alternative energy source that can be used for multiple fields of application.

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