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Quick sand filtration in restaurant waste treatment with coconut fiber and activated carbon media: application of Van der Waals Force

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Abstract. Domestic liquid waste has become the leading cause of aquatic pollution, with a percentage of 60-70%. One of the media that has the potential to process water is coco fibre. This study aimed to analyze the Effectiveness of both media in reducing restaurant waste. The experiment was conducted with variations in the Thickness of coco fibre and activated carbon media of 10, 15, and 20 cm and sand 40 mesh of 10 cm. The addition of sand media proved more effective in meeting quality standards with the Effectiveness of the reduction of Total Suspended Solid (TSS), Chemical oxygen demand (COD), and turbidity, the highest obtained at the Thickness of coco fibre media 20 cm activated carbon 20 cm, and sand 40 mesh 10 cm, which is respectively 95.78, 93.04, and 98.72%, which is influenced by the Thickness and time of contact of waste with the media.

Keywords: coco fibre, activated carbon, filtration, restaurant waste treatment

I. Introduction

Filtration is a simple, inexpensive, and effective method of treating domestic wastewater [1],[2]. Filtration is a waste treatment process that separates solids from fluids by utilizing porous media to remove colloids, suspended materials, and other substances present in waste [3]. The goal is to filter out as many contaminants as possible in wastewater using filter media [4]. The filtration system can remove color, odor, taste, heavy metals, and pathogenic bacteria in the waste [5]. The ability of the filtration media to remove contaminants comes from the adsorption mechanism. This mechanism originates from the Van der Waals force mechanism, a relatively weak electric attraction due to permanent or induced molecular polarity [6].

One of the filter media that can be used is natural fibre. Natural fibres are environmentally friendly and widely available in nature. In addition, natural fibres also have advantages such as being cheap, durable, lightweight, and non-toxic [7]. Coconut fibre is an example of filter media derived from natural fibres [8]. The advantages possessed by coconut fibre are volume value, strong surface area, and high resistance to biological degradation [9]. Coconut fibre also can reduce Biochemical Oxygen Demand (BOD) by 98.58% and Total Suspended Solid (TSS) by 83.51% in restaurant wastewater [1].

Activated carbon can absorb dissolved substances in water, both organic and inorganic [10]. The use of activated carbon in wastewater treatment is an effective method, easy to apply, and relatively inexpensive because it can be produced from natural materials such as agricultural waste, which contains much cellulose. Activated carbon can reduce Total Suspended Solid (TSS) levels of tuber washing waste with an effectiveness of 93.93% [11]. In another study, using activated carbon in batik wastewater treatment with a heap height of

80 cm and a residence time of 75 minutes in reducing BOD and TSS levels showed efficiency levels of 82.3% and 86.5% [12].

The use of coconut coir in the treatment of restaurant waste can be optimized when combined with activated carbon. Coconut coir has active scavenging components, namely lignin, and tannins, so that it can remove suspended organic matter and materials such as TSS and BOD [13]. Meanwhile, activated carbon can remove odor, color, yellow, and other harmful elements contained in restaurant waste [14]. The results of the research that has been done also show that processing restaurant waste with coconut coir media, activated carbon, and sand can reduce some of the contaminants in the waste [1].

Based on the description above, quicksand filtration using coconut coir media and activated carbon as filter media has the potential to change pH and reduce TSS, COD, and turbidity parameters in the processing of restaurant waste in an economical, effective and efficient manner and can meet applicable quality standards. However, there has yet to be research to determine its Effectiveness in treating restaurant waste. Thus, this study aimed to analyze the activity of coco coir layer media and activated carbon as a filtration medium in changing pH and reducing TSS, COD and turbidity parameters. This research is expected to be an alternative to treating restaurant wastewater in the future.

II. Method

This study uses a quantitative approach to the experimental method. The research was conducted in several locations: (i) household waste sampling in Gampong Lampugob, Syiah Kuala District, Banda Aceh City. (ii) the location of the filtration treatment was carried out at the Environmental Engineering Laboratory of UIN Ar-Raniry Banda Aceh, and (iii) the parameters for examining restaurant waste were carried out at the Environmental Engineering Laboratory of UIN Ar-Raniry.

Rapid sand filtration experiments in restaurant waste treatment using coconut coir and activated carbon media were carried out by designing a filtration unit using a PVC pipe with a diameter of 4 inches and a length of 50 cm with an output hole measuring ¾ inch and a length of 20 cm with a distance of 5 cm from the bottom. Filter media arranged vertically. The first screening layer of coconut coir with a thickness of 10 cm, 15, and 20 cm. The second filter layer consists of activated carbon with a thickness of 10 cm, 15 cm, and 20 cm [1]. Restaurant waste is put into the filtration unit as much as one liter. The treatment is carried out by opening the faucet that has been installed, and then the contact time of the waste with the filter and the discharge of water that comes out is measured and recorded [15]. Furthermore, the time and discharge of waste that comes out are recorded, and then the waste is accommodated. The treatment was repeated by adding 10 cm of 40 mesh sand media, with the same Thickness of coconut coir and activated carbon as before.

Data analysis was carried out by calculating the Effectiveness of reducing the parameters TSS, COD, and Turbidity in wastewater before and after treatment. Process efficiency is a value that compares the magnitude of the parameter values that enter a process with the values that come out of the process [16]. The amount of efficiency is expressed as a percentage (%), using equation (1).

$$\text{Effectiveness (\%)} = \frac{(A_0 - A_n)}{A_0} \times 100\% \quad (1)$$

A_0 is the pollutant level before processing, and A_n is the pollutant level after processing.

III. Results and Discussion

The results of sample measurements with the parameters pH, COD, TSS, and turbidity before and after the filtration treatment and the percentage of reduction are shown in Table 1.

Table 1. Results and Effectiveness (%) of pH, TSS, COD, and Turbidity measurements before and after filtration treatment

Medium Thickness (cm)			Time (seconds)	Debit (m^3/h)	Parameter						
Coconut Coir	Activated Carbon	Sand 40 Mesh			pH	TSS (Mg/l)	Ef TSS (%)	COD (Mg/l)	Ef COD (%)	Turbidity (NTU)	Ef Turbidity (%)
Preliminary Measurement					4.6	237	-	482	-	878	-
10			150	237.6	4.8	228	3.78	416	13.69	622	29.15
15	0		207	172.8	5.0	220	7.17	404	16.18	509	42.02
20			232.2	154.8	5.2	172	27.42	335	30.49	411	53.18
	10		120	298.8	4.9	184	22.36	411	14.73	449	48.86
0	15		137.4	259.2	5.1	212	10.54	296	38.58	476	45.78
	20		154.2	230.4	5.2	199	54.00	220	54.35	328	62.64
	10		285	126	5.3	109	16.03	240	50.20	414	52.84
10	15	0	315	111.6	5.2	216	8.86	212	46.05	495	43.62
	20		423.2	82.8	5.3	169	28.69	150	68.89	383	59.37
	10		294	122.4	5.0	100	57.80	138	71.36	308	64.92
15	15		358.8	100.8	5.4	194	18.14	129	73.23	440	49.88
	20		450	79.2	5.5	217	8.43	110.8	77.01	507	42.25
	10		363.6	97.2	5.2	93	60.75	103	78.63	302	65.60
20	15		462.8	75.6	5.5	139	41.35	92.6	80.58	398	54.66
	20		586.2	61.2	5.6	137	42.19	93.8	80.74	393	55.23
	10		1080	32.4	6.5	84	64.55	205	57.48	32.4	96.30
10	15		1200	28.8	6.6	53	67.39	130	73.02	25.4	97.10
	20		1380	25.2	6.7	41	81.70	101.5	78.94	15.6	98.22
	10		1560	21.6	6.5	78	67.08	71.3	85.20	28.0	96.81
15	15	10	1950	18	6.6	70	70.46	61.6	87.21	25.5	97.09
	20		2022	14.4	6.7	20	91.59	54.8	91.55	11.5	98.69
	10		2531	10.8	6.6	82	65.40	64.4	86.21	29.3	96.66
20	15		3488	7.2	6.7	30	87.34	56.4	88.29	13.9	98.41
	20		3725	7.2	6.8	10	95.78	53.7	93.04	11.2	98.72
quality standards					6-9	30	-	100	-	25	-

Effect of media thickness on increasing pH and decreasing TSS, COD, and turbidity parameters

a. pH Parameters

The Thickness of the media affects changes in the pH value. Based on Table 1, the thicker the media, the greater the pollutant allowance. The results of statistical analysis with sig also support this. pH 0.000 <0.05, meaning that the media's Thickness affects changes in the pH value. The thicker the media used, the more absorption of organic substances that cause acids or bases in the waste [17]. Based on the results in Table 1, the pH value of the measurement results tends to be acidic. This is because restaurant waste contains many organic or fatty acids derived from ingredients or processed food products. Acidity in restaurant waste is caused by organic substances such as organic acid molecules, organic carbon nitrate, and phosphate [18]. These substances can lower the waste's pH, causing the waste to be acidic. With filtration, some substances that cause acidity are adsorbed on the media. The Thickness of the media in the filtration process affects the results of the filtration process. This is because the thicker the filtration media, the wider the surface area for holding or binding the contaminants and the longer the distance traveled by the waste, so the processing results are more optimal. Figure 1 shows differences in treatment results with coconut coir media and activated carbon with variations in Thickness.

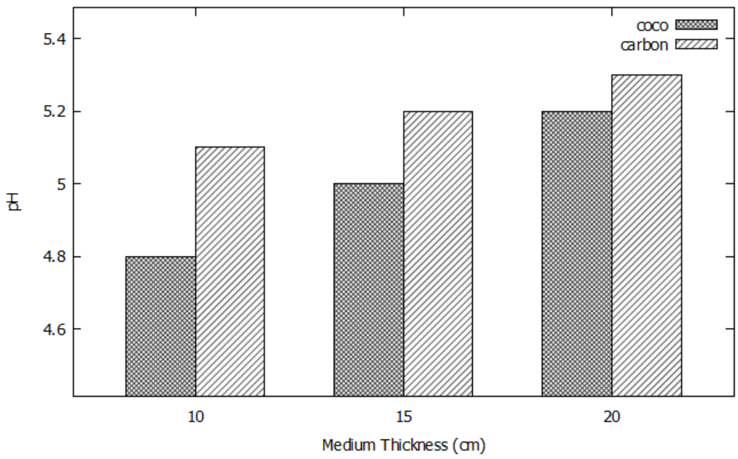

Figure 1. Diagram of increasing pH on a single media filter.

Based on the measurement results shown in Table 1 and Figure 1, filtration with coconut coir and activated carbon can change the pH value, although it does not meet the quality standards. The ability of coconut coir to bind organic substances could be more optimal. This indicates that filtration with these media requires additional media to obtain more optimal results. These results follow the findings of [19], which stated that filters with coconut coir media increased the pH of the wastewater. However, this value needs to meet the quality standard. These results also corroborate the findings of [1], which reported that using coconut coir as a single medium is not optimal in reducing pollutant content in restaurant waste. This indicates that filtration with coconut coir requires other media to optimize the Effectiveness of the filtration. Figure 1 also shows that activated carbon media can increase the pH more optimally than coconut coir. This indicates that activated carbon has a better absorption capacity for organic acids than coconut coir. These findings indicate that the increase in pH is affected by the type and Thickness of the media; the thicker the media used, the higher the increase in pH. The greater the amount or volume of activated carbon used in adsorption, the better the adsorption quality.

In addition, the sand media also can hold pollutant particles in the waste. The smaller the size of the sand, the more pollutants will be retained in its pores. This indicates that, in its application, the Thickness of the media needs to be considered so that the filtration becomes effective. Based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.68/Menlhk-Setjen/2016 Concerning Domestic Wastewater Quality Standards, the allowed pH is 6-9. Thus, the treatment results with a combination of coconut coir-activated carbon-sand media have met the quality standards.

b. TSS Parameters

TSS or suspended solids are substances not dissolved in water [20]. TSS is an organic or inorganic pollutant that is often found in liquid waste, which makes the water cloudy and blocks sunlight from entering the waters so that it can interfere with the photosynthesis process. The TSS value is determined by the number of solid particles in wastewater [21]. Based on Table 1, the concentration of TSS in restaurant waste before filtration was 273 mg/l. Figure 2 shows a decrease in TSS with coconut coir media successively as the thickness increases.

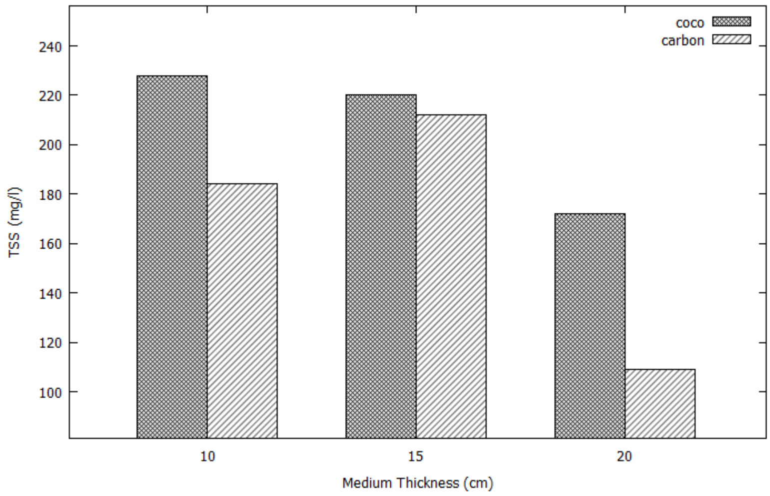

Figure 2. TSS reduction diagram on a single media filter

Coconut coir contains lignin and tannins, which can absorb organic substances to remove the TSS content in waste [1]. The thicker and more coconut coir used the more entangling substances that can bind organic substances that cause TSS and cause turbidity in the water. This result is also strengthened by statistical analysis, which shows a sig TSS value of $0.000 < 0.05$, which means that the TSS removal is affected by the Thickness of the media. However, the removal of TSS by activated carbon media occurs fluctuating; this is thought to be due to the presence of residual activated carbon and causes suspended substances in the waste to increase, as shown in Figure 1. This also occurs in the media combination of coconut coir and carbon active shown in Table 1 and Figure 3.

The amount of TSS in waste is not only caused by a large number of suspended particulates but also by substances dissolved in water, such as the color of the materials used [22]. The quality of the activated carbon used as a filter media needs to be considered as well as the raw material and manufacturing process because it affects the filtration process results. The use of activated carbon as a filter media needs to be combined with other media; this is intended so that the additional media can capture and retain the remnants of activated carbon residue. Apart from the presence of residues, the reduced Effectiveness of TSS absorption by activated carbon can also be due to the distribution of adsorbate molecules that enter the filtration media particles as adsorbents that are not absorbed optimally and the contact time is too short [1].

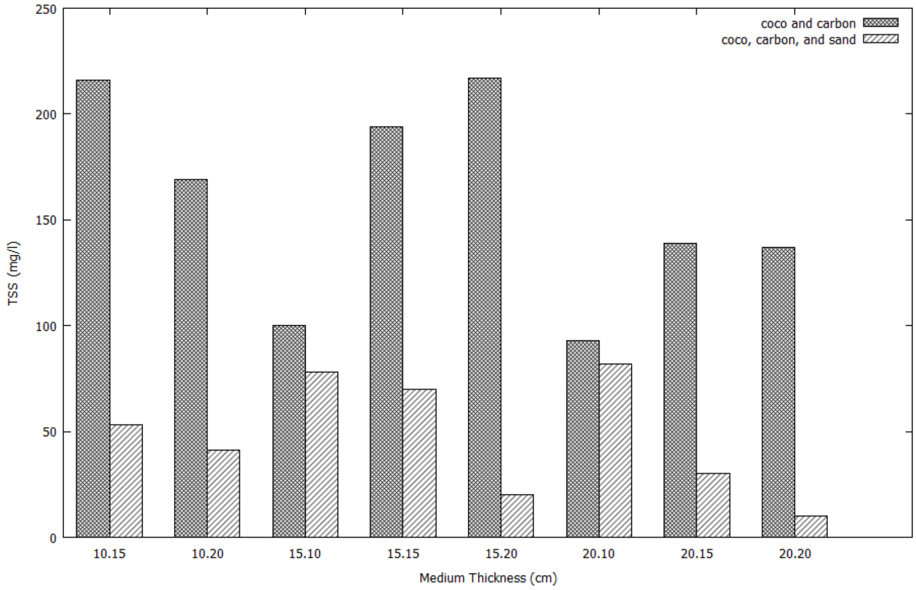

Figure 3. Diagram of TSS reduction in media combinations.

Based on Table 1 and Figure 3, the results of treatment with the addition of sand media were able to reduce TSS more optimally. The most optimal reduction occurred in the Thickness of 20 cm of coconut coir, 20 cm of activated carbon, and 10 cm of sand, 10 mg/l, with an effectiveness of 95.78%. This indicates that the sand media can remove TSS in waste and residual particles from activated carbon which causes high TSS. The removal of pollutant particles by sand is influenced by the shape and size of the sand used. This size shape functions to hold certain particles that cause TSS when passing through the media. The smaller the size of the sand, the aggregate structure or mineral groups will be denser so that the filter results will be better. Sand is a good filter media and can be used in the clarification process because of its porous, degraded, and uniformity-free grain properties. Sand grains with pores and gaps can absorb and hold particles in water. During filtering, colloids or substances suspended in water will be retained in the porous media to improve the water quality. However, sand must be optimized with activated carbon to remove odor and taste [23].

c. COD Parameters

Chemical oxygen demand (COD) is the need for oxygen to chemically oxidize organic compounds in irrigation [15]. Based on Table 1, restaurant waste before treatment has a COD value of 482 mg/l. This value does not meet quality standards, so processing is needed to reduce COD levels in waste. Organic substances produced by restaurant activities influence the high COD in wastewater. Treatment using coconut coir and activated carbon media can periodically reduce the COD content in waste and its Thickness. The results of the treatment can be seen in Figure 4.

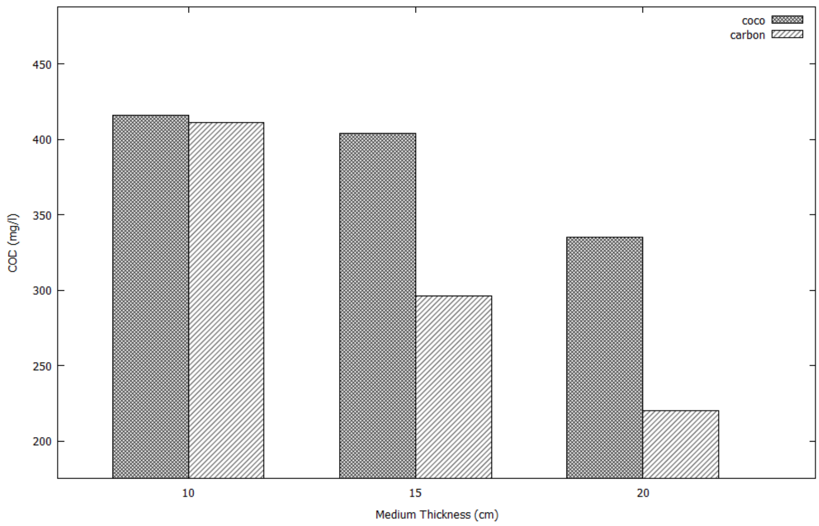

Figure 4. COD reduction diagram on a single media filter

Figure 4 shows that coconut coir and activated carbon media can reduce COD periodically as the thickness increases. The decrease in COD parameters with a single media is proportional to the increase in pH in Figure 1, where the activated carbon media can adsorb organic matter better than the coconut fibre media. Adsorbed organic substances are assumed to be substances that cause acidity in the waste. This indicates that the more significant the COD removal, the higher the increase in pH. Treatment with a combination of coconut coir media and activated carbon reduces COD more optimally to meet quality standards. The decrease in COD with this combination of media can be seen in Figure 5.

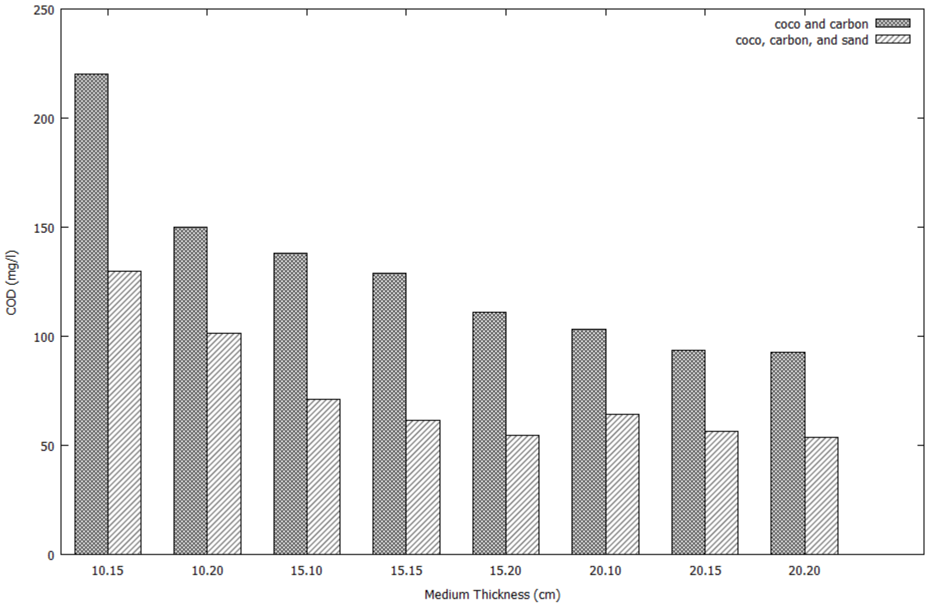

Figure 5. COD reduction diagram on combined media

Figure 5 shows that the media combination of coconut coir and activated carbon can reduce COD to meet the quality standard of 92.8 mg/l at a thickness of 20 cm coconut coir and 15 cm carbon. Treatment with a thickness of 20 cm coconut coir and 20 cm carbon reduced COD by 93.6 mg/l. This treatment showed that the combination of coconut coir and activated carbon was effective in reducing COD. Coconut coir has a content that can bind organic materials to waste. In addition, coconut coir fibers can absorb organic substances, while activated carbon can adsorb contaminants using its pores. The tannins contained in coconut coir can bind organic materials to remove COD content in wastewater [1].

Figure 5 also shows the treatment using sand media. The decrease in COD in this treatment was more significant, namely 53.7 mg/l for a thickness of 20 cm of coconut coir and 20 cm of activated carbon, with a COD removal effectiveness of 93.04%. The addition of sand media makes the media thicker so that the waste has a longer travel time and the absorption of pollutants by the media is also more optimal. This shows that the thicker the media used, the longer the waste of contact time with the media and the higher the removal, so the percentage of the reduction in pollutant levels will be even more significant. This study is by research [24], which states that adding sand media will cause the flow of wastewater to be longer so that more and more contaminants stick to the media.

d. Turbidity Parameters

Turbidity measurements in this study were carried out with a turbidimeter with the NTU scale (Nephelometric Turbidity Unit). Suspended particles in the wastewater cause turbidity in wastewater. Based on Table 1, restaurant waste before processing has a turbidity value of 878 NTU; after processing, it decreases. Where the thicker the media, the greater the turbidity allowance. The results of this study were confirmed by statistical analysis, which obtained a turbidity sig value of 0.000 <0.05, indicating a relationship between media thickness and turbidity reduction. The results of the treatment and measurement of turbidity can be seen in Figure 6.

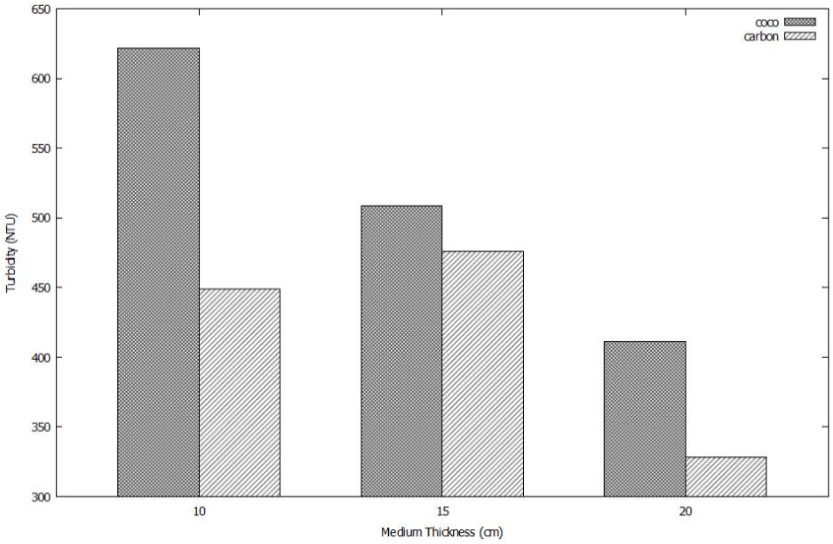

Figure 6. Turbidity reduction diagram on a single media filter

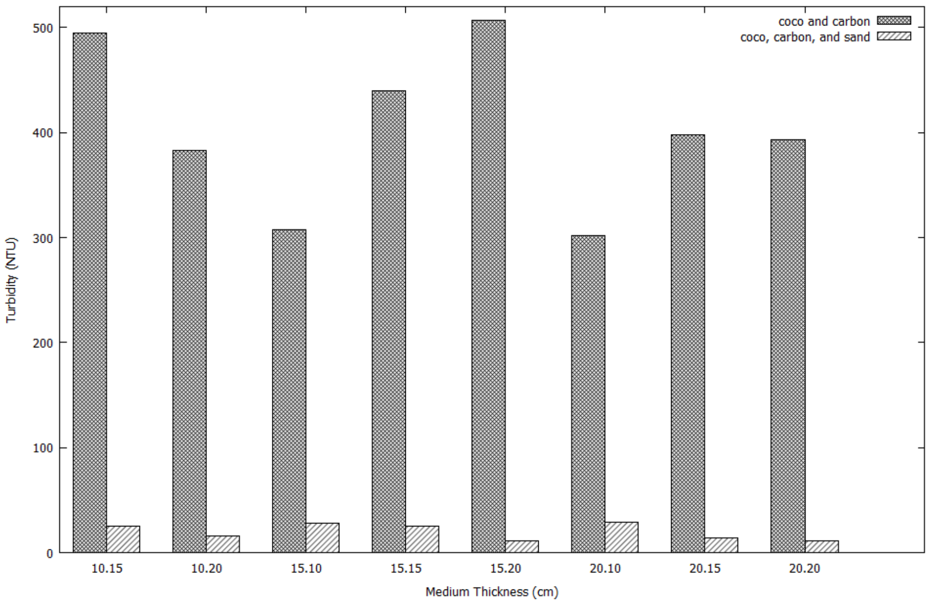

Figure 7. Turbidity reduction diagram on combined media

Based on Figure 6 and Figure 7, the decrease in turbidity with activated carbon media and a combination of coconut coir and activated carbon occurs fluctuating. It is assumed that there is an influence from the activated carbon residue, which causes an increase in TSS levels and turbidity in the waste. Still, based on Figure 8, adding sand media can reduce turbidity more optimally. The decrease in turbidity with the addition of sand media was significant. The most optimal turbidity reduction was 20 cm of coconut coir, 20 cm of activated carbon, and 10 cm of sand, reaching 11.2 NTU with an effectiveness of 98.72% and meeting the quality standard. The results of these measurements indicate that adding sand media as a filter media makes the flow rate slow and the contact time longer, so the adsorption capacity is also improving. Additionally, it is believed that this is because of the sand's capacity to retain suspended waste particles. One of the reasons for reducing turbidity in wastewater is the ability of activated carbon filtration media to form complex bonds between cellulose and turbidity levels. The bond formed is so strong that it is difficult to let go [25].

Based on Figure 7, the decrease in turbidity in the treatment using coconut coir media and activated carbon, compared to the reduction in TSS in Figure 3, has the same form of reduction. This shows that there is a linear relationship between TSS parameters and turbidity. The greater the TSS, the greater the turbidity value because one of the causes of turbidity is the presence of suspended solids. This research is different from the research conducted by [26]. In this study, TSS affects turbidity, so TSS and turbidity have a linear relationship. At the same time, research [26] states that the relationship between TSS and turbidity is not always linear because it is not certain that a smaller TSS level will have a small turbidity value. Apart from suspended solids, the cause of turbidity can also be caused by color and others.

The Effectiveness of coconut coir and activated carbon media as filtration media increases pH and decreases TSS, COD, and turbidity parameters.

In addition to the influence of the Thickness of the media used, contact time also plays an important role in the adsorption process of the adsorbate by the adsorbent. Indirectly, the thickness and pore size of the media affect the filtration rate and contact time and affect the Effectiveness of reducing pollutant levels. Based on this, it is necessary to pay attention to the selection of media and the size of the pores to obtain optimal results. The Thickness of the media will affect the flow rate and contact time [24]. The magnitude of this speed will affect the filtration process. The higher the flow rate, the finer particles will easily escape. The movement of media grains will close the pore holes, which will accelerate the occurrence of clogging. The speed of filtration time is affected by the Thickness of the media and affects the results of waste treatment. The most optimal treatment results were 20 cm thickness of coconut coir media, 20 cm of activated carbon, 10 cm of sand had a pH value of 6.8, able to reduce TSS up to 10 mg/l, COD 53.7 mg/l and turbidity 11.2 NTU.

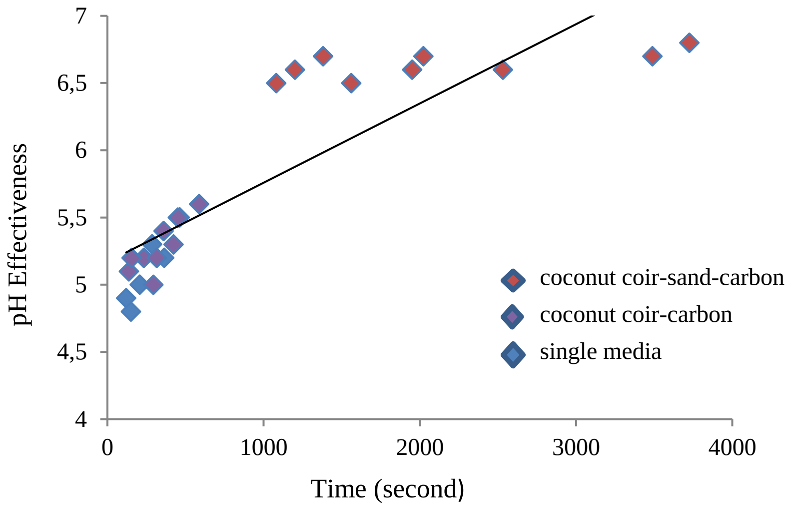

Figure 8. Graph of the effect of time on pH

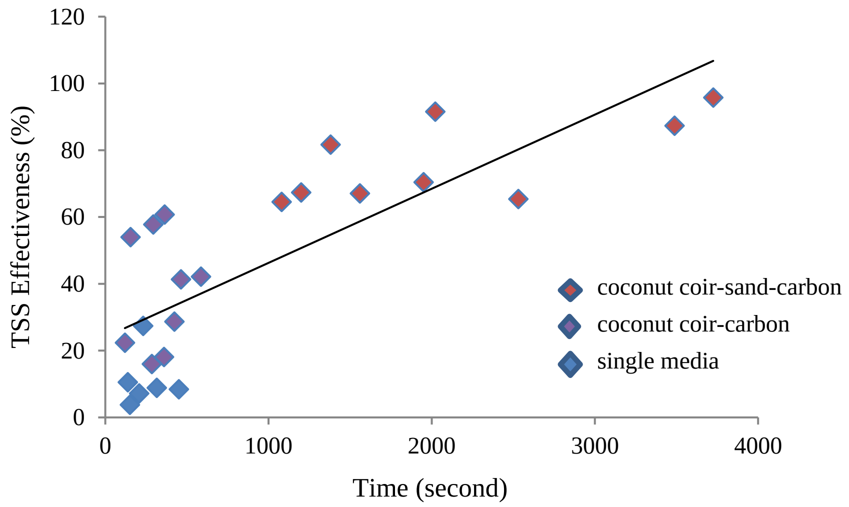

Figure 9. Graph of the effect of time on the Effectiveness of reducing TSS

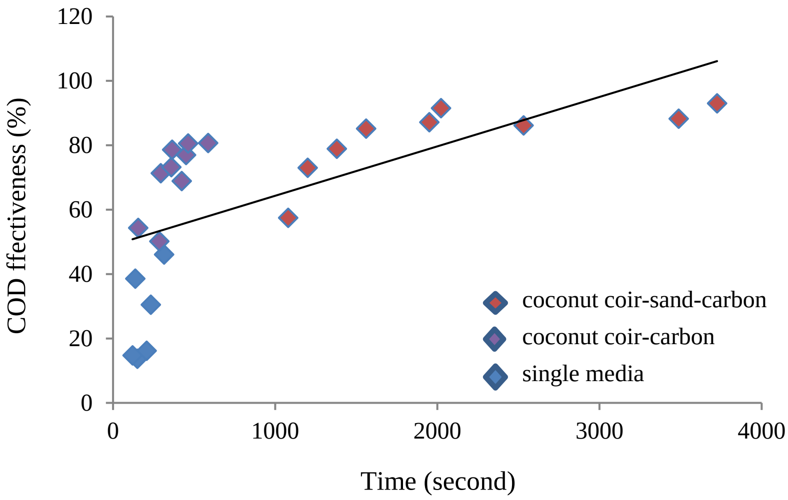

Figure 10. Graph of the effect of time on the Effectiveness of reducing COD

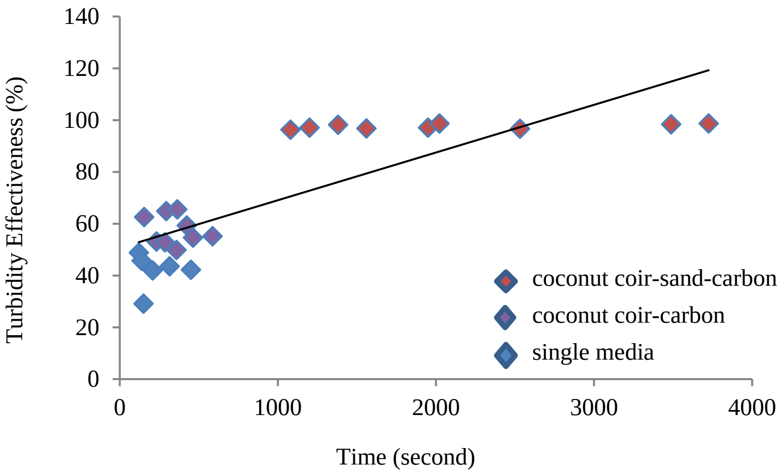

Figure 11. Graph of the effect of time on the Effectiveness of reducing turbidity

Based on the graph, as the contact time increases, the Effectiveness of removing pollutant material also increases. Adding sand media to the coconut coir and activated carbon media removed TSS, COD, and turbidity up to 95.78%, 93.04%, and 98.72% effectiveness at 20 cm coconut coir media thickness 20 cm activated carbon. This is because the addition of sand media makes the media higher, and the flow becomes slower so that the waste has a longer contact time and the absorption of pollutants by carbon is higher. The results of this treatment are almost the same as the research conducted by [27]; the results show that the higher the filtration media, the longer the absorption time will be, so the Effectiveness of absorption of pollutants will also be higher.

The Effectiveness of reducing the parameters of TSS, COD, and turbidity in the waste will decrease along with the longer operating time of the filtration process [26]. This is because the ability of activated carbon to absorb pollutant parameters contained in waste is decreasing over time. In this study, the reduced ability of activated carbon is also due to the pores on the surface of activated carbon, which were initially empty and filled with pollutant substances that it absorbed. The Effectiveness of reducing this parameter is also influenced by sand media, which has pores and gaps that can absorb and retain particles in contaminants in the waste. During filtration, colloids or suspended matter in the air will be retained in an increase.

The results showed that coconut coir and activated carbon media could reduce pollutant levels in the waste, but it would be more optimal and effective when combined with sand media. The performance of activated carbon will be optimal if the Thickness of the media is higher or when combined with other media with a small grain size, such as sand. The addition of media can restrain the filtration rate. The waste has a long contact time with activated carbon, so absorption takes place optimally. Sand can hold pollutant particles in the waste in its pores and control the flow rate. However, it should be noted that using activated carbon can leave residue from the material and cause an increase in TSS levels, as in treatment with coconut coir media and activated carbon. The addition of sand can capture the active carbon residue so that the filter results are more precise.

This study used multivariate analysis to see the effect of media type, Thickness, and contact time on increasing pH and decreasing TSS, COD, and turbidity parameters. The results of the multivariate analysis test showed that the Thickness of the media affected the increase in pH and decrease in COD. The thicker the media, the greater the absorption of pollutants and the more optimal the processing results. However, the TSS and turbidity parameters are not affected by the Thickness of the media. However, they are caused by the presence of sand media, which makes the flow longer and slower so that the waste has a long contact time with the media. Contact time uses the ability of adsorption to absorb adsorbate so that the results will be more optimal and meet quality standards. In addition, it is also influenced by the ability of the sand media used. The smaller the size of the sand used, the longer the contact time and the more particles that can be retained so that the filtration results are more optimal.

IV. Conclusion

Based on the results of these studies, it can be concluded that the Thickness of the media affects the increase in pH and decrease in TSS, COD, and turbidity. The thicker the media, the more significant the increase in pH and decrease in TSS, COD, and turbidity. However, it is necessary to pay attention to the use of activated carbon media because it can leave residues that affect TSS and turbidity in the waste.

Treatment with single media was able to reduce pollutant levels but was unable to meet quality standards. Treatment with a combination of coconut coir and activated carbon media reduced COD to meet quality standards. Treatment with the addition of sand media proved to be more effective in meeting quality standards, with the highest Effectiveness in reducing TSS, COD, and turbidity at 20 cm thickness of coco coir media and 20 cm of activated carbon and 40 mesh of 10 cm of sand, each of which was 95.78. 93.04 and 98.72%.

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