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Green Method: The Performance of Biochar in Water Filtration

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ABSTRACT

The results of measuring the power of Hydrogen (pH) of 5.5 mg/l and Total Dissolved Solid (TDS) of 3.20 mg/l level of water wells in a village, including in a school of Madrasah Tsanawiyah Negeri 5 in Tanjung Medan Rokan Hulu is considered not within permissible limit of World Health Organization (WHO) standards. For that reason, experimental research was conducted by firstly designing and making a water filtration device from Polyvinyl Chloride pipe of 4 inch in diameter, 100cm long, and 1 inch channel in and out. With the green method treatment, the biochar used are Coconut Shell Charcoal (CSC) and Bagasse Charcoal (BC), with additives material such as River Sand (RS), Fiber Palm (FP), and Crushed Gravel (CG). The results of the analysis prove that the best performance of Biochar in Water Filtration (BWF) to increase the content the pH of water to 89.09% is done by Coconut Shell Charcoal (CSC) biochar. While the best for reducing the water TDS level is performed by Bagasse Charcoal (BC) at 64.06%. The performance for pH increases and at the same time decreases the TDS level of water is done by Bagasse Charcoal (BC) biochar with a pH of 7.8 mg/l, and a TDS of 1.15 mg/l. Meanwhile, the filtration combination matrix that produces water according to the WHO standard permissible criteria is ($A_6+B_6+C_6+D_1+E_6$), ($A_6+B_6+C_2+D_2+E_6$), ($A_6+B_6+C_3+D_3+E_6$), ($A_6+B_6+C_4+D_4+E_6$), and ($A_6+B_6+C_5+D_5+E_6$), as well ($A_6+B_6+C_1+D_6+E_6$). So, it can be concluded that Biochar in Water Filtration (BWF) needs to be developed.

Keywords: Performance; biochar; water filtration; power of Hydrogen; Total Dissolve Solid.

I. INTRODUCTION

Green method can be illustrated in the reaction of solutions by using organic materials [1], namely the use of corriandrum sativum leaf extract as a substitute for the use of chemicals in the reaction process of zinc oxide and sodium hydroxide nanoparticles [2]. Other examples are rainwater filtration with bentonite and corn cobs [3], and synthetic graphene nanofiber based on direct interaction, without using harmful chemicals as reducers [4]. This is an effective response of the green method to the current needs of the earth [5, 6]. The simple technique of filtration process using wastewater adsorption method with biochar [6, 7] is an environmentally friendly application, and is one solution to reduce waste as well as environmental pollution [8].

Based on biochar, coconut shell has a thickness of 2 to 8mm [9] is the best adsorbent with a complex structure, where the surface is rough, irregular, and uneven [10, 11]. It can be made in the form of charcoal with incomplete oxidation process [5, 12]. The size can also be made in the form of particles as large as gravel to powder. It is able to remove chlorpyrifos elements in wastewater, and increase the power of Hydrogen (pH) of water [13] Similarly, the absorbent from bagasse charcoal has a high and stable adsorption capacity, can reduce the dissolved iron content in water, and removes the color of a liquid, due to its morphological and physiochemical characteristics [13, 14]. Bagasse charcoal is very well used for wastewater remediation which has a good separation speed and can be recycled [15].

While the water filtration process by using river sand can reduce turbidity and increase the power of water hydrogen [16, 17] and it can also reduce water hardness around 11, 6% [18] and reduce iron content [19]. River sand can also reduce the content of manganese element in peat water at around 6.92 mg/l, iron content at 0.08 mg/l, with a filtration time of 30 minutes [20]. However, the grain size of river sand can affect the flow rate of the water filtration process that occurs [21]. Crushed stone can also be used as a water filtration material along with river sand which is generally placed at the bottom layer [3]. This crushed stone contains silica which can be used in household wastewater filtration processes to lowers the value of iron content, in which it has good wettability [22, 23]. While the use of palm in the filtration process can reduce water turbidity [24, 25], and serves as a larger dirt filter because it has flexibility and texture density [26]. Ijuk (black fiber of palm tree) is also able to lower the value of iron dissolved in water [23] reduce nitrite, nitrate, and ammonia as well as other impurities dissolved in water. So that it can maintain dissolved oxygen levels in treated water [27, 28].

Measurements of acidity or wetness of water are performed using a power of Hydrogen meter and measurements to determine the content of dissolved minerals in water are performed using a Total Dissolved Solid meter [12, 29]. Where dissolved solids can affect the original properties of water [30] as a determinant of the quality of groundwater [31]. The amount of dissolved solids contained in groundwater is influenced by the origin of the water source and can be removed through a filtration process using organic, natural or other materials [32]. The water filtration system aims to remove bacteria, impurities and harmful elements as well as purify the water in an effort to obtain standard quality levels of power of Hydrogen and Dissolved Solid water [3, 33, 34]. Where power of Hydrogen is a chemical parameter that must be in the level of 6.5 to 8.5 mg/l and Total Dissolved Solid as a physical parameter must be above 1.00 mg/l, but below 5.00 mg/l. This value is in accordance with the standard permissibility threshold of the World Health Organization [35].

The surface characteristics of the materials used can affect the water produced due to the contact of the water interface to the material during the filtration process [9, 10, 36]. The length of the contact time and the adsorbent used also affect the filtration process [13, 37]. Water from the filtr ation process must be measured as a determinant of whether it is fit for human consumption or not [38]. This study will show the Performance of Biochar in Water Filtration.

II. MATERIAL AND METHODOLOGY

This experimental study was conducted to determine how the performance of Biochar in Water Filtration (BWF) by linking the results of the process to the levels of power of Hydrogen (pH) and Total Dissolved Solid (TDS) from well water samples of Madrasah Tsanawiyah Negeri 5 Tanjung Medan-Rokan Hulu. The biochar used is Coconut Shell Charcoal (CSC) and Bagasse Charcoal (BC) with additional ingredients of Sand River (SR), Fibers Palm (FP), and Crushed Gravel (CG).

2.1 Water Sample

The water sample is the result of observations at the well of Madrasah Tsanawiyah Negeri 5 Rokan Hulu, it is known that the water is cloudy and contains iron. This is evidenced by the presence of sediment and yellowish stains attached to the walls of the reservoir. Meanwhile, the results of the measurement of the power of Hydrogen (pH) level are 5.5 mg/l and the Total Dissolved Solid (TDS) level is 3.20 mg/l. The water sample used in the biochar in water filtration process is 50 liters for each material thickness variation.

2.2 Biochar

The materials used based on biochar are Coconut Shell Charcoal (CSC) and Bagasse Charcoal (BC). The treatment of both types of materials is through an incomplete oxidation process in the furnace. Then after the oxidation process is incomplete, the material is then pounded using a mortar and sieved using sieves of 5 mesh and 20 mesh. Meanwhile, the treatment of additional materials such as Crushed Gravel (CG) is performed through the process of striking using a hammer. The crushed gravel fragments are between 10 to 20mm in size then washed with clean water and dried under the sun. For Sand River (SR) material, the treatment is only by washing using clean water, drying, and sifting through a 20 mesh sieve. As for Fibers Palm (FP), the initial treatment is soaking the fibers in clean water for 36 hours, and then it is dried and chopped. Then it is washed again using clean water, and left in the sun to dry, before being sieved using a mesh size 10 sieves. The materials resulting from the treatment are as shown in Table 1.

Table 1. Filtration Materials

Name	Size	Photo
Bagasse Charcoal (BC)	Passed Mesh 20	
Coconut Shell Charcoal (CSC)	Passed Mesh 5	
Fibers Palm (PF)	Passed Mesh 10	
River Sand (RS)	Passed Mesh 20	
Crushed Gravel (CG)	Between 10 to 20mm	

After the biochar and additional materials are in a ready-to-use condition, then they are put into a water filtration device. This device is made of 4 inch diameter Polyvinyl Chloride pipe, 1 inch diameter water inlet and outlet, with a length of 100 cm. The process of measuring the power of Hydrogen (pH) and Total Dissolved Solid (TDS) level of water is according to the thickness variation of each material either with or without combination.

2.3 Biochar Thickness Variations

Variation in the thickness of biochar and additives shown in Table 2 is performed for the suitability of the filtration process measurement of treated water samples. In addition, it is to suit the measurement of performance through the measurement of power of Hydrogen (pH) and Total Dissolved Solid (TDS) level of water before and after the filtration process is performed.

Table 2. Biochar thickness, pH, and TDS initial water

							pH (mg/l)	TDS (mg/l)
	River Sand (SR)							
Code	A^1	A^2	A^3	A^4	A^5	A^6	5.5	3.20
Thickness (cm)	5	10	20	30	40	80		
	Fibers Palm (FP)							
Code	B^1	B^2	B^3	B^4	B^5	B^6	5.5	3.20
Thickness (cm)	5	10	20	30	40	80		
	Bagasse Charcoal (BC)							
Code	C^1	C^2	C^3	C^4	C^5	C^6	5.5	3.20
Thickness (cm)	5	10	20	30	40	80		
	Coconut Shell Charcoal (CSC)							
Code	D^1	D^2	D^3	D^4	D^5	D^6	5.5	3.20
Thickness (cm)	5	10	20	30	40	80		
	Crushed Gravel (CG)							
Code	E^1	E^2	E^3	E^4	E^5	E^6	5.5	3.20
Thickness (cm)	5	10	20	30	40	80		

III. RESULTS AND DISSCUSION

3.1 Biochar in Water Filtration (BWF)

The results of the Biochar Water Filtration (BWF) are measured to the increase in the levels of power of Hydrogen (pH) and Total Dissolved Solid (TDS) of treated water according to variations in thickness, as shown in Table 3.

Table 3. pH and TDS measurement results from BWF

	River Sand (RS)					
Code	A^1	A^2	A^3	A^4	A^5	A^6
pH (mg/l)	5.7	5.8	6.0	6.1	6.4	6.7
TDS (mg/l)	3.00	2.95	2.85	2.70	2.40	1.90
	Fibers Palm (FP)					
Code	B^1	B^2	B^3	B^4	B^5	B^6
pH (mg/l)	5.5	5.6	5.7	5.8	6.0	6.2
TDS (mg/l)	3.10	3.00	2.90	2.85	2.70	2.30
	Bagasse Charcoal (BC)					
Code	C^1	C^2	C^3	C^4	C^5	C^6
pH (mg/l)	6.8	7.2	7.4	7.5	7.6	7.8
TDS (mg/l)	1.70	1.65	1.50	1.48	1.26	1.15
	Coconut Shell Charcoal (CSC)					
Code	D^1	D^2	D^3	D^4	D^5	D^6
pH (mg/l)	9.7	9.9	10.0	10.1	10.2	10.4
TDS (mg/l)	2.04	1.90	1.85	1.75	1.60	1.57
	Crushed Gravel (CG)					
Code	E^1	E^2	E^3	E^4	E^5	E^6
pH (mg/l)	5.6	5.7	5.8	6.1	6.4	6.7
TDS (mg/l)	3.10	3.05	2.90	2.85	2.60	2.25

3.2 Performance of Biochar in Water Filtration (PBWF)

Based on Table 3, the measured Biochar in Water Filtration (BWF) performance analysis for each material shows that it can increase pH levels and reduce TDS levels of treated water. River Sand (RS) material can increase the pH level of water up to $1.2^{(+)}$ mg/l, or by 21.81%, and reduce the TDS level of water up to$1.3^{(-)}$ mg/l, or by 40.62%. Fiber Palm (FP) can increase the pH level of water up to $0.7^{(+)}$ mg/l, or by 12.72%, and reduce the TDS level of water up to $0.9^{(-)}$ mg/l, or by 28.12%. Crushed Gravel (CG) can increase the pH level of water up to $1.2^{(+)}$ mg/l, or by 21.81%, and reduce the TDS level of water up to $0.95^{(-)}$ mg/l, or by 29.68%. Bagasse Charcoal (BC) biochar can increase water pH up to $2.3^{(+)}$ mg/l, or 41.81%, and reduce water TDS level up to $2.05^{(-)}$ mg/l, or 64.06%. While Coconut Shell Charcoal (CSC) can increase the pH level of water up to $4.9^{(+)}$ mg/l, or 89.09%, and reduce water TDS levels up to $1.63^{(-)}$ mg/l, or 50.95%.

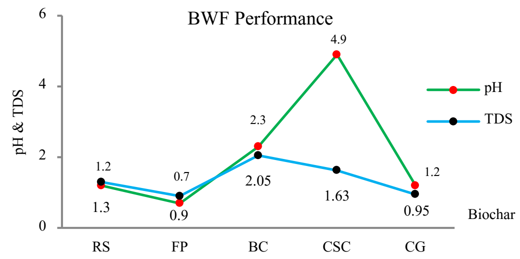

Figure 1. BWF Performance

Comparison of Biochar in Water Filtration (PBWF) increases the pH and TDS levels of water based on variations in the thickness of each biochar and additives. The difference in pH and TDS levels of water shows its performance in the filtration process of treated water, as shown in Figures 2.

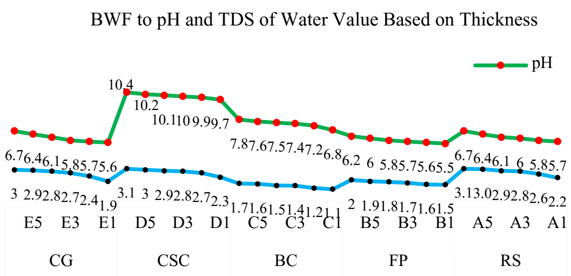

Figure 2. The Comparison of reduction of pH and TDS Level performed by BWF

Based on Figure 2 that the average value of the increase in the pH level of the water of the whole material is $1.58^{(+)}$, this indicates that the initial water pH level of 5.5 mg/l has increased; then the final water pH level is 7.08 mg/l. this indicates that the initial water TDS level of 3.2 mg/l has decreased, then the final water TDS level is 0.91 mg/l. While the average increase in water pH levels for each material is shown in Figure 3.

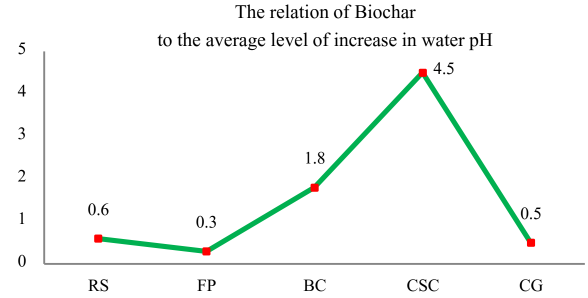

Figure 3. The Comparison of the average level of increase in water pH

Based on Figure 3 that the average level of increase in water pH of River Sand (RS) biochar is 0.61 mg/l, Palm Fibers (FP) is 0.3 mg/l, Bagasse Charcoal (BC) is 1.88 mg/l, and Coconut Shell Charcoal (CSC) is 4.55 mg/l and Crushed Gravel (CG) is 0.55 mg/l. So that for biochar with the highest average value can raise the pH of water is to use Coconut Shell Charcoal (CSC). As for the average increase in water TDS level of each biochar as shown in Figure 4.

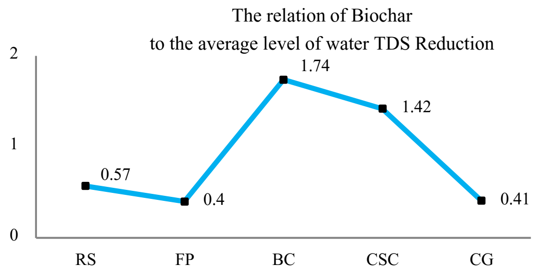

Figure 4. The comparison of the average level of water TDS Reduction

Based on Figure 4, the average level of water TDS reduction by River Sand (RS) is 0.57 mg/l, Fibers Palm (FP) is 0.4 mg/l, and Crushed Gravel (CG) is 0.41 mg/l. Meanwhile, Biochar Bagasse Charcoal (BC) is 1.74 mg/l and Coconut Shell Charcoal (CSC) is 1.42 mg/l. Then the highest average level that can reduce the TDS of water is Biochar Bagasse Charcoal (BC). As for Biochar in Water Filtration (BWF) by combining all the materials, it is a combination matrix pattern. Based on the 36 types of matrix incorporation of materials, there are 6 matrix patterns of combining the best Biochar in Water Filtration (BWF). The matrix patterns combination are $(A_6+B_6+C_6+D_1+E_6)$, $(A_6+B_6+C_2+D_2+E_6)$, $(A_6+B_6+C_3+D_3+E_6)$, and $(A_6+B_6+C_4+D_4+E_6)$, $(A_6+B_6+C_5+D_5+E_6)$, and $(A_6+B_6+C_1+D_6+E_6)$, where the pH and TDS levels of the water produced meet the criteria of the World Health Organization standards.

IV. CONCLUSION

The treatment of biochar in filtration materials and the Biochar in Water Filtration (BWF) process on water samples is carried out using the green method; no adverse effect on the environment. While the best performance of Biochar in Water Filtration (BWF) is Coconut Shell Charcoal (CSC) biochar with an increase in pH level of $4.9^{(+)}$ mg/l or 89.09%. Meanwhile, for the best reduction in water TDS levels is performed by Biochar Bagasse Charcoal (BC) at $2.05^{(-)}$ mg/l or 64.06%. For increasing pH levels and decreasing water TDS at the same time, the best biochar performance is done by Bagasse Charcoal (BC) with a water pH of 7.8 mg/l and a TDS of 1.15 mg/l. Meanwhile, for the 6 types of matrix patterns combination in Biochar in Water Filtration (BWF) they are (A_6+B_6+C_6+D_1+E_6), (A_6+B_6+C_2+D_2+E_6), (A_6+B_6+C_3+D_3+E_6), (A_6+B_6+C_4+D_4+E_6), and (A_6+B_6+C_5+D_5+E_6), and (A_6+ B_6+C_1+D_6+E_6), which produce water according to permissible standards of the World Health Organization.

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