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Coffee Grounds and Coconut Husk in Layered Filter Treatment for Efficiency Removal and Degradation Capacity of Pollution Parameters in North Aceh Waters

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Abstract—Polluted estuaries can result in oxygen depletion, accumulation of toxic substances and heavy metals, and become a source of pathogens that are threaten for cultivated aquatic biota and coastal tourists. This research aims to analyze 1) pollution index; 2) status of water pollution in Bangka Jaya and Tanoh Anoe Regencies; and 3) testing the level of effectiveness of Layered Filtered Treatment (LFT) using analysis of removal efficiency and degradation capacity on water quality. LTF is a filtration media that composed of coconut husk, membrane and coffee grounds made into briquettes, LFT used to filter polluted estuary waters. The pollution parameters analyzed at Bangka Jaya were nitrate, phosphate, *Escherichia coli* bacteria and ammonia, while the pollution parameters at Tanoh Anoe were heavy metals Pb and Cd. The research results showed that the pollution status of Bangka Jaya estuary (A1) and Bangka Jaya coastal waters (A2) are moderately polluted, with indices at stations A1, A2 and A3 respectively is 9.19; 8.42; and 8.42. Meanwhile, the water pollution status in Tanoh Anoe estuary are heavily polluted (station B1) and moderately polluted (station B2) with the pollution index at each station being 14.07 and 9.36. The conclusion of this research is that LFT has not been proven capable of removing and degrading the pollutant parameters nitrate, phosphate, *E.coli* bacteria and ammonia, however the LFT method has been proven capable of increasing dissolved oxygen, stabilizing sea acid, temperature and also water salinity. LFT has also been proven to be able to prevent ocean acidification with a degradation capacity percentage of 6.60%.

Keywords—Layered Filter Treatment (LFT), Coconut Husk, Coffee Ground Briquettes, Water Pollution, Waters Pollution Index, Eficiency removal, Degradation capacity

I. INTRODUCTION

Pollution of the aquatic environment originating from land activities [1] is a threat to marine life and is a cause that can threaten human life. The water that flows in the estuary will be directly channeled into the ocean, even though the estuary is a place for diverse aquatic biota and uniform communities, this is because the estuary is a semi-enclosed water body which is a place where fresh water from rivers meets sea water [2], Due to their complex nature, estuaries can become places where pollutants accumulate before the waste is released into the ocean. Land activities such as aquaculture, agriculture, animal husbandry, plantations and tourism can cause water pollution [3]. This pollution can reduce water quality values and increase water pollution parameter values. Some water qualities that can decrease in value as a result of pollution are pH, salinity and dissolved oxygen. Meanwhile the pollution parameters are nitrate, phosphate, ammonia, Escherichia coli bacteria, heavy metals Pb and Cd.

Nitrate, phosphate and ammonia are nutrients that determine water fertility, their presence helps phytoplankton to grow [4], However, if nitrate phosphate and ammonia exceed the threshold, they can indirectly affect the reduction in dissolved oxygen, the lack of dissolved oxygen can harm aquatic biota. *E. coli* bacteria are pathogenic bacteria that can cause various health problems such as diarrhea and urinary tract infections [5] and itching [6]. *E. coli* bacteria come from human and animal waste [6], The indicated presence of E.coli in Muara Term Baya is the lack of public awareness regarding good sanitation such as the availability of toilets with septic tanks.

Heavy metals will experience bioconcentration, bioaccumulation and biomagnification [7]. If there is a source of heavy metal pollution in waters, heavy metals will continue to accumulate and cannot be degraded [9], as a result the quantity of heavy metals in waters will continue to increase, if the quantity of heavy metals continues to increase it will harm aquatic biota, in this study were pond fish whose pond water

used the surrounding water environment. At the observation location, the suspected origin of the heavy metal lead (Pb) is from vehicle exhaust that uses Pb as an anti-knocking[8]. If Pb contaminates the human body, Pb can result in babies being born with low birth weight [9] while Cd is a heavy metal that comes from agricultural activities that use pesticides, insecticides and fungicides [10],if Cd accumulates in the human body it can damage kidney function; breast, lung, pancreas, increases the risk of endometrial cancer; and impaired calcium homeostasis [11]. Nitrate, phosphate, ammonia, *E. coli*, Pb and Cd are water pollution parameters. Pollution is very dangerous for aquatic biota and humans through the food chain. To find out how a body of water is said to be polluted, the analysis used is the pollution index.

Coffee grounds are leftover material from coffee beans which have value, as do coconut dregs. North Aceh has excellent agricultural potential, with the average yield of coffee and coconut plantations being 187 tons/year and 1030 tons/year [12]. The market demand for coffee beans is very high in North Aceh, because of the large number of coffee shops and coffee consumers. However, coffee sellers do not know how to properly manage coffee grounds waste. Coconut fiber is currently a problem in North Aceh, because there are so many sellers of young coconuts, so the amount of coconut fiber waste is also increasing, this is caused by a poor waste management system. Coffee grounds and coconut fiber which are considered waste, can be used as filtration. Filtration is used as a solution to the high pollution index value of a body of water, this filtration method is called Layer filter treatment (LFT). In this research, coffee grounds are converted into brickets, through the process of drying, filtering, forming and activated carbon test. The activation carbon process can expand the pores in the brickets and increase the adsorption capacity of water and increasing the effectiveness in filtering water. The activation process can be carried out physically with thermal activation of heating to a temperature of 650 – 800 °C.

II. METHODS

A. Time and Location of Research

This research was conducted in September-October 202 with four research stages, namely: (1) taking research samples in the form of estuary water in the Bangka Jaya Beach area; (2) making the LFT filtration model; (3) observing water quality and pollution index before LFT; (4) observing water quality and pollution index after LFT treatment. Activities 2 and 3 were conducted at the Laboratory of the Banda Aceh Industrial Services Standardization Center (BSPJI). The sampling locations were divided into two locations, Bangka Jaya, North Aceh District (Figure 1) and Tanoh Anoe, North Aceh District (Figure 2).

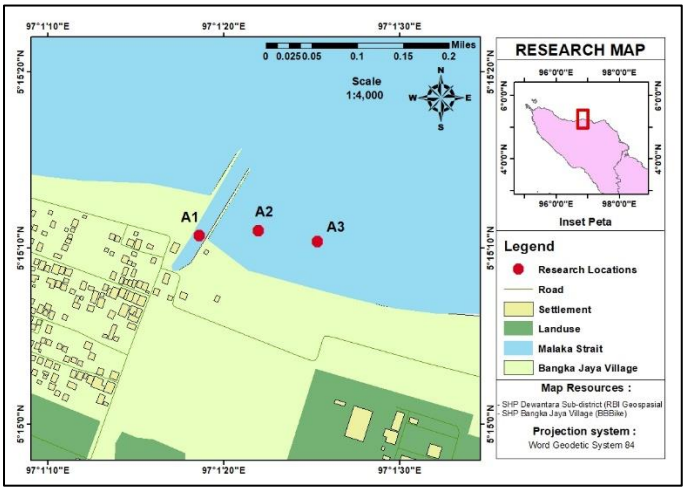

Figure. 1. 1st sampling location

The Bangka Jaya Estuary was chosen because it is close to a swimming tourism area that requires quality of water. The Krueng Mane estuary was used for sampling because of its complex criteria, where pollutants can enter through agricultural irrigation, aquaculture, plantations, and residential areas. This area is also interesting to observe because of its massive sedimentation dynamics.

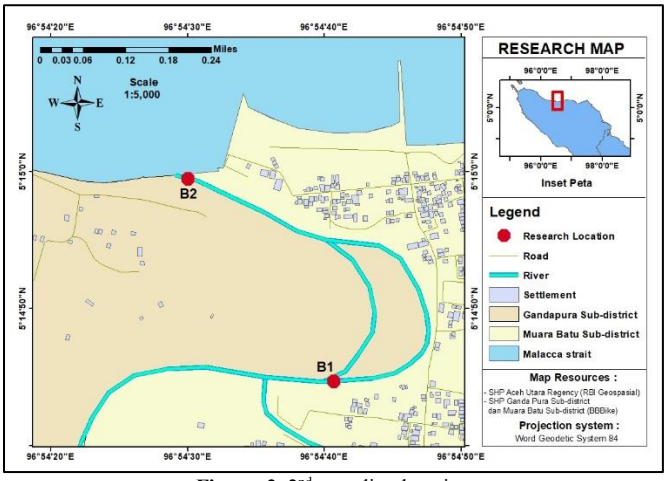

Figure. 2. 2nd sampling location

B. Methods and Stages of Research

Data measurements were conducted in situ and ex situ. Each parameter was measured using different tools and materials. Water quality parameters measured were pH, salinity, and DO. While the parameters measured as an index of pollution are nitrate, phosphate, ammonia, and Escherichia coli (*E. coli*) bacteria (in Bangka Jaya Estuary), heavy metals Pb and Cd (Tanoh Anoe Estuary). Samples were brought to the laboratory and analyzed for physico-chemical parameters following standard methods (APHA, 1989).

C. Water quality sampling and observation

Sampling of estuarine water was carried out using a purposive sampling method. This method uses predetermined sample criteria. This study determines 2 observation locations with each location there are 2 sampling points located in the body of the estuary and parallel to the coastline. Water samples taken are surface water samples and bottom waters. Samples were taken at 1 liter with three repetitions. Water samples were taken using a bucket while bottom water samples (0.5 m above the sediment bed) were taken using a Niskin bottle [13]. Samples for *E. coli* bacteria observation was taken using a bucket and put into an air and light tight pyrex sample bottle. The samples were then put into a cool box with a temperature of 4°C [14]. The samples were then observed in the laboratory. Analysis of *E. coli* bacteria using filtration, purification, and isolation methods.

D. Preparation of layered filter treatment (LFT)

Filtration is an alternative to improving water quality [15]. This method is widely used in the industrial bottled water industry. This filtration method uses materials as absorbents. Coffee is a good absorbent to improve water quality because it contains activated carbon. However, activated carbon in coffee grounds can only purify water with low pollutants [16]. The filtration picture can be seen in Figure 3.

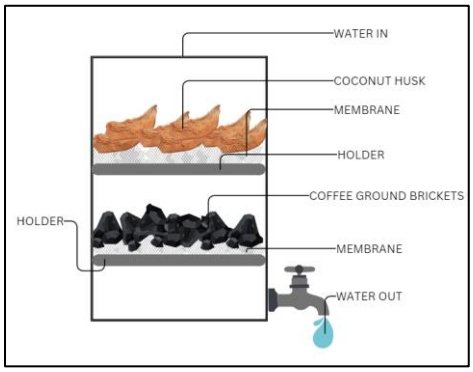

Figure. 3. Layered Filter Treatment

The utilization of activated carbon as an absorbent is an efficient alternative so it is often used to purify water [17]. The steps for making activated carbon from coffee grounds are as follows (1) roast 1 kg of coffee at 100°C; (2) cook tapioca flour until thickened and clear with the composition of coffee and flour is 3:1; (3) mix roasted coffee with tapioca flour; (4) stir until evenly distributed and print using a pipe; (5) remove from the mold and heat in the oven at 120°C for 1 day; (6) the activated carbon is then arranged in a row at the lowest level of filtration media. Preparation of coconut waste for filtration is by separating the skin and coconut shell with the coir, the coir is used in the top layer of filtration media. This layered filtration is called layered filter treatment.

E. Data Analysis

Analysis of water quality

pH is the acidity or basicity of a solution. The pH of seawater is important to observe because low pH can threaten the life of marine ecosystems [18]. The pH of seawater in this study was measured using a pH meter dipped into the water body (for surface water samples), while for water at the bottom it was taken first using a bucket and then measured with a pH meter. Dissolved oxygen in the incubated samples was measured for 5 days, under dark conditions and a fixed temperature (20°C) called DO5. The difference between DOi and DO5 (DOi - DO5) is the BOD value (mg/L) [19]. DO meter was measured using a DO meter.

Analysis of River Pollution Load

Nitrate is a nitrogen compound with an oxidation state of +3. It is water-soluble and stable. In a water body, nitrate is the main source of nutrients for plant and algae growth. The source of nitrate comes from industrial waste from explosives and fertilizers. Analysis of nitrate, phosphate and heavy metals using spectrophotometric devices [20]. Now another method has developed, namely the brucine method in limnology. The Pollution Index formula is:

$$\sqrt{\frac{\left(C_i/L_{ij}\right)M^2+\left(C_i/L_{ij}\right)R^2}{2}} \quad (1)$$

Notes:

PIj : H Pollution index which is a function of Ci/Lij;

(Ci/Lij) M : Maximum value of Ci/Lij;

(Ci /Lij) R : Average value of Ci /Lij;

Lij : States the concentration of the water quality parameter that is at the quality standard of the Water designation (j);

Ci : concentration of water quality parameter (i) obtained from the analysis result

Pollution status:

Pollution index <1 : Unpolluted

1≤ Pollution Index<5 : Lightly polluted

5≤ Pollution Index<10 : Moderately polluted

Pollution Index≥ 10 : Heavily polluted

Analysis of effectiveness level

Analysis of the level of effectiveness in this study was carried out to determine how effectively coffee grounds and coconut fiber absorb and reduce pollutants through the calculation of absorption capacity and degradation efficiency.

Absorption capacity formula:

$$Qe = \frac{(Co-Ce)\times V}{W} \quad (2)$$

Notes:

Qe : Absorption capacity

Co : After-treatment results

Ce : Natural identification result

V : Volume of the sample water

W : Weight of adsorbent (coffee grounds and coconut fiber)

The degradation efficiency formula:

$$Q = \frac{(Co-Ce)\times 100\%}{C_o} \quad (3)$$

Notes:

Q : Degradation efficiency

Co : Results after the treatment

Ce : Natural identification results

III. RESULT AND DISCUSSION

Complaints from tourists related to water quality require prompt resolution. One of the efforts to solve the problem is to analyze the pollution index, pollution status, filtration with the LFT method, removal efficiency analysis and degradation capacity.

Table 1. is data obtained based on field data collection and laboratory analysis. The pH value can affect the high uptake of nitrate and phosphate, where the pH value of 7-9 is the optimal range for waters in phosphate uptake and pH 5-7 is the optimal range of waters in absorbing nitrate [21]. At station A1, waters have a higher ability to absorb nitrate than phosphate, whereas at stations A2 and A3 the ability to absorb phosphate is higher, due to the influence of water pH. The tendency of the value of each parameter at station A1 is because station A1 is an estuary that has indications as a source of pollutants for waters. Except at station A3, where this station is adjacent to the factory, so that the high concentration of ammonia starts from station A3, then A2 and A1. Based on Table 1 The The status of pollution in the estuary and Bangka Jaya Beach tourism area is moderately polluted (MP). The presence of *E. coli* bacteria that exceeds the quality standard can affect the comfort of beach tourism activities in this area. Exposure to *E. coli* contaminated seawater through direct skin absorption can increase the risk of skin infections, and exposure through ingestion can cause tourists to develop gastrointestinal diseases.

TABLE 1.
ANALYSIS OF WATER POLLUTION INDEX AND STATUS IN BANGKA JAYA WATERS

PARAMETERS	TEST METHOD	STATION A1	STATION A2	STATION A3	QUALITY STANDARDS: TOURISM
DO (mg/L)	INSITU	5.9	7.5	8.3	>5
Salinity (ppt)	INSITU	17.6	30	29	Natural
pH	INSITU	6.96	8.6	8.6	7-8.5
Temperature (°C)	INSITU	27.5	30.4	30.1	Natural
Nitrate (mg/L)	IK.5.0401.16 (Spektrofometri)	1.1	0.9	0.9	0.008
Phosphate (mg/L)	IK.5.0401.37 (Spektrofometri)	0.26	0.1	0.09	0.015
E. coli (APM/100 mL)	Standard Methods Th. 2017 Butir 9221G	3500	0	0	200
Ammonia (mg/L)	SNI. 06-6989.30-2005	0.024	0.041	0.045	Natural
POLLUTION INDEX		9.19	8.42	8.42	
POLLUTION STATUS		MP	MP	MP	

Based on Table 2, heavy metal Pb was detected in the sediments of stations B1 and B2. Heavy metal Cd was only present in station B1. While in the water column, heavy metals Pb and Cd were not detected at both observation stations. The presence of Pb and Cd heavy metals in sediments is part of the process of adsorption, complexation, flocculation, and sedimentation [22]. Heavy metal sources that enter water bodies will eventually be absorbed into sediments. Heavy metals Pb and Cd can be toxic to plants, animals and humans based on the food chain. Because some heavy metals are bioaccumulating, persistent, and toxic to the environment [23]. Bioaccumulation is the nature of being able to accumulate in the body of living things, while persistence is the nature of heavy metals that will continue to increase and difficult to degrade. Heavy metals are present in the sediment but not in the water column, due to the low water temperature at the observation location, where when the water temperature is low, heavy metals will be adsorbed to the surface of the sediment and will decompose back into the water column when the water temperature is high. Heavy metal Pb in these waters is thought to come from air pollution that has been polluted with Pb^{2+} ions as antiknocking in gasoline type fuels, while the existing conditions of heavy metal Cd can come from agricultural activities, aquaculture, and plantations. Based on the obsertavtion of this research, Tanoh Anoe estuary waters are heavily pollutes (HP) and moderately polluted (MP) (Table 2.)

TABLE 2.
HEAVY METAL POLLUTION INDEX ANALYSIS OF WATERS IN TANOH ANOE

PARAMETERS	TEST PARAMETERS	STATION B1	STATION B2	QUALITY STANDARDS: BIOTA
Sample of Estuary Waters				
DO (mg/L)	INSITU	8.4	8.3	>5
Salinity (ppt)	INSITU	0	0	Natural
pH	INSITU	7.5	7.8	7-8.5
Temperature (°C)	INSITU	26.9	30.1	Natural
Pb (mg/L)	IK.5.04.01.35 (AAS-HVG)	<0.0003*	<0.0002*	0.008
Cd (mg/L)	IK.5.04.01.36 (AAS-HVG)	<0.0003*	<0.0002*	0.001
Sample of Estuary Sediment				
Pb (mg/kg)	SNI.06-6992.3-2004	1.52	1.79	0.008
Cd (mg/kg)	SNI.06-6992.3-2004	4.13	<0.0005*	0.001
POLLUTANT INDEX		14.07	9.36	
POLLUTANT STATUS		MP	HP	

The high quantity of heavy metals Pb and Cd in the sediment of Tanoh Anoe Estuary is feared to have a negative impact on humans based on the food chain, where in this estuary there are many fish and shrimp ponds that utilize the surrounding water for aquaculture activities. Bioaccumulation of heavy metals in pond fish that occurs continuously, cannot be degraded by the fish body, humans as top predators have the possibility to be exposed to heavy metals as well. The danger of heavy metals to the human body is that they can block the body's natural metabolic work, making humans more susceptible to cancer and gene mutation. To minimize the level of water pollution, the researchers made filtration efforts with the LFT method, the results of the LFT test can be seen in Table 3. There are several parameters that cannot be analyzed because they have a quantity below the capability of the detection tool and are called BDV (below the detector value).

TABEL 3.
ABSORPTION CAPACITY AND DEGRADATION EFFICIENCY OF LFT ON WATER QUALITY AND POLLUTANTS

PARAMETERS	STATION A1 dan B1	RESULT of TREATMENT SAMPEL	QUALITY STANDARDS	ABSORPTION CAPACITY	DEGRADATION EFFICIENCY (%)	NOTES
DO (mg/L)	5.9	6.5	>5	0.6	9.23	Efficient
Salinity (ppt)	17.6	20	Natural	2.4	12	Efficient
pH	6.96	6.5	7-8.5	0.46	6.06	Efficient
Temperature (°C)	27.5	27.8	Natural	0.3	1.07	Efficient
Nitrat (mg/L)	1.1	4	0.008	-2.9	-263.63	Inefficient
Phosphate (mg/L)	0.26	0.44	0.015	-0.18	-69.23	Inefficient
E. Coli (APM/100 mL)	3500	92000	200	-88500	-2528.57	Inefficient
Ammonia (mg/L)	0.024	0.038	Natural	-0.014	-58.33	Inefficient
Pb (mg/L)	BDV	BDV	0.008	BDV	BDV	No data
Cd (mg/L)	BDV	BDV	0.001	BDV	BDV	No data

Data observed at the Muara Bangka Jaya research site were DO, salinity, pH, temperature, nitrate, phosphate, *E. coli* and ammonia. While at the Muara Tanoh Anoe research location, the samples taken were water and sediment. However, LFT media was only used in water samples, with the test parameters being heavy metals Pb and Cd. The difference in data collection is based on indications of regional pollution loads. Where, at the first observation location, it is a marine tourism area where massive input of pollutants occurs in the estuary. Likewise with the second research location, there are many indications of pollution sources, such as agricultural areas, fisheries and plantations, which are the basis for choosing heavy metals as a parameter of pollutants. This study aims to determine the efficiency of LFT in optimizing the value of water quality parameters based on estuarine water quality standards set by the Government Regulation of the Republic of Indonesia (2021).

In Table 3. it can be seen that the parameters that can change according to the quality standards by LFT are DO, salinity, pH and temperature, while heavy metals are not filtered because there are no Pb and Cd ions in these waters. It can be explained that the activated carbon in coffee briquettes, which is a component of the LFT method, has been activated using acid, so that the surface of the activated carbon pores still contains acidic functional surface groups that will be desorbed into wastewater and result in a decrease in pH [24].

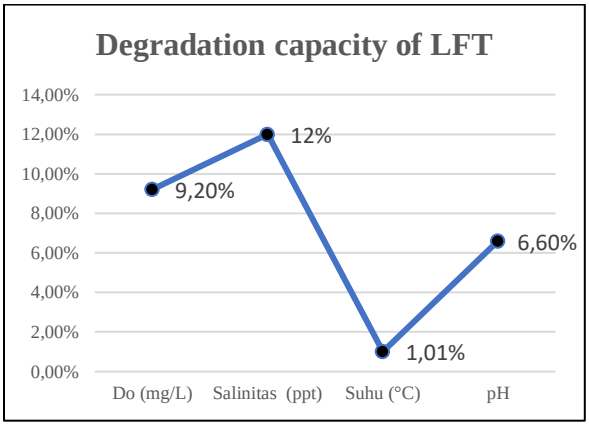

Figure 4. Degradation capacity of water quality parameters by LFTs

Nitrate, phosphate, ammonia and *E. coli* bacteria do not have a degradation efficiency value, so the LFT method is not proven to be able to absorb and degrade these pollutant parameters. E.coli bacteria can be removed only by sterilization treatment (UV light) and disinfectants with large concentrations [25]. Degradation capacity (Figure 4.) of water parameters shows that LFT has the highest efficiency ability against salinity, which is 12%, and answers the research objectives, namely being able to change the pH of the estuary to approach the quality standard value, so that the LFT method is proven to be able to prevent ocean acidification.

IV. CONCLUSIONS

Based on the research that has been carried out and the results that have been identified, the conclusions of this research are:

1) the pollution status of the estuary at Bangka Jaya is moderately polluted (MP), with the index at stations A1, A2 and A3 each being 9.19; 8.42; and 8.42. Meanwhile, the pollution status in Muara Tanoh Anoe is heavily polluted (HP) and moderately polluted (MP), with the pollution index at stations B1 and B2 being 14.07 and 9.36 respectively;
2) the LFT method was not proven capable of absorbing and degrading the pollutant parameters nitrate, phosphate, E. coli bacteria and ammonia; However, the LFT method has been proven to be able to increase dissolved oxygen, stabilize sea acid, temperature and salinity in the water column, and the LFT method has been proven to be able to prevent ocean acidification with a degradation efficiency percentage of 6.60%.

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