Biofilter Effectiveness *Moving Bed Biofilm Reactor* Activated Carbon Combination in Domestic Wastewater Treatment on Barrang Island Lompo Makassar City

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Article Info	Abstract
	BACKGROUND: In Indonesia, such as on Barrang Lompo Island, much domestic waste is dumped directly into the environment, causing serious water pollution and threatening public health and the ecosystem. The use of a Moving Bed Biofilm Reactor (MBBR) biofilter combined with activated carbon can be an effective solution to this problem. AIM: This research aims to determine the effectiveness of the MBBR biofilter combined with activated carbon in reducing BOD, COD and TSS levels in domestic wastewater on Barrang Lompo Island. METHOD: The type of research used is *quasi experimental designs* by using a plan in the form of *pre-test post-test*. The population in this study is domestic liquid waste found on Barrang Lompo Island, and the sample is domestic liquid waste taken from the communal wastewater treatment plant on Barrang Lompo Island as a sample. *pre-test* and domestic liquid waste taken at the MBBR combined activated carbon biofilter outlet after processing as samples *post-test*. RESULTS: The research results showed that BOD levels had decreased by a percentage of 66.65% from the initial levels, COD levels had decreased by a percentage of 75.55% from the initial levels, TSS levels had decreased by a percentage of 45.3% from the initial levels. CONCLUSION: The MBBR biofilter combined with activated carbon is effective in reducing BOD and COD levels and quite effective in reducing TSS levels.

INTRODUCTION

Domestic wastewater is wastewater originating from businesses and/or residential activities, restaurants, offices, commerce, apartments and dormitories. Based on this understanding, it can be concluded that water originating from the cleanliness of daily activities in residential areas, namely kitchen, bathroom, toilet, laundry, and so on, is waste water domestic (1). The average composition of liquid waste contains organic materials and mineral compounds originating from food waste, urine and soap. Some household waste is in the form of suspension, others are in the form of dissolved materials (2).

The type of liquid waste produced is divided into two types, namely *black water* and *grey water*. *Black water* is waste that comes from the process of disposing of feces or human waste which is processed in *septic tank* so no further processing is required (3). *Grey water* is domestic liquid waste that comes from washing activities such as washing dishes, bathing and washing clothes. *Grey water* which is domestic waste, is usually not processed further so it is often thrown directly through the gutter or left to seep into the ground (4).

According to data obtained from India, every year around 50,000 billion liters of waste water is generated from urban areas, both from industry and domestically. In India, only around 2.8% of domestic wastewater and 60% of industrial wastewater can be treated by existing wastewater treatment infrastructure. Therefore, a lot of liquid waste is not processed and is directly discharged into rivers. The impact of liquid waste discharged into rivers can cause environmental pollution and endanger the health of people who use river water as a source of drinking water (5).

One step that can be implemented to deal with domestic waste problems is a waste water treatment system. Wastewater treatment systems can be divided into 3 types, namely physical, chemical and biological (6). Biological processes generally utilize microorganisms as decomposing substances, this activity is usually called a biological process. The biological wastewater treatment process can be carried out under aerobic conditions

(with air), anaerobic conditions (without air), or anaerobic and aerobic conditions. The biggest obstacle to biological processing is the slow process of microbial degradation of organic pollutants (7).

Wastewater treatment technology has evolved significantly since its inception, adapting to growing needs and stricter environmental standards. These developments not only focus on the efficiency of pollutant removal but also on the sustainability of wastewater treatment operations (8). There are many types of wastewater treatment systems in Indonesia, for example the implementation of domestic Wastewater Treatment Plants (IPAL) through biological processes with technology. *Moving Bed Biofilm Reactor* (MBBR). MBBR technology is one of the biological processing units that utilizes *biofilm* or microorganisms that grow on the media (9). MBBR technology differs from common biofilters in several aspects. MBBR uses *biocarrier* which supports growth *biofilm*, increasing process efficiency, especially in the removal of nutrients such as COD, BOD, nitrogen and phosphorus. The MBBR design offers advantages in terms of flexibility, efficiency and adaptability to various wastewater treatment needs(10).

Activated carbon is a carbon compound whose adsorption has been increased by carrying out carbonization and activation processes. Activated carbon is a very effective adsorbent material and is widely used in wastewater treatment technology because of its large surface area and high ability to adsorb various types of pollutants. The use of activated carbon in wastewater treatment offers an efficient solution for reducing organic and inorganic contaminants, including heavy metals, chlorine, pesticides and other organic materials from water (11).

Biochemical Oxygen Demand or often referred to as BOD is the amount of dissolved oxygen required by microorganisms to decompose organic matter under aerobic conditions (12). COD (*Chemical Oxygen Demand*) often referred to as Chemical Oxygen Requirement (KOK) is the amount of oxygen in ppm or mg/l needed under special conditions to chemically decompose organic matter (13). *Total Suspended Solid* (TSS) is a fine substance found in water and consists of a mixture of silt, organic material, microorganisms, industrial waste and household waste (14).

Domestic waste on islands differs from domestic waste in urban areas due to limited access to large waste treatment systems and resources such as fresh water. This creates challenges in effective waste management, so smaller, decentralized processing solutions are often the preferred choice. In urban areas, waste processing infrastructure is more advanced and efficient. These differences need to be taken into account in developing domestic waste management strategies to suit geographical conditions and available resources (15).

Syamsir and Muis in their research in 2019 on Barrang Lompo Island, Makassar City found that the majority of people channeled household waste to land outside the house. This habit creates pollution problems that need to be addressed immediately, especially on small islands. Arranging settlements in coastal areas and small islands and applying sanitation technology to manage household waste is a solution to reduce the environmental burden caused by this waste (16).

Based on this background, it is necessary to conduct research on the effectiveness of biofilters *Moving Bed Biofilm Reactor* (MBBR) Combination of Active Carbon in Domestic Wastewater Treatment on Barrang Lompo Island, Makassar City.

METHOD

The type of research used in this research is quasi experimental designs using designs in the form of *pre test-post test*. The location of this research is divided into 2 places, namely the sampling location, namely on Barrang Lompo Island, and the sample testing location, namely at the Makassar Health Polytechnic Laboratory, Department of Environmental Health. The research was conducted in February – March 2024. The population is all the characteristics that are the object of research. The population in this study is domestic liquid waste found in the six communal IPALs that are still actively operating on Barrang Lompo Island. The sampling technique in this research is by *purposive sampling* namely a sampling technique based on certain characteristics that are considered relevant to the research. The sample in this study was domestic liquid waste taken from the RW 1 communal IPAL on Barrang Lompo Island which was the sample *pre-test* and Domestic liquid waste taken at the MBBR biofilter outlet combined with activated carbon after processing is a sample *post-test*.

In this research, various tools and materials were used to measure wastewater quality and ensure the effectiveness of its treatment. The equipment used includes MBBR technology biofilter reactors, activated carbon media reactors, as well as BOD measurement tools such as Winkler bottles, incubators and burettes; COD measurement tools such as reflux flasks and condensers; as well as TSS measurement tools such as Gooch

cups and heating ovens. The materials used include waste water samples, Kaldness model K1, activated carbon, and chemical solutions for measuring BOD, COD, and TSS. All these tools and materials are used systematically to measure BOD, COD and TSS in wastewater samples, allowing assessment of the effectiveness of the applied treatment technology.

RESULTS AND DISCUSSION

This research was carried out on 26 February 2024 – 22 March 2024 on Barrang Lompo Island, Makassar. This research includes examining BOD, COD and TSS parameters in domestic wastewater taken at the Communal wastewater treatment plant located in RW 1. Domestic wastewater samples were taken from the communal IPAL located in RW 1 which accommodates approximately 7 families. Samples were taken from 9 jerry cans with a capacity of 30L. The examination was carried out four times, namely once before processing and three times after processing with an MBBR (Moving Bed Biofilm Reactor) biofilter combined with activated carbon. Sample examination was carried out at the Ministry of Health Polytechnic, Department of Environmental Health, Makassar.

Waste products from daily human activities that use water are categorized as domestic wastewater or household wastewater *(grey water)* which consists of kitchen, bathing, washing and house cleaning waste. *Grey water* contains chemicals that are used in household activities and must be processed so that they do not pollute and do not endanger health and the environment. The conditions for the disposal of waste water originating from households include not polluting water sources, not causing odors, and not polluting the ground surface.[15].

Many of the IPALs on Barrang Lompo Island are no longer operating due to overflowing waste water from within the IPALs. So residents generally immediately dispose of their household waste water in their yards, which can later cause soil pollution. Management of household liquid waste needs to be carried out to minimize the occurrence of more sustainable pollution on Barrang Lompo Island.

The parameters BOD, COD, and TSS are the parameters of domestic liquid waste that are measured. The results of laboratory examinations of the levels of these three parameters compared with the quality standards measured in the Regulation of the Minister of the Environment of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 can be seen in the following table:

Table 1. Domestic Wastewater Laboratory Test Results on Barrang Lompo Island in 2024

Parameter	Result (mg/L)	Quality Standards (mg/L)
BOD	597.6	30
COD	600	100
TSS	222	30

In table 1 above, it is known that the laboratory test results show that all parameters tested have exceeded the standard standards set by the Regulation of the Minister of Environment of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016. It can be seen that the BOD level shows 597.6 mg/L while the maximum allowable limit is only 30 mg/L. COD levels also show a figure of 600 mg/L with a maximum limit of 100 mg/L. Likewise, TSS showed a figure of 222 mg/L while the maximum limit was only 30 mg/L.

Biofilters with MBBR technology utilize porous media to facilitate biofilm growth. Process *seeding* (cultivation) in the biofilter utilizes microorganisms obtained from wastewater that flows into the reactor which contains 40% of the reactor volume as K1 caldnes media until a biofilm is formed. This biofilm functions to degrade organic materials and eliminate pathogenic microorganisms in liquid waste.

Process *seeding* lasts for approximately 2 weeks until a black-brown biofilm layer is formed and sticks tightly to the media. After process *seeding* is completed, then an acclimatization process is carried out which aims to adjust or adapt a microorganism to the new environment (17). Acclimatization is carried out by gradually replacing the waste water used in the process *seeding* with new wastewater.

Biological wastewater treatment with an aerobic biofilter system using MBBR technology is experiencing rapid development because of its relatively low cost and simple and easy to operate technology. The biofilter reactor uses barrel-shaped plastic material which has a processing capacity of 60 liters. The aerobic process is carried out by activating the aerator, while the activated carbon reactor functions as an adsorbent medium.

The waste water flows into the initial settling tank where the waste water first enters and undergoes initial effluent settling before heading to the MBBR reactor. This initial settling tank is connected to the MBBR reactor

which uses an aerobic method with a top to bottom flow system *(down flow)*. In the next stage, waste water enters the second tank, namely the main processing site which uses MBBR technology aerobically with a residence time of 1 hour. Inside there is an aerator as a driving force to help the growth of biofilm on K1 caldnes media.

The biofilter reactor in the MBBR tank is connected to the active carbon reactor via a pipe with a flow system *down flow*. The third tank is an advanced processing stage that uses activated carbon to decompose organic substances that cannot be broken down by aerobic bacteria with a residence time of 1 hour. Activated carbon plays an important role in absorbing contaminants and increasing the purity of processed water. This tank is connected to the final reservoir using a pipe with a flow system *down flow*. The final settling tank functions as a place final reservoir that receives processing results from the MBBR technology aerobic tank and activated carbon.

The final stage of the wastewater treatment process is through a chlorinator. Before the processed wastewater is discharged into the environment, the water passes through a chlorinator reactor as the final processing stage. This chlorinator functions to disinfect water by adding chlorine or chlorine compounds. The aim of this process is to kill or eliminate pathogenic microorganisms such as bacteria, viruses and parasites, so that the waste disposed of is safe for water bodies.

Laboratory test results show that BOD levels in domestic wastewater have decreased after processing. The results of checking the reduction in BOD levels and the percentage reduction before and after processing can be seen in the following table:

Table 2. BOD Parameters and Percentage of Effectiveness After Processing with Biofilter *Moving Bed Biofilm Reactor* Combination of Activated Carbon in Domestic Wastewater in 2024

No.	Test	BOD Initial (mg/L)	BOD After (mg/L)	Decline (mg/L)	Percentage (%)	Quality Standards
1.	Experiment 1	597.6	273.9	323.7	54.12	BOD≤30 mg/L
2.	Experiment 2	597.6	199.2	398.4	66.67	(PermenLH
3.	Experiment 3	597.6	124.5	473.1	79.16	P.68/Menlhk/
	Average				66.65	Setjen/Kum.1/8/2016

Table 2 shows that domestic wastewater treatment using an MBBR biofilter combined with activated carbon is able to reduce BOD levels, although it still does not meet the specified quality standards. The initial BOD level was 597.6 mg/L. In three experiments, BOD levels decreased: the first experiment decreased by 323.7 mg/L to 273.9 mg/L (54.12%), the second experiment decreased by 398.4 mg/L to 199.2 mg/L (66, 67%), and the third trial decreased by 473.1 mg/L to 124.5 mg/L (79.16%). The average effectiveness of reducing BOD levels is 66.65%.

BOD testing is used to measure the amount of oxygen needed by microorganisms to decompose organic matter contained in wastewater under aerobic conditions. A high BOD value indicates a high concentration of organic matter in the water, which can reduce water quality and endanger aquatic life. BOD testing is also important for evaluating the effectiveness of wastewater treatment plants. By monitoring BOD, managers can determine how effective the processing process is in reducing organic pollutants. In addition, BOD testing results can be used to ensure that wastewater released into the environment meets applicable regulatory standards, thereby minimizing negative impacts on local ecosystems [18].

Initial examination of BOD parameters in domestic wastewater on Barrang Lompo Island before processing showed a figure of 597.6 mg/L where the BOD level had exceeded the quality standards set by the Regulation of the Minister of Environment of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016, namely 30 mg/L. High BOD levels in domestic wastewater pose a risk of decreasing water quality, death of aquatic life, excessive algae growth, and increasing the burden on wastewater treatment facilities [12]. Based on research results, it is known that BOD levels in domestic wastewater on Barrang Lompo Island decreased after processing using an MBBR biofilter combined with activated carbon. After carrying out 3 experiments, the percentage of effectiveness in reducing BOD levels was 66.65%. Pitriani et al (2022) in the criteria for wastewater treatment effectiveness, reducing BOD levels is said to be effective because it is in the range of 60% < X ≤ 80% [19].

This research is in line with research conducted by Aniriani et al (2022) regarding the effectiveness of adding MBBR to domestic wastewater treatment at the Lamongan Islamic University student Islamic boarding school. The research results showed that the BOD processing results decreased by 62.40% after adding MBBR.

From this research, it is known that reducing the concentration of BOD pollution in domestic liquid waste is more effective using caldnes media with MBBR treatment (20).

Laboratory test results show that COD levels in domestic wastewater have decreased after processing. The results of the examination of the reduction in COD levels and the percentage reduction before and after processing can be seen in the following table:

Table 3. COD Parameters and Percentage of Effectiveness After Processing with Biofilter

No.	Test	COD Initial (mg/L)	COD After (mg/L)	Decline (mg/L)	Percentage (%)	Quality Standards
1.	Experiment 1	600	200	400	66.67	COD≤100 mg/L
2.	Experiment 2	600	160	440	73.33	(PermenLH
3.	Experiment 3	600	90	520	86.67	P.68/Menlhk/
	Average				75.55	Setjen/Kum.1/8/2016

In table 3 above, it can be seen that the COD level in domestic wastewater before processing is 600 mg/L. Three repetitions of the experiment were carried out on the samples. In the first experiment, COD levels fell by 400 mg/L to 200 mg/L with a percentage of 66.67%. The second experiment was found to also reduce COD levels by 440 mg/L to 160 mg/L with a percentage of 73.33%. Meanwhile, the third experiment was found to reduce COD levels by 520 mg/L to 80 mg/L with a percentage of 86.67%. After averaging, the effectiveness percentage was obtained at 75.55%.

COD testing in wastewater is often used to measure the total amount of oxygen required to oxidize organic and inorganic materials in water. COD testing is an important method for determining pollution levels and the efficiency of wastewater treatment systems. By knowing COD levels, an assessment of the pollution load and process effectiveness can be carried out applied processing, as well as assisting in planning and operating processing facilities more efficiently. This method is also useful for ensuring that wastewater released into the environment meets established water quality standards (21).

The results of the initial examination of COD parameters before processing were obtained were 600 mg/L. This figure is known to have far exceeded the quality standards set by the Minister of Environment Regulation of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016, namely 100 mg/L. The high levels of COD in wastewater are due to the high use of materials that cannot be biochemically degraded such as detergents, phenol and pesticides. High COD concentrations can cause the dissolved oxygen content in the water to become low (4). Processing using an MBBR biofilter combined with activated carbon is known to be effective in reducing COD levels with an average reduction percentage of 75.5%. According to Pitriani et al (2022) in the criteria for wastewater treatment effectiveness, reducing COD levels is said to be effective because it is in the range of 60% < X ≤ 80% (19).

This research is in line with research conducted by Kusuma et al (2019) regarding wastewater processing *laundry* using the MBBR method. COD levels in wastewater are known to have decreased from the original value of 910.5 mg/L to 56.3 mg/L with a reduction effectiveness of 93.81%. Kaldnes K1 media can provide a surface area large enough for bacteria to adhere (± 500 m²/m³) and the small media volume ratio compared to the reactor water volume causes this reactor to have random movement/turbulence between the media exposed to aeration so that each media will be in a moving condition and increase the effectiveness of COD (22).

Laboratory test results show that TSS levels in domestic wastewater have decreased after processing. The results of the examination of the reduction in TSS levels and the percentage reduction before and after processing can be seen in the following table:

Table 4. TSS Parameters and Percentage of Effectiveness After Processing with Biofilter *Moving Bed Biofilm Reactor* Combination of Activated Carbon in Domestic Wastewater in 2024

No.	Test	TSS Initial (mg/L)	TSS After (mg/L)	Decline (mg/L)	Percentage (%)	Quality Standards
1.	Experiment 1	222	198	28	12.6	TSS≤30 mg/L
2.	Experiment 2	222	146	76	34.2	(PermenLH
3.	Experiment 3	222	23	196	88.3	P.68/Menlhk/
	Average				45.3	Setjen/Kum.1/8/2016

In table 5.4 above, it can be seen that the TSS level in domestic wastewater before processing is 222 mg/L. Three repetitions of the experiment were carried out on the samples. In the first experiment, TSS levels

fell by 28 mg/L to 194 mg/L with a percentage of 12.6%. The second experiment was found to also reduce TSS levels by 76 mg/L to 146 mg/L with a percentage of 34.2%. Meanwhile, the third experiment was found to reduce TSS levels by 196 mg/L to 26 mg/L with a percentage of 88.3%. After averaging, the percentage of effectiveness was obtained at 45.3%.

TSS testing is used to assess and manage the quality of wastewater before it is discharged into the environment. Reducing TSS is important to prevent pollution, protect aquatic life, and ensure the effectiveness of wastewater treatment systems. High TSS levels can inhibit the penetration of light in water, disrupt photosynthesis, and cause a decrease in dissolved oxygen which is necessary for the life of aquatic biota. Related studies show that effective reduction of TSS in wastewater treatment systems can play a vital role in maintaining the health and safety of aquatic ecosystems (23).

Before processing, it was discovered that the TSS level in domestic wastewater samples was 222 mg/L. The quality standard for TSS parameters according to the Regulation of the Minister of Environment of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 is 30 mg/L, so it is known that the initial TSS level does not meet the quality standard. High TSS in household waste can come from various activities such as bathing, washing, or other activities that use water. TSS in water can increase the turbidity value so that it will inhibit the penetration of sunlight into the water and ultimately affect the photosynthesis process in the waters (4). The results obtained after repeating the experiment 3 times showed that TSS levels had successfully decreased by a percentage of 45.3%. According to Pitriani et al (2022) in the criteria for wastewater treatment effectiveness, reducing TSS levels is said to be quite effective because it is in the range $40\% < X \le 60\%$ (19).

Meanwhile, research conducted by Sinaga et al (2023) used biosand filters with active carbon media in processing rubber industrial wastewater. The research results showed that TSS levels were successfully reduced by 79%. This effectiveness is achieved through a combination of physical adsorption, biofilm formation, and the activity of microorganisms that degrade suspended particles and organic compounds (24). Activated carbon is known to absorb dissolved organic compounds that contribute to TSS, reduce water turbidity and improve the quality of the water produced.

CONCLUSION

Based on the results of research, it can be concluded that domestic liquid waste processing uses Biofilters *Moving Bed Biofilm Reactor* (MBBR) with a combination of activated carbon has proven to be very effective in reducing BOD and COD levels, with an average reduction of 66.65% and 75.55% respectively. Apart from that, this technology is also quite effective in reducing TSS levels, with an average reduction percentage of 45.3%.

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