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Use of Lactobacillus Bacteria to Degrade Oil and Grease in Restaurant Wastewater

Novirina Hendrasarie¹¹, Syahrul Romadon¹, RKH Putro¹, Aussie A.¹

¹ Environmental Engineering Department, Faculty of Engineering, Universitas Pembangunan Nasional “Veteran” Jawa Timur, Indonesia

Abstract. Restaurant wastewater poses a significant environmental challenge, especially concerning the removal of oil and grease, which is known to be highly persistent. To tackle this issue, the research utilized a Lactobacillus bacteria consortium to effectively degrade oil and grease present in the wastewater. The Lactobacillus bacteria consortium was applied in an aerobic environment within the Grease Trap, while various treatment conditions, such as hydraulic retention time (HRT) and aeration rate, were evaluated to determine the optimal settings for the SBR. By employing this combined pre-treatment and SBR approach, distinct aerobic and anaerobic conditions were created, leading to significant removal of pollutant parameters by microorganisms. Remarkably, the study's findings demonstrated that at a 24-hour retention time and a 14 L/minute aeration rate, the Lactobacillus bacteria consortium achieved an impressive 97.42% removal of oil and grease, compared to only 84.54% removal by the Grease Trap without bacteria. The pretreatment of the Lactobacillus bacteria consortium led to even higher reductions in other pollutant parameters. By harnessing the power of the Lactobacillus bacteria consortium and employing the SBR in combination with pre-treatment, this approach holds great potential for addressing the persistent challenge of oil and grease removal in restaurant wastewater and improving overall water quality.

¹ Corresponding author: novirina@upnjatim.ac.id

1 Introduction

Use The growth of the human population and rapid development of the industrial and domestic sectors have resulted in an increase in the amount of wastewater from human activities. Under the same conditions, the availability of land used for wastewater treatment activities is becoming increasingly limited. Effective, efficient, and land-saving wastewater treatment is required to prevent environmental pollution [1] [26]. Modification of wastewater treatment reactors, such as the addition of media, bacterial modification, alteration and development of treatment schemes, or the installation of new mechanical facilities, can provide a solution to improve effectiveness without the need to expand the land area or alter the overall building structure, making the treatment process more efficient [2] [24] [28].

The Sequencing Batch Reactor (SBR) is one of the wastewater treatment reactors that utilize microorganism processes to degrade pollutants in wastewater. Sequencing Batch Reactor effectively degrades organic pollutants such as COD, BOD, Total Nitrogen, Phosphate, and Oil & Grease, while remaining space-saving and highly flexible [3][18][19]. SBR can treat domestic and industrial sectors with relatively high pollution loads, such as slaughterhouses, restaurants, food and beverage industries, hospitals, etc. [4] [21]. Generally, each industry or domestic sector has specific modifications to enhance the effectiveness of its wastewater treatment, such as the addition of granular activated carbon (GAC), modification of SBR schemes, or the addition of a pre-treatment reactor [4] [5] [6]. Improvements are often carried out to explore reactor abilities and development to achieve maximum removal efficiency according to the specific wastewater used [7] [25] [31]. This study analyzed the removal of organic pollutants, especially oil, and grease, using an aerobic Grease Trap as Pre-treatment to treat wastewater from restaurants. Restaurant wastewater was chosen due to its large number of pollutants, limited land conditions, and inadequate wastewater treatment. The microorganisms used were specially cultured with high oil and grease degradation capabilities. The study was conducted by adding microorganisms in different pre-treatment conditions, varying the treatment's hydraulic retention time (HRT), and aeration flow rates to determine the optimum conditions for the reactor.[32][34] This research aims to determine the combination and development of conventional grease traps so they can be applied to the medium-sized industrial and domestic sectors to reduce environmental pollution.

2 Research Methods

This research aims to analyze the effect of aerobic pre-treatment combined with oil and grease microorganisms and a Sequencing Batch Reactor on removing pollutants from wastewater. The study was conducted in two stages; (1) The first stage began by seeding and acclimatizing the microorganisms cultured from wastewater. The wastewater used came from a restaurant with a wastewater quantity of approximately 2000 L/ day. The activated sludge produced was then used as the main microorganism in the SBR unit. Microorganisms used in the modified aerobic pre-treatment reactor were prepared separately to not interfere with the overall wastewater treatment processes. (2) The second research stage was the primary study conducted on a laboratory scale, with a pre-treatment reactor volume of 20 L and an SBR volume of 4 L, consisting of 12 SBR reactors. The study began by treating the wastewater with a pre-treatment reactor. Differences were observed in the effluent of conventional pre-treatment wastewater as a control, with aerobic pre-treatment and bacterial addition. Subsequently, both results were continued in SBR treatment with variations in aeration rate and HRT to determine the maximum effectiveness of the treatment..

Table 1. Sequencing Batch Reactor and Grease Trap Specification

Design	Unit	Value
(a) Sequencing Batch Reactor		
- Total Volume	L	10
- Volume Used	L	4
- Sludge Volume (50%)	L	2
- Wastewater Volume (50%)	L	2
SBR Reactor Specification		
- Reactor Diameter	Cm	10
- Reactor Height	Cm	15
Hydraulic Retention Time	Hours	24; 48; 72
Aeration Rate	L/m	7;14
(b) Grease Trap		
- Total Volume	L	24
- Volume Used	L	22
- Lactobacillus Volume (25%)	L	5,5
- Wastewater Volume (75%)	L	16,5
Grease Trap Specification		
- Reactor Height	Cm	30
- Reactor Width	Cm	20
- Reactor Length	Cm	40
Hydraulic Retention Time	Hours	2
Aeration Rate	L/m	45

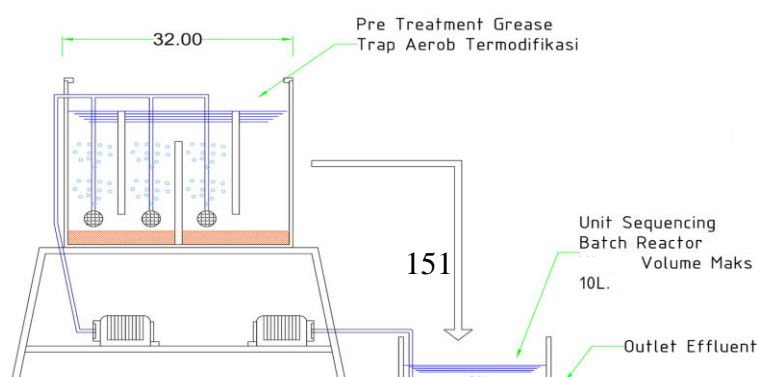


Figure 1. Arrangement of the Grease Trap Reactor and Research Sequencing Batch Reactor

The independent variable in this study is the difference in the pre-treatment reactor, which includes a conventional anaerobic grease trap and a modified aerobic pre-treatment. In addition, variations were made in the HRT (24, 48, and 72 hours) and aeration rate (7 L/min and 14 L/min) during the treatment. The optimal condition of the entire study reactor and the influence of microorganism activity on the overall wastewater removal ability was observed. The dependent variables that were observed were the parameters of wastewater pollutants, including COD, oil and grease, total nitrogen, and phosphate.

4. Results and Discussion

4.1. Aerobic Pre-Treatment Reactor Combined with Oil and Grease Microorganism Performance

In the Grease Trap, the use of *Lactobacillus* to break down oil and grease will be examined. We will contrast the Grease Trap with *Lactobacillus* bacteria

and the Grease Trap without *Lactobacillus* bacteria in this study.

Based on the results obtained in **Figure 2**, the performance of the conventional and aerobic pre-treatments with oil and grease-degrading bacteria on several treatment parameters was known and analyzed. The pollutant load of the wastewater has a relatively high value. The effectiveness of the modified pre-treatment reactor with aeration and the addition of oil and grease-degrading bacteria for COD, oil and grease, phosphate, total nitrogen, and TSS parameters are 54.54%, 73.23%, 1.5%, 4.43%, and 36.84%, respectively. The highest effectiveness is in the oil and fat and COD parameters, with the oil and fat removal rate reaching > 1700 mg/L. The conventional pre-treatment reactor without aeration and bacteria addition did not show a significant decrease for all parameters. There are two underlying factors. There is, no essential biological activity occurring in the treatment, and second, there is a short hydraulic retention time, resulting in only physical treatment occurring in the conventional pre-treatment reactor

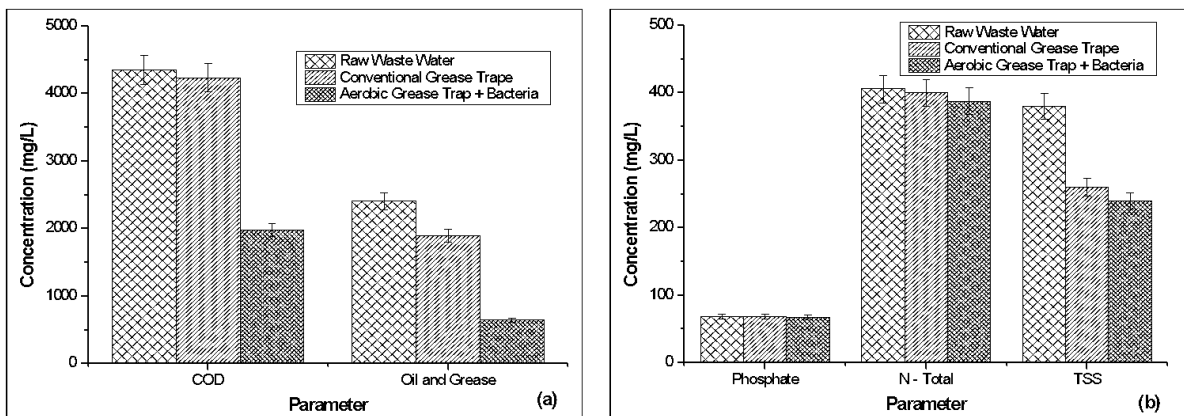


Figure 2. Results from Different Pre-Treatment Reactors (a) COD, Oil and Grease, (b) Total Phosphate, Total Nitrogen, and Total Suspended Solids (TSS)

The sufficiently good microorganism activity in the aerobic pre-treatment reactor was dominated by *Lactobacillus sp.* as probiotic bacteria, followed by *Bacillus sp.* and *Pseudomonas sp.* These bacteria increase enzymatic activity, such as Lipase, which can convert complex oil and grease structures into fatty acids and glycerol. *Bacillus sp.* and *Pseudomonas sp.* are known to be actively involved in degrading long-chain oil structures and are often used in the bioremediation of marine pollution [8] [20] [27]. Enzymatic activity will ease the removal of pollutant parameters during the process. Using aerobic pre-

treatment combined with oil and grease-degrading bacteria can improve effectiveness and optimize the results of domestic wastewater treatment.

4.2. Sequencing Batch Reactor Performance in Removing Organic Compounds in Wastewater

The results of the overall parameters in Sequencing Batch Reactor treatments can be seen in **Table 2**. The study results show a significant difference

in processing performance using a Sequencing Batch Reactor, especially with the addition of an aerobic pre-treatment reactor with oil and grease-degrading bacteria. The overall Sequencing Batch Reactor processes showed significant processing results in the first 24 hours of treatment, with a difference in efficiency of more than 10% overall. In addition, the pre-treatment reactor catalyzes all parameters due to the addition of Hydraulic Retention Time (HRT) and stabilization of the initial wastewater condition. Adding pre-treatment improves the effectiveness and efficiency

of the wastewater treatment time to achieve smaller values.

Table 2. Findings from Various Sequencing Batch Reactor (SBR) Conditions

SBR Condition	Aeration Rate	HRT (Hours)	% Removal COD	% Removal Oil & Grease	% Removal Nitrogen Total	% Removal Phosphate	% Removal TSS
SBR + Aerobic GT	7 L/m	24 Hours	85,45%	95,01%	45,81%	85,37%	68,42%
SBR + Conventional GT	7 L/m		73,64%	82,54%	52,22%	69,79%	63,16%
SBR + Aerobic GT	14 L/m		89,09%	97,42%	41,13%	86,48%	73,68%
SBR + Conventional GT	14 L/m		79,09%	84,54%	58,37%	71,23%	52,63%
SBR + Aerobic GT	7 L/m	48 Hours	89,09%	96,01%	61,08%	93,69%	84,21%
SBR + Conventional GT	7 L/m		86,36%	86,53%	75,37%	88,29%	73,68%
SBR + Aerobic GT	14 L/m		94,55%	98,09%	55,17%	93,67%	89,47%
SBR + Conventional GT	14 L/m		97,27%	88,03%	75,37%	90,18%	73,68%
SBR + Aerobic GT	7 L/m	72 Hours	94,55%	98,42%	75,37%	94,69%	89,47%
SBR + Conventional GT	7 L/m		90,91%	93,52%	80,54%	91,84%	94,74%
SBR + Aerobic GT	14 L/m		97,27%	99,25%	72,91%	95,13%	100%
SBR + Conventional GT	14 L/m		93,64%	93,93%	83,99%	90,32%	100%

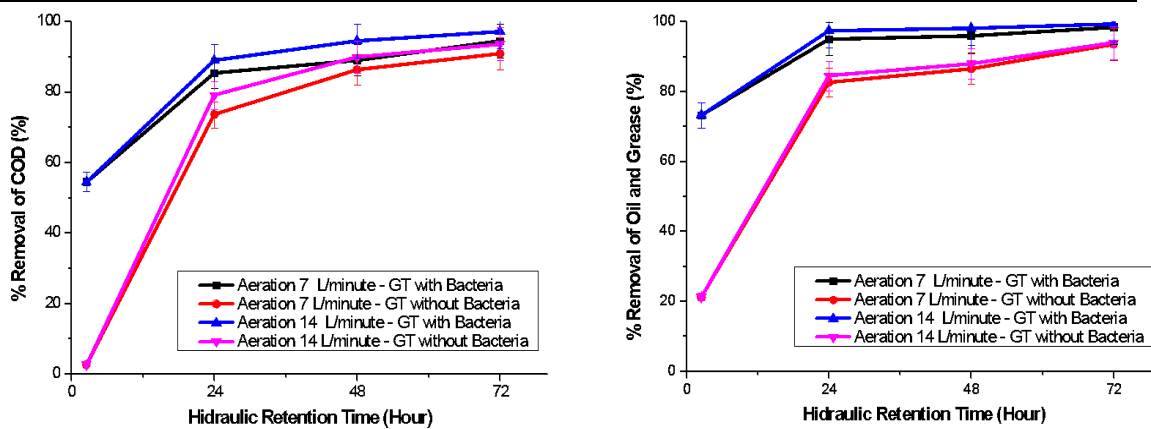
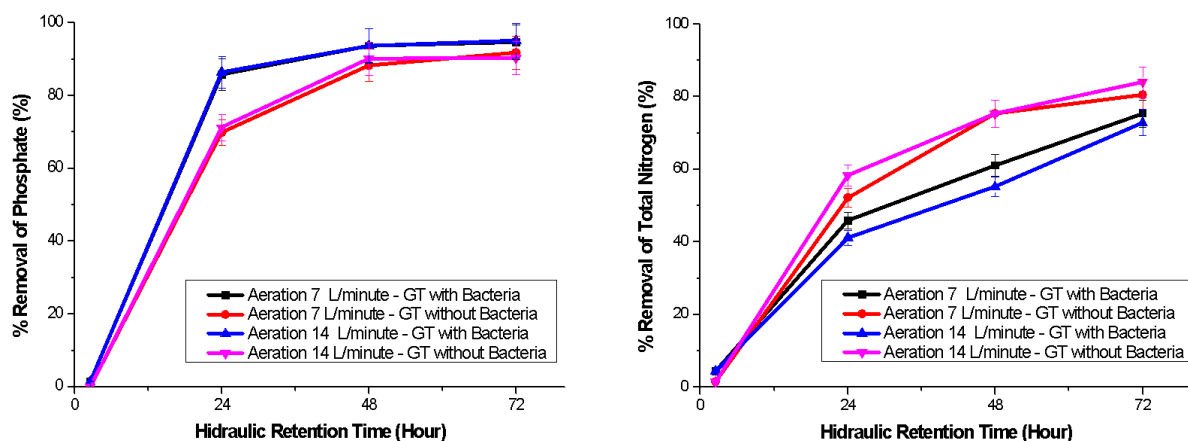


Figure 3. Graphic Removal of COD, Oil and Grease in Reactors



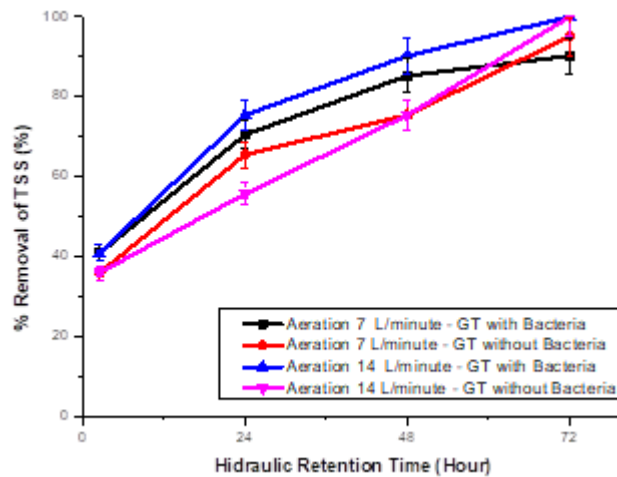


Figure 4. Graphic Removal of Phosphate, Total Nitrogen, and TSS in Reactors

The Sequencing Batch Reactor has a great ability to remove high pollutant loads in wastewater. The highest efficiency percentage occurs at an HRT of 72 hours, an aeration rate of 14 L/minute, and aerobic pre-treatment combined with oil and grease-degrading bacteria, the results can be seen in pictures 3 and 4. The removal efficiencies for COD, oil & grease, phosphate, total N, and TSS are 97.27%, 99.25%, 95.13%, 83.99%, and 100%, respectively. The optimum removal condition occurs at an HRT of 48 hours, an aeration rate of 14 L/minute, and pre-treatment treatment with adding bacteria and aeration, with an average removal efficiency of 90%. Based on the research data, the combined pre-treatment reactor and Sequencing Batch Reactor as the primary treatment can effectively treat wastewater compared to the conventional SBR unit.

There are differences in the improvement of several parameters due to different pre-treatment reactors. In aerobic pre-treatment treatment, a high percentage of parameter removal was obtained for all parameters except Total Nitrogen. Adding an anaerobic phase in conventional pre-treatment reactors provides time for nitrification and denitrification microorganisms to reduce the total N parameter in wastewater effectively [9] [29]. The balanced anaerobic and aerobic phases will help the nitrification cycle (conversion of ammonia nitrogen to nitrate) and denitrification (conversion of nitrate to nitrogen gas) to occur ideally [10] [11]. Based on this analysis, the addition of an anaerobic phase at the beginning of SBR is considered important as it can remove nitrate and phosphate pollutants more optimally.

4.3. The Effectiveness of Sequencing Batch Reactors as Determined by Research Supporting Parameter Analysis

Aside from the main parameters, there are several supporting parameters in the study, such as DO, TSS, pH, and temperature, that serve as support for the response variable. Supporting parameters in this study

include dissolved oxygen, total suspended solids (TSS), pH, and temperature.

According to **Figure 5 (a)**, there is a significant influence between HRT, aeration discharge, and oxygen solubility in wastewater. The initial wastewater had a DO concentration of 0 mg/L. After entering the pre-treatment process with the addition of bacteria and aeration, the DO concentration increased to 0.923 mg/L after a 120-minute aerobic reaction. This differs from the pre-treatment treatment, which does not include bacteria or aeration and has a dissolved oxygen concentration of 0 mg/L. The pre-treatment with bacteria and aeration also had a significant impact on the solubility of oxygen in the water in the SBR reactor's final yield. Due to the high solubility of oxygen in water, the process of removing pollutant loads from treated wastewater will be hampered. According to **Figure 5 (a)**, better DO results were obtained in the pre-treatment SBR reactor, both with aeration rates of 7 L/minute and 14 L/minute. At 72 hours of HRT, the optimal DO concentration is 5.304 mg/L for 14 L/minute aeration discharge and 4.288 mg/L for 7 L/minute aeration flow.

There is no significant difference in the decrease in TSS data in terms of HRT based on the data in **Figure 5 (b)**. The optimal aeration rate is 14 L/min because it is capable of removing 10% more TSS than the final SBR reactor's aeration rate of 7 L/min. Graph 4.15 depicts the efficiency of TSS removal. The presence of microorganisms that grow to bind or reduce suspended solids so that they can be deposited with the biomass during the final sedimentation phase results in TSS removal. TSS removal in biological reactors is proportional to the contact time with microorganisms (HRT), the longer the HRT, the more efficient the microorganisms are at binding and reducing suspended solids in wastewater to be deposited during sedimentation. In this study, the efficiency of TSS removal was quite good at 48 hours of HRT, with the average TSS value being less than 100 mg/L, meeting the quality standard. The SBR reactor, with an HRT of 72 hours and an aeration rate

of 14 L/minute has the highest efficiency of reducing TSS, reaching 100%. TSS concentrations in the SBR reactor can be reduced by a variety of factors, including HRT, aeration discharge, bacterial conditions (activated sludge), and wastewater pH. The shape of the SBR reactor used can also influence TSS reduction during the sedimentation phase. Because it provides a more turbulent flow and space for dead-activated sludge, the addition of a sludge zone to SBR can reduce TSS and increase the effectiveness of other parameter removals (Anisah & Hendrasarie, 2022).

The pH data for the entire reactor revealed a consistent value in the range of 7.5 to 8.5. The pH close to neutral indicates that microorganism activity is good, allowing the removal of pollutant loads in wastewater to run smoothly. Furthermore, the pH range

in the research reactor meets the quality standards required by East Java Governor Regulation No. 72 of 2013 regarding domestic wastewater quality standards (**Figure 5 c**). During the processing, the temperature in this study ranged between 26 and 30 °C. The temperature range commonly used in biological treatment processes is listed above (**Figure 5 d**). [35][36][33]

According to the overall findings of the research, there is a significant influence between the three independent variables, which are the pre-treatment grease trap, the difference in HRT, and the aeration discharge in the SBR reactor. The difference between the three variables is generally positive, the higher the HRT and aeration discharge, the better the results of the parameter degradation [22] [23] [30].

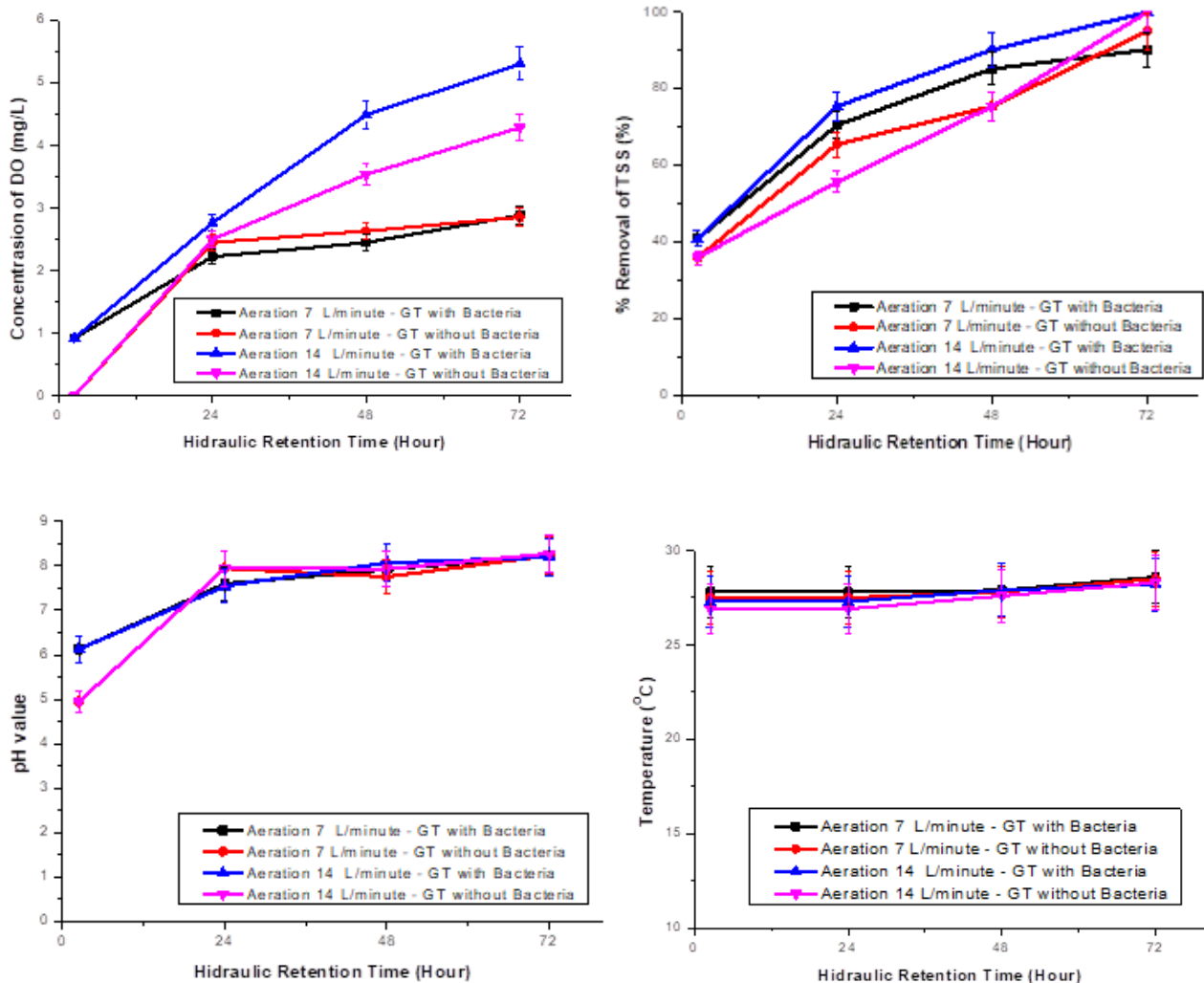


Figure 5. Supporting data for research (a) dissolved oxygen, (b) total suspended solids, (c) pH, and (d) temperature

5. Conclusion

Based on the research results and data analysis, an aerobic pre-treatment reactor combined with oil and grease microorganisms is most effective in removing wastewater pollutants in the first treatment stage. The highest removal efficiency was achieved for the COD

and oil and grease parameters with 54.4% and 73.23% removal percentages, respectively. The aerobic pre-treatment treatment with aeration functioned as a catalyst in the Sequencing Batch Reactor, which significantly impacted the effectiveness by more than 10% at an HRT of 24 hours, and the optimal time was achieved at 48 hours with an average efficiency of over 90%. *Bacillus sp.*, *Pseudomonas sp.*, and *Lactobacillus*

sp bacteria can produce beneficial enzymatic activities in wastewater treatment, particularly in the degradation of oil and grease. The research results provide an overview of the increased effectiveness of the Sequencing Batch Reactor with the addition of aerobic pre-treatment and bacteria. The provision of aerobic and anaerobic pre-treatment can be considered to improve the overall percentage removal of parameters by microorganisms, especially for removing total nitrogen and phosphate in the nitrification and denitrification processes.

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