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Wastewater Processing of Chicken Slaughterhouses Using Combination of Trickling Filter and Rotating Biological Contactor

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ABSTRACT

This research was conducted to explore the effectiveness of combined Trickling Filter (TF) and Rotating Biological Contactor (RBC) method in processing liquid waste from chicken slaughterhouses through local and economical media. Microorganisms were grown by inserting liquid waste into a TF tank containing gravel, used ceramics, coconut shells, and pumice. Subsequently, liquid waste flowed into a rotating biological contactor added with local microorganisms from stale rice and fermented banana stems. Waste treatment was carried out with variations in retention time of 1, 3, and 6 h. The results showed that at 6 h, the organic compound decreased significantly. The removal efficiency obtained was 87.05%, 82.11%, 90.51%, 22.57%, 79.36%, and 88.66% for Biological Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Total Dissolved Solids, Turbidity, and Ammonia, respectively. This high efficiency was supported by the collaboration between the activity of microorganisms attached to the TF biofilm and the use of local microorganisms in decomposing organic compounds in the rotating biological contactor. The combination of the two methods has been proven to help waste treatment process from chicken slaughterhouses in an environmentally friendly and efficient manner.

1. INTRODUCTION

Changes in the quality of the aquatic environment are caused by the discharge of waste-containing pollutants exceeding the natural processing capacity of water (Kanwar *et al*., 2023; Liu *et al*., 2021). One of the hazardous wastes is wastewater from chicken slaughterhouses, which contains significantly high organic compounds in the form of blood solution of 3.50%/kg, protein 8.5-10.5%/kg, fat 1.30%/kg, and suspended solids 1.65%/kg (Dong *et al*., 2020). This wastewater pollutes rivers, affecting water quality, aquatic life, and damages the ecosystem, causing eutrophication which reduces oxygen levels in water (Ma *et al*., 2021).

Wastewater from chicken slaughterhouses will seep into soil and disrupt the balance of microorganisms, thereby affecting soil fertility and plant health (Deepali, 2021). This wastewater, containing pathogens such as Escherichia coli (E. coli), Salmonella, and disease-causing viruses, can easily spread when contaminated (Wang *et al*., 2019). Waste generated from market activities is discharged into the river directly connected to seawater which allows the mixing of seawater and wastewater, particularly during high tide (Adam *et al*., 2023).

Previous reports showed that pollutant levels in wastewater from chicken slaughterhouses were significantly high, containing biological oxygen demand (BOD) of 600 mg/L, chemical oxygen demand (COD) of 2,785.4 mg/L, total suspended solids (TSS) of 161 mg/L, and turbidity of 507 NTU (Handriani, 2021). When these pollutants are directly discharged and received by water body without prior treatment, there will be a negative impact on the environment.

Therefore, intensive analysis is needed for control to ensure that the organic load received by the aquatic environment is in the quality standard threshold.

Wastewater processing technology can be carried out through several methods that are appropriate to waste characteristics (Hanafy *et al*., 2022; Faisal *et al*., 2016a; 2016b; 2015). Specifically, wastewater from chicken slaughterhouses contains highly organic compounds, showing the need for processing through biological processes using microorganisms. The combination of biological process of Trickling Filter (TF) and Rotating Biological Contactor (RBC) which uses microorganisms attached to the media and Local Microorganisms (MOL) is rarely applied during treatment (Chen *et al*., 2021). This biological treatment will change hazardous organic compounds into harmless forms and become nutrients for microorganisms (Suwahdendi & Purnama, 2020).

Treatment technology with a combination of TF and RBC methods can reduce BOD, COD, oil, and fat content in wastewater containing organic compounds (Powar *et al*., 2023). This combination uses the performance of microorganisms by positioning biofilms as a place for attachment, thereby allowing the reduction of organic compounds in waste (Subhadarsini & Dash, 2020). The use of these microorganisms is produced from several media according to its reactor. Gravel, ceramic, coconut shell, and pumice are used as media for biofilm formation in the TF Reactor. The MOL of stale rice and banana stems to be fermented are attached to the RBC tank for RBC processing.

Combined method of TF and RBC has been used to reduce organic content in wastewater from chicken slaughterhouse (Zhang *et al*., 2020), which is treated with reverse osmosis, air flotation, and activated sludge (Lecompte & Mehrvar, 2017). The method has also been used to treat domestic waste (Patel *et al*, 2021; García *et al*, 2016; Gaber *et al*., 2024). The use of coconut shell waste as a medium in TF is also essential to minimize the levels of agricultural waste. This method can increase economic value by improving the efficiency of agricultural waste for the growth of microorganisms (Buczynska *et al*., 2019).

Thompson *et al*., (2022) reported that unused ceramics could be selected to process waste into value-added materials. In comparison, RBC is a fairly good method by using MOL of stale rice and banana stems as a source of nutrition for microorganisms (Khan *et al*., 2020). Serving as a carbon source, stale rice and banana stems contain carbohydrates, additional potassium, magnesium, and phosphorus. This combination can increase the decomposition of organic waste by improving microbial activity in biological processes (aerobic or anaerobic) (Bi *et al*., 2021). To reduce waste generation and increase the effectiveness of treatment methods, exploring the potential of food waste as a biological stimulant is an innovative strategy (Abbasi *et al*., 2022). Therefore, this research explored the performance of combined TF and RBC method in the treatment of wastewater from chicken slaughterhouses.

This study is expected to provide significant benefits in the management of wastewater from chicken slaughterhouses by improving water quality through decreasing harmful pollutants. Furthermore, using natural materials such as coconut shells, stale rice, and banana stems as biofilm carriers in the treatment process might reduce operational costs, increase agricultural waste utilization, and improve microbial effectiveness in breaking down organic compounds.

2. RESEARCH MATERIALS AND METHODS

2.1. Research Materials and Equipment

The materials used included wastewater from chicken slaughterhouses obtained at Al-Mahirah market, Banda Aceh City. The filter media in TF tank with a size of 2.5-7.5 cm^2 consisted of gravel, coconut shells, pumice, wood carcoal and ceramics. For the cultivation of microorganisms, the materials used were 200 g stale rice, 75 g granulated sugar, 1 liter water, banana stems, shrimp paste, coconut water, palm sugar, and distilled water.

2.2. Methods

Raw materials in TF tank were used with a height of each media of 5 cm. Based on the design in Figure 1, TF tank was made of glass and equipped with a pump and aerator. Wastewater samples used in processing were taken at 08:00 a.m. Measurement of water quality parameters such as pH, temperature, and Dissolved Oxygen (DO) was carried out during sampling to ensure the initial condition of wastewater. When pH of wastewater was not neutral, adjustments were made using NaOH solution to achieve a neutral pH. Subsequently, wastewater was left for 30 minutes to allow for the settling of larger dissolved particles, facilitating the filtration process.

The filtered wastewater was flowed into TF tank containing special media for biological filtration process. Before entering the tank, aeration was carried out to increase DO levels, which were important for the activity of microorganisms in the process of degrading organic compounds. Furthermore, the acclimatization process was carried out through the seeding method by adding microorganisms to form biofilm on the filter media. This biofilm functioned as a place for microorganisms to attach and reproduce, which was important in the decomposition of pollutants. The seeding process lasted for 6-7 days until the optimal formation of biofilm for wastewater treatment. The combination of TF and RBC research tool designs is shown in Figures 1.

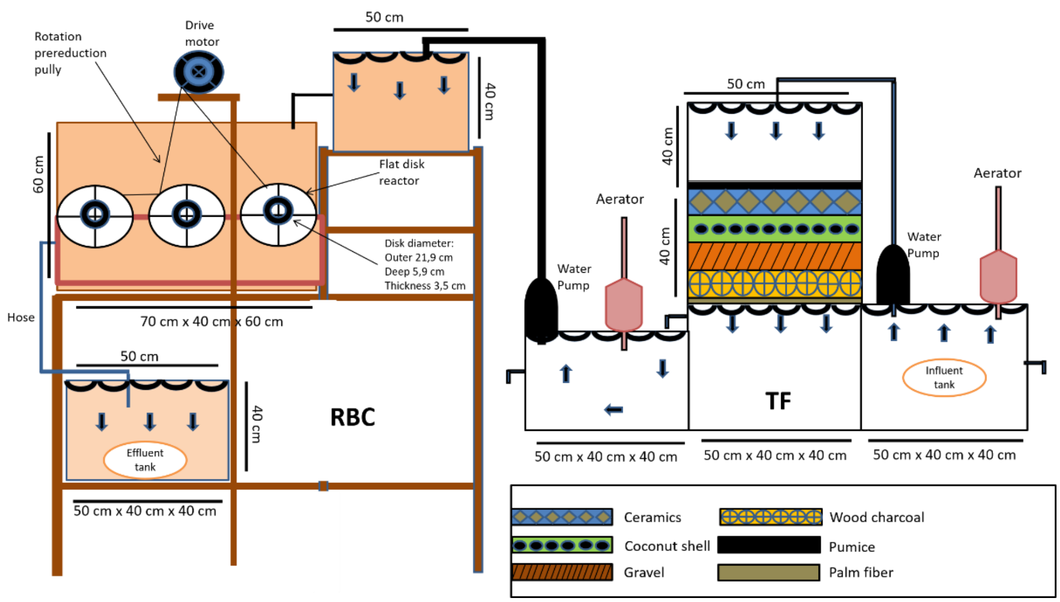

Figure 1. Combination of TF and RBC research tool design

After passing through TF stage, wastewater flowed to RBC process. RBC equipment design consisted of several main components, namely a glass tank as a reactor, a series of flat disk reactors, supports for stability, and a drive system that included belts, drive motors, rotation reduction pulleys, gears, and chains. This design enabled the disk to rotate constantly, allowing microorganism biofilm on the surface to maximize the process of decomposing organic compounds in wastewater.

In RBC process, the raw material used was the media for forming MOL. The stale rice MOL was made by adding 1 liter of water to a container containing stale rice, followed by the addition of 5 tablespoons of granulated sugar to accelerate the development of microorganisms. The fermentation process was allowed to take place for 2-3 days until the mixture produced a distinctive tape aroma, indicating the formation of the desired microorganisms. To prepare banana stem MOL, the finely chopped sample was combined with mashed shrimp paste, palm sugar, and coconut water. This mixture was put into a container of banana stem, which was tightly closed and left for 7-14 days at a temperature of 25-30°C. During the fermentation period, the mixture was stirred every 2-3 days to ensure that the fermentation process was even and effective.

After preparing MOL, waste processing was continued by activating RBC machine at a speed of 5 rpm, followed by monitoring the movement to achieve full stability. Furthermore, MOL of stale rice and banana stem were added as adhesive media to RBC tank to support the growth of microorganisms. The processing was carried out using retention times of 1, 3, and 6 h on TF and RBC systems. After the processing process, wastewater flowed into the final storage tank to be tested for water quality parameters, including BOD, COD, TSS, Turbidity, Mixed Liquor Suspended Solid (MLSS), and Mixed Liquor Volatile Suspended Solids (MLVSS). The removal efficiencies were calculated by comparing the initial and final concentrations before and after the TF and RBC processes using the following equation.

$$\text{Removal efficiency} = \frac{(Co-Ce)}{Co} \times 100\% \tag{1}$$

where: C_0 is the initial concentration (mg/L), and C_e is the final concentration (mg/L)

3. RESULTS AND DISCUSSION

3.1. Initial Characteristics of Waste

The results of waste testing before processing are shown in Table 1. The analysis of wastewater from chicken slaughterhouses showed a significant level of pollution, exceeding the threshold set in environmental regulations. Waste had pH of 3.0, showing acidic properties, along with BOD value of 1,583 mg/l and COD of 2,765 mg/l, which exceeded the permitted threshold. This showed a very high organic content, which required a large amount of oxygen for the decomposition process. Furthermore, waste contained a fairly high TSS of 1,135 mg/l, and a turbidity of 487 NTU. This showed the presence of solid particles that could damage the physical quality and clarity of water when directly discharged into the environment. The ammonia content of 113 mg/l, accompanied by MLVSS and MLSS values of 627 mg/l and 793 mg/l were found in the additional test results, respectively.

Table 1. Initial Test Results of Wastewater Levels in Chicken Slaughterhouses

No.	Parameter	Result
1.	pH	3.0
2.	BOD	1.583 mg/l
3.	COD	2.765 mg/l
4.	TSS	1135 mg/l
5.	TDS	875 mg/l
6.	Turbidity	487 NTU
7.	Ammonia	113 mg/l
8.	MLVSS	627 mg/l
9.	MLSS	793 mg/l

The comparison of wastewater characteristics showed a high pollution level from various chicken slaughterhouses. According to Indah *et al.* (2023), chicken slaughterhouse wastewater in Kota Lama, Kedung Kandang, Malang, has a COD level of 1,448.53 mg/l and TSS of 1,500 mg/l. Whereas COD value reached 5,600 mg/l, BOD 3,360 mg/l, and TSS 548 mg/l in Jember Regency (Novita *et al*., 2021), showing high levels of organic compounds and suspended solids in wastewater due to pollution levels that exceeded quality standards. Ratnawati & Al-Kholif (2018) reported that BOD values were between 400-3,000 mg/l, COD 400-3,000 mg/l, and TSS 400-3,000 mg/l from chicken slaughterhouse wastewater.

3.2. Biofilm Formation Process

Biofilm formation starts with seeding stage where microorganisms are inoculated into media with porous or rough surfaces to facilitate attachment. At this stage, wastewater flows into TF tank after complete inoculation, as microorganisms interact with organic compounds to support initial colonization and the formation of a thin layer of biofilm. This is followed by acclimatization stage for 6-7 days, where microorganisms adapt to the environmental conditions of the reactor, grow, and reproduce, attaching more strongly to the surface of the media (Sugihhartati *et al.,* 2024). The extracellular matrix in the form of exopolysaccharides is successfully produced by microorganisms which function to strengthen the biofilm structure. Subsequently, a mature and stable biofilm layer is formed to allow efficient degradation of organic matter.

Wastewater flowed into the RBC tank added with MOL from stale rice and fermented banana stems after the acclimatization stage in the TF. There was an increase in interaction in the RBC tank, between microorganisms that had adapted to organic compounds. The biofilm formed on the surface of the media acted as an active biological layer, where aerobic and anaerobic microorganisms were very important in degrading pollutants through complex metabolic processes. To improve the efficiency of wastewater treatment, this formation played a significant as mature biofilms have a high capacity to reduce pollution levels and decompose organic compounds.

In this study, MOL is needed during biofilm formation in the wastewater treatment reactor of chicken slaughterhouses. Various microorganisms such as bacteria, yeast, and fungi are abundantly contained in MOL from the fermentation of organic materials, such as stale rice and banana stems. These microorganisms act as inoculum or sources of microbes, which are available to colonize the media in waste processing reactor. The advantages of MOL depend on easy availability and low cost because it can be obtained from organic waste rich in nutrients. Generally, nutrients such as carbohydrates and proteins contained in MOL support the growth of microorganisms that are effective in degrading complex organic compounds in waste.

Microorganisms originating from the fermentation of stale rice and banana stem start to interact with organic compounds in waste using the existing substrate to grow and develop. This process triggers the formation of biofilm, which is a layer of microorganisms that adhere to the surface of the media plate. Biofilm functions as a major component in biological treatment, namely microorganisms bound to biofilm work synergistically to decompose organic matter and reduce the level of pollutants in waste. During the acclimatization stage, microorganisms in MOL adapt to environmental conditions in RBC tank using the existing organic matter as a source of energy and nutrients. The formation of mature biofilm is very important to increase treatment efficiency because biofilm functions as an active biological reactor. Therefore, microorganisms contained in biofilm can degrade various pollutants, including BOD, COD, TSS, turbidity, and ammonia, helping to reduce pollution levels in wastewater effectively. The formation of microorganisms in biofilm is shown in Figure 2.

a. Before Biofilm Formation   b. After Biofilm Formation

Figure 2. Biofilm Formation in TF Tank

Biofilm formation occurs in both TF and RBC tanks, playing an important role in improving the efficiency of wastewater treatment. In TF tank, media such as gravel are used because their rough surface facilitates the attachment of microorganisms. This increases the contact surface area between microorganisms and wastewater. Oxygen from the air naturally diffuses into the formed biofilm, allowing microorganisms to efficiently oxidize organic compounds in wastewater. The phenomenon significantly leads to a decrease in BOD and COD parameters, as organic compounds decompose into simple forms such as water, carbon dioxide, and microbial biomass. Organic compounds are reduced gradually due to the continuous process, showing a BOD decrease efficiency of approximately 80% in domestic wastewater treatment (Hamza *et al.,* 2022).

Media rotation in the RBC tank accelerates the degradation of organic compounds by increasing turbulence and improving gas exchange. This process increases the efficiency of organic compound decomposition in wastewater to support the metabolism of aerobic microorganisms. Subsequently, the rotating RBC media is alternately submerged in wastewater and exposed to air, creating consistent aerobic conditions. This increases the efficiency of degradation due to increase in the contact between organic matter in wastewater and microorganisms. According to Ma *et al*. (2021), the use of RBC reduced COD concentrations in industrial wastewater with an efficiency of more than 80%.

After passing TF, wastewater is flowed to RBC, followed by addition of MOL from stale rice and fermented banana stems to provides nutrients that accelerate biofilm formation. Microorganisms in the MOL strengthen the biofilm on the RBC media because it is rich in nutrients such as carbohydrates and proteins. With the biofilm acting as an active biological reactor because the combination of TF and RBC increases the overall efficiency of wastewater treatment so that it is able to decompose organic compounds and reduce pollutant levels such as BOD, COD, TSS, and ammonia significantly.

3.3. Removal Efficiency of BOD, COD, TSS, TDS, turbidity, ammonia, MLVSS, and MLSS

This research used variations in retention time of 6, 3, and 1 h, which affected the effectiveness of organic matter degradation in chicken slaughterhouse wastewater treatment. Microorganisms have enough time to optimally decompose organic compounds at a retention time of 6 hours, resulting in a significant decrease in pollutant parameters such as BOD and COD. Longer retention times result in higher and more stable treatment efficiency because they provide an opportunity for microorganisms to reproduce and maximize the degradation process. There was a decrease in pollutant parameters at shorter retention times of 3 h and 1 h, but the efficiency was lower compared to a treatment time of 6 h. This results in less stable and unoptimal final results because microorganisms do not have enough time to optimally degrade organic compounds (Al-Shammari *et al*., 2024).

In biological treatment systems (TF and RBC), retention time is a major factor. Longer duration enhances the biodegradation process because the contact between microorganisms and organic compounds in wastewater increases. The consistent decrease of pollutant parameters at 6 h indicates that microorganisms can reach the equilibrium point and maximum efficiency in the treatment process. Meanwhile, due to the limited capacity in degrading existing organic compounds, shorter duration tends to produce unstable reduction. At a longer retention time of 6 h, microorganisms have sufficient time to maximally degrade organic compounds, thereby increasing the efficiency of pollutant decomposition. This condition occurred because microorganisms in biofilm on TF and RBC media have developed optimally and reached their full capacity to decompose the remaining organic matter in wastewater.

Repeated treatment processes cause biofilm to become thicker and saturated with microorganisms, which increases the effectiveness of organic compound degradation. The combination of TF and RBC can maximize contact between waste and microorganisms continuously, causing a gradual decomposition in organic matter. The results of parameter testing during contact times of 6, 3, and 1 h are shown in Table 2. Based on the research data in Table 2, it is evident that as the retention time increases, the values of the wastewater parameters tend to decrease. This decline indicates that the poultry slaughterhouse wastewater treatment process becomes more effective over time. With longer retention times (6 hours), microorganisms have sufficient time to degrade organic compounds, contributing to the reduction of BOD, COD, TSS, turbidity, and ammonia levels.

The BOD parameter, which indicates the amount of oxygen required to decompose organic material, shows a significant reduction. At a retention time of 6 hours, BOD decreased from 450 mg/l at hour 2 to 205 mg/l at hour 6. The COD parameter, which reflects the level of chemical contamination, decreased from 950 mg/l at hour 2 to 415 mg/l at hour 6. The TSS, which measures the amount of dissolved solid particles in the wastewater, consistently decreased. At 6 hours of retention time, TSS dropped from 375 mg/l at hour 2 to 93 mg/l at hour 6. This reduction indicates improved effectiveness in the sedimentation and filtration of dissolved solids. TDS also decreased, though with smaller fluctuations, from 775 mg/l at hour 2 to 677 mg/l at hour 6, reflecting more efficient separation of dissolved substances.

Turbidity significantly decreased from 178 NTU at hour 2 to 51 NTU at hour 6. The reduction in this parameter indicates that more fine particles are being settled or filtered out over time. The ammonia content, associated with organic pollution, also decreased drastically, from 48 mg/l at hour 2 to 11 mg/l at hour 6. The MLVSS and MLSS parameters, which represent the amount of biomass in the system, also showed consistent reductions. MLVSS decreased from 540 mg/l at hour 2 to 420 mg/l at hour 6. Meanwhile, the pH value remained stable with slight variation, ranging from 7.1 to 7.3 at 6 hours of retention time, indicating that the treatment process did not significantly affect the acidity or alkalinity of the water. Overall, the combined treatment method efficiently reduced the concentration of contaminants in the wastewater, with different removal efficiencies. The efficiency of waste parameter removal at various retention times is shown in Figure 3.

Table 2. Test results of parameters during contact time of 6, 3, and 1 hour

Retention time (hours)	Testing (hours)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	TDS (mg/l)	Turbidity (NTU)	Ammonia (mg/l)	MLVSS	MLSS	pH
6	2	450	950	375	775	178	48	540	720	7.1
6	3	320	690	270	710	128	32	420	680	7.2
6	4	235	490	168	690	88	18	410	610	7.3
6	5	210	450	110	682	60	12	400	600	7.3
6	6	205	415	93	677	51	11	420	605	7.3
3	1	760	1435	630	815	345	77	540	740	6.9
3	1.5	540	1150	460	790	265	55	490	675	7.0
3	2	380	875	315	760	180	40	460	650	7.1
3	2.5	320	720	250	735	135	28	450	635	7.1
3	3	295	675	248	729	128	25	470	650	7.1
1	0.2	1095	1950	970	850	460	102	600	770	6.6
1	0.4	865	1640	735	835	350	85	580	740	6.7
1	0.6	690	1365	540	805	265	65	570	730	6.7
1	0.8	610	1215	480	798	228	55	565	725	6.8
1	1	585	1160	475	792	220	53	550	720	6.8

3.3.1. Biological Oxygen Demand (BOD)

Table 2 and Figure 3 showed that waste treatment with a combination of TF and RBC reduced BOD values significantly. The initial BOD value measured at 1,583 mg/l decreased to 205 mg/l after a retention time of 6 hours, with a removal efficiency of 87.05%. This reduction showed the effectiveness of TF and RBC in treating organic waste, particularly those with high pollutant concentrations. However, the final results did not meet the established quality standards when compared to phytoremediation which used water hyacinth, kale, and water jasmine plants. The BOD reduction efficiency reached 94.20% using water hyacinth plants, 81.10% with kale, and 92.70% with water jasmine (Novita *et al.,* 2021). Biofilm formed in both the combined TF and RBC systems allowed microorganisms to interact with wastewater and accelerate the decomposition process of organic compounds. This process causes a significant decrease in BOD value because the degradation of organic compounds in wastewater increases. With organic compound molecules diffusing into the microorganism cells as a source of carbon and nutrients, biofilms are needed to enhance biological decomposition (Boltz & Motta, 2007).

The effectiveness of microorganisms at a retention time of 6 h was found to be higher compared to 1 and 3 h. A longer duration increases the decomposition capacity of organic compounds because sufficient biofilm growth is possible. This is because microorganisms adapt better to the environmental conditions of continuously flowing waste and provide more time for the decomposition process (Liu *et al.,* 2021). The TF and RBC systems support the aerobic biological degradation process of organic compounds due to the ability to maintain sufficient oxygen conditions. In the exponential phase, microorganism will optimize the degradation process causing rapid cell division and growth which allows degradation in a shorter duration (Zhang *et al.,* 2020). Moreover, combined TF and RBC can be an effective alternative method to treat organic waste due to high BOD concentration.

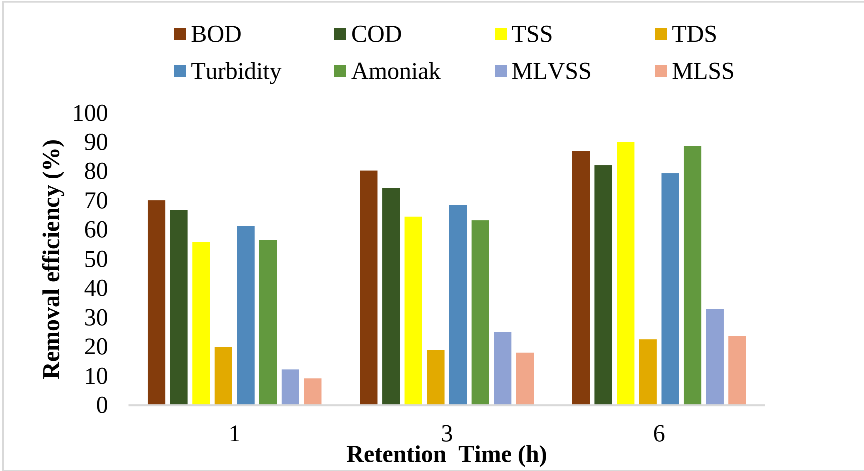

Figure 3. Removal efficiency of BOD, COD, TSS, TDS, turbidity, ammonia, MLVSS and MLSS at various retention times

3.3.2. Chemical Oxygen Demand (COD)

Table 2 and Figure 3 shows that the initial COD of wastewater is 2.765 mg/l. After treatment at 6 hours, this value decreased to 494 mg/l with a removal efficiency of 82.11%. Based on the results, the treatment process was effective in reducing organic compounds that were difficult to degrade biologically. Therefore, microorganisms in the TF and RBC systems could decompose complex organic compounds. Microorganisms in biofilms use organic compounds as a source of nutrients for growth (Zhang *et al*., 2020) showing the effectiveness of biofilm formation to reduce COD values in TF and RBC, thereby supporting the decomposition process of organic compounds (Yang *et al*., 2019).

The application of TF and RBC shows better results in reducing COD compared to the biofilter method, which only has approximately 70% reduction (Aguilera *et al.,* 2021). In the treatment of organic waste with high concentrations, the use of biological reactors such as RBC and TF is more efficient than biofilter (Sugihhartati *et al.,* 2024, Rodrigues *et al*., 2021).

3.3.3. Total Suspended Solids (TSS)

The initial TSS of 1,135 mg/l decreased to 106 mg/l (90.51%) after treatment at 6 hours, as shown in Figure 3. This suggested the successful removal of suspended solid particles in wastewater due to biological system in the TF and aerobic reactor. According to Herlambang & Marsidi (2003), longer contact times and proper acclimatization processes could also increase treatment effectiveness.

The potential to increase the interaction between microorganisms and wastewater is shown by the filtration process using biofilm media and MOL applications. Microorganisms found in biofilms will reduce the amount of dissolved solids in wastewater as well as retain and bind suspended solids (Khatoon *et al*., 2021). According to Baruah *et al*., (2019), the use of biofilms in wastewater treatment systems can reduce TSS with very good efficiency (in a short retention time it can reach more than 80%). Compared to the phytoremediation method, the results obtained are better reaching 70-80% (Wulandari *et al*., 2022).

3.3.4. Total Dissolved Solids (TDS)

After a retention time of 6 hours, the initial TDS of wastewater was 875 mg/l, decreasing to 678 mg/l with a reduction efficiency of 22.57%, as shown in Table 2. Although not excessively large when compared to other parameters, this shows a decrease in the content of dissolved substances in wastewater. Efforts should be made to reduce the concentration of dissolved substances in treated wastewater because high TDS levels can damage water quality and endanger aquatic ecosystems.

The decrease in TDS levels occurs through several mutually supporting mechanisms. There is a decrease in the concentration of dissolved substances in water. This is because some dissolved particles will be adsorbed or bound to the surface of the media when wastewater passes through the treatment in the TF (Baruah *et al.,* 2019). The recirculation process that occurs in the TF and RBC also contributes to the decrease in TDS. The recirculation process provides additional time for microorganisms to decompose more dissolved compounds when the treated wastewater is returned to the system (Herlambang & Marsidi, 2003). This suggests a decrease in TDS because recirculation extends the interaction time between microorganisms and wastewater. Sedimentation and deposition can also occur in the system, as larger dissolved particles reduce TDS levels (Ma *et al*., 2021).

A smaller TDS removal is observed compared to the reduction of TSS and COD (Hamza *et al.,* 2021). The use of anaerobic systems can achieve greater TDS reduction in wastewater treatment from chicken slaughterhouses, with an efficiency of approximately 35%. This is due to the ability of microorganisms in anaerobic systems to affect the reduction of TDS in wastewater to decompose complex organic compounds into simpler forms (Li *et al*., 2023).

3.3.5. Turbidity

The initial turbidity of 487 NTU decreased to 101 NTU with a removal efficiency of 79.36% after 6 hours of treatment. This suggested that the reduced particles causing turbidity through biological activities by microorganisms in the TF and RBC media biofilms and physically using sedimentation and settling of larger particles.

In water, dissolved particles and contaminants can be absorbed by charcoal through the adsorption process. Therefore, the use of charcoal media in the TF system can reduce turbidity levels. This is because the large pore structure provides a large surface for the growth of microorganisms and accelerates the biological degradation of pollutants. The rough surface and high porosity provide optimal space for aerobic microorganisms to grow (Bowman *et al*, 2024). These microorganisms, through aerobic decomposition process, decompose organic compounds found in waste, thereby reducing particles that cause turbidity (Huang *et al*., 2023). In TF system, charcoal is used as a breeding ground, leading to a reduction in the content of organic and inorganic particles in wastewater. There are also carbon elements that can be used as a source of nutrients, supporting growth and metabolic activities that are more effective in reducing waste turbidity (Zhang *et al.,* 2020). These results are slightly lower than the use of sand filtration which can reduce turbidity by approximately 85% (Dezotti *et al.,* 2018). However, the use of biological systems such as TF and RBC was found to reduce BOD and COD more effectively compared to sand filtration (Yang *et al.,* 2019).

3.3.6. Ammonia

As shown in Table 2, at a retention time of 6 h, ammonia value decreased significantly from 113 mg/l to 12.7 mg/l, with a removal efficiency of 88.66%. This significant decrease showed that wastewater treatment with TF and RBC systems was effective in reducing ammonia content, and polluting the environment. Microorganisms in the reactor oxidize ammonia into safer compounds, such as nitrite and nitrate, through the nitrification process. Microorganisms carry out the nitrification process by converting ammonia (NH_3) into nitrite (NO_2^-) and nitrate (NO_3^-) through biofilm on the surface of TF and RBC media (Lu *et al.,* 2021). Coconut shells have been proven to reduce ammonia levels in wastewater by around 85% in a short time (Oktavitri *et al.,* 2017). This provides a place for microorganisms with high absorption capacity for organic compounds and ammonia in waste.

The success of ammonia treatment is influenced by aeration process in the system, which provides oxygen needed by microorganisms for aerobic metabolism (Huang *et al*., 2023). Retention time of 6 h allows microorganisms to carry out the nitrification process more effectively. At retention times of 1 and 3 h, ammonia reduction efficiency was only 56.52% and 63.30%. These results were slightly different from other research using sand media biofilters, which succeeded in reducing ammonia concentrations by approximately 90% in the treatment of wastewater from chicken slaughterhouses (Tewari *et al.,* 2023). Although biofilter system with sand and zeolite media showed higher ammonia reduction efficiency, waste treatment with a combination of TF and RBC remained an effective and more comprehensive option for wider as well as efficient treatment in a limited space.

3.3.7. MLVSS and MLSS

The initial MLVSS and MLSS of wastewater at 627 mg/l and 793 mg/l decreased to 420 mg/l and 605 mg/l after 6 h of treatment, showing removal efficiencies of 32.98% and 23.69%, respectively. One of the mechanisms contributing to the decrease in MLVSS and MLSS levels was found to be the activity of aerobic development in biofilm formed in the processing media. These microorganisms reduce the concentration of MLVSS and MLSS by consuming organic compounds and suspended solids, thus supporting efficient degradation (Huang *et al.,* 2023). Furthermore, wastewater recirculation in TF and RBC systems contributes to the reduction of MLVSS and MLSS levels because they are able to continuously decompose organic compounds (Gao *et al*., 2022). Gravel media has been shown to accelerate the degradation process of organic matter because it can increase the interaction time of microorganisms with waste and retain microorganisms longer (Kumar *et al*., 2019).

4. CONCLUSION

From the results of this research, the processing of chicken slaughterhouse liquid waste was effective in reducing BOD, COD, TSS, TDS, turbidity, ammonia, MLVSS, and MLSS levels when applying a combination of TF and RBC systems. At a retention time of 6 h, there was a decrease in BOD levels of 87.05%, COD by 82.11%, TSS by 90.51%, turbidity by 79.36%, and ammonia by 88.66%. The presence of biofilm on the filter media showed the effectiveness of this treatment because it was able to decompose organic compounds and other pollutants. The aerobic biological process that occurred in the microorganism biofilm in both systems supported the nitrification process which reduced ammonia levels in waste. The results of the removal efficiency showed that the combination of TF and RBC systems could be used as an alternative for effective, efficient, and competitive organic waste processing. This method showed high effectiveness in treating wastewater with high organic compounds, offering more structured and efficient control, which showed potential for application on an industrial scale.

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REFERENCES

Abbasi, H., Abbasi, S., Haeri, S.A., Rezayati, S., Kalantari, F., & Heravi, P.M.R. (2022). Electromembrane extraction using biodegradable deep eutectic solvents and agarose gel as green and organic solvent-free strategies for the determination of polar and non-polar bases drugs from biological samples: A comparative study. *Analytica Chimica Acta*. ***1222***(22), 339986. https://doi.org/10.1016/j.aca.2022.339986

Adam, M.S., Nugrohoputri, A.S., Rahmadi, R., Astuti, A.D., & Kurniawan, A. (2023). Treatment of palm oil mill effluent using modified rotating biological contactor with organic loading rate variations. *Earth and Environmental Science*. ***3***(2), 1263-012061. https://doi.org/10.1088/1755-1315/1263/1/012061

Aguilera, M.M., Ávila, V., Castillo, M.N.A., Cardona, A., Carranza, C., & Ocampo, R. (2021). Biodegradation of carbamazepine and production of bioenergy using a microbial fuel cell with bioelectrodes fabricated from devil fish bone chars. *Journal of Environmental Chemical Engineering*. ***9***(6), 106692. https://doi.org/10.1016/j.jece.2021.106692

Al-Shammari, M.M.A., Al-Lami, A.K., Hammadi, A.M., Al-Maliki, A.A., & Al-Lami, N. (2024). The determination of ground water balance (GW) using modeling flow, a case study west of Karbala Province. *Iraqi Journal of Science*. ***65***(6), 3492-3504. https://doi.org/10.24996/ijs.2024.65.6.41

Baruah, A., Chaudhary, V., Malik, R., & Vijay K.T. (2019). 17-nanotechnology based solutions for wastewater treatment. *nanotechnology in water and wastewater treatment*. *Theory and Applications Micro and Nano Technologies*, 337-368. https://doi.org/10.1016/B978-0-12-813902-8.00017-4

Bi, Y., Han, Z., Feng, S., Wang, X., Xu, Z., Zhang, Y., Su, H., Zhuang, X., & Xu, S. (2021). Microbial community changes in a full-scale wastewater treatment system with a rotating biological contactor integrated into anaerobic-anoxic-oxic processes. *Desalination and Water Treatment*, ***228***, 165–175. https://doi.org/10.5004/dwt.2021.27346

Boltz, J.P., & Motta, L.E.J. (2007) Kinetics of particulate organic matter removal as a response to bioflocculation in aerobic biofilm reactors. *Water Environment Research*. ***79***, 725-735. https://doi.org/10.2175/106143007X156718

Bowman, B.M., Hunt, D.V.L., & Rogers, C.D.F. (2024). Visualising the surface water system: an environmental justice-led approach. *Sec. Water and Human Systems*. ***6***, 1423247. https://doi.org/10.3389/frwa.2024.1423247

Buczynska, A.Z., Ciesielski, S., Zabczynski, S., & Cema, G. (2019). Bacterial community structure in rotating biological contactor treating coke wastewater in relation to medium composition. *Environmental Science and Pollution Research*. ***26***(19), 19171-19179. https://doi.org/10.1007/s11356-019-05087-0

Chen, Y., Zheng, R., Sui, Q., Ritigala, T., Wei, Y., Cheng, X., Ren, J., Yu, D., Chen, M., Wang, T. (2021). Coupling anammox with denitrification in a full-scale combined biological nitrogen removal process for swine wastewater treatment. *Bioresource Technology*, ***329***, 124906. https://doi.org/10.1016/j.biortech.2021.124906

Deepali, J. (2021). Biological treatment process for industrial waste. *International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)*, ***8***(4), 1492-1506.

Dezotti, M., Lippel, G., & Bassin, J.P. (2018). *Advanced biological processes for wastewater treatment: Emerging, consolidated technologies and introduction to molecular techniques*. Springer. https://link.springer.com/book/10.1007/978-3-319-58835-3

Dong, C., Qingye, P., & Yaquan, S. (2020). Research on the mechanism of simultaneous and efficient removal of ammonia, NO_2^- NO_3^- and TN in the coking wastewater. *IOP Conference Series: Earth and Environmental Science*. ***508***(1), 012150. http://dx.doi.org/10.1088/1755-1315/508/1/012150

Faisal, M., Gani, A., Mulana, F., & Daimon, H. (2016a). Effect of organic loading on the production of methane biogas from tofu wastewater treated by the thermophilic stirred anaerobic reactor. *Rasayan Journal of Chemistry*. ***9***(2), 133-138. https://www.researchgate.net/publication/304943456

Faisal, M., Gani, A., Mulana, F., & Daimon, H. (2016b). Treatment and utilization of industrial tofu waste in Indonesia. *Asian Journal of Chemistry*. ***28***(3). http://dx.doi.org/10.14233/ajchem.2016.19372

Faisal, M., Mulana, F., Gani, A., & Daimon, H. (2015). Physical and chemical properties of wastewater discharged from tofu industries in Banda Aceh City, Indonesia. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, ***6***(4), 1053-1058.

Gaber, M.E., Yehia, A.A., Abdulrahim, A., Alzahrani, Mohamed, H., & Abdel, A. (2024). Optimizing organic contaminants removal using rotating biological contactors – A kinetic and equilibrium study. *Journal of Ecological Engineering*, ***25***(3), 143–154. https://doi.org/10.12911/22998993/178384

Gao, R., Peng, Y., Li, J., Liu, Y., Deng, L., Li, W., & Kao, C. (2022). Mainstream partial denitrification-anammox (pd/a) for municipal sewage treatment from moderate to low temperature: Reactor performance and bacterial structure. *Science of The Total Environment*, ***806***, 150267. https://doi.org/10.1016/j.scitotenv.2021.150267

García, T.P., Borgne, S.L., & Revah, S. (2016). Ozone and hydrogen peroxide as strategies to control biomass in a trickling filter to treat methanol and hydrogen sulfide under acidic conditions. *Appl Microbiol Biotechnol*, ***100***, 10637–10647. https://doi.org/10.1007/s00253-016-7861-5

Hamza, R., Hamodaa, M.F., & Elassa, M. (2022). Energy and reliability analysis of wastewater treatment plants in small communities in Ontario. *Water Science & Technology*, ***85***(6), 1824. https://doi.org/10.2166/wst.2022.093

Hanafy, M., Fouad, H., & Elhefny, R. (2022). Rotating biological contactor wastewater treatment using geotextiles, sugarcane straw, and steel cylinder for green areas irrigation. *Egyptian Journal of Chemistry*, ***65***(6), 59–72. https://doi.org/10.21608/ejchem.2021.82581.4065

Handriani. (2021). Pengolahan limbah cair rumah pemotongan ayam dengan metode *trickling filter*. [*Undergraduated Thesis*]. Teknik Lingkungan Universitas Islam Negeri Ar-Raniry, Banda Aceh. https://repository.ar-raniry.ac.id/id/eprint/22954/

Herlambang, A., & Marsidi, R. (2003). Denitrification process with a biofilter system for treating wastewater containing nitrates. *Jurnal Teknologi Lingkungan BPPT*, ***4***(1), 46-55.

Huang, J., Wen, X., Tang, Q., Liu, D., & Chen, S. (2023). An innovative waterwheel-rotating biological contactor (wrbc) system for rural sewage treatment. *Water*, ***15***(7), 1323. https://doi.org/10.3390/w15071323

Indah, S., Kiki, P.U., & Suci, P. (2023). Perencanaan instalasi pengolahan air limbah (IPAL) Rumah Potong Ayam PD.X. *Rekayasa Hijau: Jurnal Teknologi Ramah Lingkungan*, ***7***(1). https://doi.org/10.26760/jrh.v7i1.37-48

Kanwar, R.M.A., Khan, Z.M., & Farid, H.U. (2023). Fate of biofilm activity in cascade aerating trickling filter for wastewater treatment: comparison of two types of indigenous support media. *Biochemical Engineering Journal*, ***194***, 108875. https://doi.org/10.1016/j.bej.2023.108875

Khan, A.A., Gaur, R.Z., Tyagi, V.K., Khursheed, A., Lew, B., Mehrotra, I., & Kazmi, A.A. (2020). Sustainable options of post treatment of UASB effluent treating sewage: A review. *Resources, Conservation and Recycling*. *Chemosphere*, ***55***(12), 1232-1251. https://doi.org/10.1016/j.resconrec.2011.05.017

Khatoon, H., Penz, K.P., Banerjee, S., Rahman, M.R., Minhaz, T.M., Islam, Z., Mukta, F.A., Nayma, Z., Sultana, R., & Amira, K.I. (2021). Immobilized *Tetraselmis* sp. for reducing nitrogenous and phosphorous compounds from aquaculture wastewater. *Bioresource Technology*, ***338***, 125529. https://doi.org/10.1016/j.biortech.2021.125529

Kumar, M., Gogoi, A., & Mukherjee, S. (2019). Metal removal, partitioning and phase distributions in the wastewater and sludge: Performance evaluation of conventional, upflow anaerobic sludge blanket and downflow hanging sponge treatment systems. *Journal of Cleaner Production*, ***249***, 119426 https://doi.org/10.1016/j.jclepro.2019.119426

Lecompte, B.C., & Mehrvar, M. (2017). Slaughterhouse wastewater: treatment, management and resource recovery. *Physico-Chemical Wastewater Treatment and Resource Recovery*, ***153***, 74. http://dx.doi.org/10.5772/65499

Li, Q., Guo, Y., Yu, J., Yao, L., Liu, S., Yahua, L., Chen, D., Peng, F., Xu, D., Wu, Z., Zhou, Q. (2023). Construction of hybrid constructed wetlands for phosphorus chemical industry tailwater treatment in the middle yangtze river basin: Responses of plant growth and root-associated microbial communities. *Water Biology and Security*, ***2***(3), 100144. https://doi.org/10.1016/j.watbs.2023.100144

Liu, J., Zhang, Y., Li, J., & Yue, T. (2021). Effects of filler voidage on pressure drop and microbial community evolution in fungal bio-trickling filters. *Chemosphere*, ***273***, 129710. https://doi.org/10.1016/j.chemosphere.2021.129710

Lu, J., Hong, Y., Wei, Y., Gu, J.-D., Wu, J., Wang, Y., Ye, F., & Lin, J.-G. (2021). Nitrification mainly driven by ammonia-oxidizing bacteria and nitrite-oxidizing bacteria in an anammox-inoculated wastewater treatment system. *AMB Express*, ***11***, 158. https://doi.org/10.1186/s13568-021-01321-6

Ma, W.-J., Ren, Z.-Q., Yu, L.-Q., Wu, X.-X., Yao, Y.-X., Zhang, J.-T., Guo, J.-Y., Fan, N.-S., Jin, R.-C. (2021). Deciphering the response of anammox process to heavy metal and antibiotic stress: Arsenic enhances the permeability of extracellular polymeric substance and aggravates the inhibition of sulfamethoxazole. *Chemical Engineering Journal*, ***426***, 130815. https://doi.org/10.1016/j.cej.2021.130815

Novita, E., Agustin, A., & Pradana, H.A. (2021). Pengendalian potensi pencemaran air limbah rumah pemotongan ayam menggunakan metode fitoremediasi dengan beberapa jenis tanaman air (Komparasi antara tanaman eceng gondok, kangkung, dan melati air). *Agroteknika*, ***4***(2), 106–119.

Oktavitri, N. I., Purnobasuki, H., Kuncoro, E., & Purnamasari, I. (2017). Ammonia removal using coconut shell-based adsorbent: Effect of carbonization duration and contact time. *IPTEK Journal of Proceedings Series*, ***2017***(4), Article 3072. https://doi.org/10.12962/j23546026.y2017i4.3072

Patel, A., Mahboubi, A., Horváth, I. S., Taherzadeh, M. J., Rova, U., Christakopoulos, P., & Matsakas, L. (2021). Volatile fatty acids (VFAs) generated by anaerobic digestion serve as feedstock for freshwater and marine oleaginous microorganisms to produce biodiesel and added-value compounds. *Frontiers in Microbiology*, ***12***. https://doi.org/10.3389/fmicb.2021.614612

Powar, P., Nejkar, V., Patil, P., & Naik, V. (2023). Dairy wastewater treatment with rotating biological contactor as secondary unit and use of treated effluent for agriculture. *E3S Web of Conferences*, ***405***, 01006. http://dx.doi.org/10.1051/e3sconf/202340501006

Ratnawati, R., & Al-Kholif, M. (2018). Aplikasi media batu apung pada biofilter anaerobik untuk pengolahan limbah cair rumah potong ayam. *Jurnal Sains dan Teknologi Lingkungan*, ***10***(1). https://doi.org/10.20885/jstl.vol10.iss1.art1

Rodrigues, A.A.M., Costa, R.R., Santos, L.F., Silva, S.M., Britto, D., & Lima, M.A.C. (2021). Properties and characterization of biodegradable films obtained from different starch sources. *Food Sci. Technol, Campinas*, ***41***(2), 476-482. https://doi.org/10.1590/fst.28520

Subhadarsini, L., & Dash, R.R. (2020). Treatment of industrial wastewater using single-stage rotating biological contactor. *IOP Conference Series: Materials Science and Engineering*, ***970***(1), 012025. https://doi.org/10.1088/1757-899X/970/1/012025

Sugihhartati, Dj.R., Rochmah, L., Indranoviyani, W., Susilo, W.H., Permadi, D.A., Soleh, S.A., & Salsabila, G. (2024). Seeding and acclimatization of microorganisms in a moving bed biological reactor (MBBR) for process optimization at a compact septage treatment plant. *Water Science and Technology*. https://doi.org/10.20944/preprints202405.0917.v1

Suwahdendi, M.P.A., & Purnama, I.G.H. (2020). Uji efektivitas batu vulkanik dan arang sebagai media filter pengolahan air limbah laundry dengan menggunakan sistem pengolahan constructed wetland. *Archive of Community Health*, ***5***(1), 67–76.

Tewari, A., Bhutada, D.S., & Wadgaonkar, V. (2023). Heavy metal remediation from water/wastewater using bioadsorbents: A review. *Nature Environment and Pollution Technology*, ***22***(4), 2039–2053. https://doi.org/10.46488/NEPT.2023.v22i04.029

Thompson, M., Moussavi, S., Li, S., Barutha, P., & Dvorak, B. (2022). Environmental life cycle assessment of small water resource recovery facilities: Comparison of mechanical and lagoon systems. *Water Research*, ***215***, 118234. https://doi.org/10.1016/j.watres.2022.118234

Wang, W., Wang, Y., Wang, X., Zhang, Y., & Yan, Y. (2019). Dissolved oxygen microelectrode measurements to develop a more sophisticated intermittent aeration regime control strategy for biofilm-based canon systems. *Chemical Engineering Journal*, ***365***, 165-174. https://doi.org/10.1016/j.cej.2019.02.033

Wulandari, D.T., Prihatini, N.S., and Nirtha, R.I.N. (2022). Penyisihan cod pada limbah cair rumah potong hewan martapura dengan system lahan basah buatan aliran horizontal bawah permukaan menggunakan tanaman cyperus alternifolius dan canna indica. *Jurnal Reka Lingkungan*. ***2***(2), 125-44. https://doi.org/10.26760/rekalingkungan.v10i2.125-134

Yang, Z., Li, J., Liu, J., Cao, J., Sheng, D., & Cai, T. (2019). Evaluation of a pilot-scale bio-trickling filter as a vocs control technology for the chemical fibre wastewater treatment plant. *Journal of Environmental Management*, ***246***(15), 71-76. https://doi.org/10.1016/j.jenvman.2019.05.102

Zhang, Z., Zhang, Y., & Chen, Y. (2020). Recent advances in partial denitrification in biological nitrogen removal: From enrichment to application. *Bioresource Technology*, ***298***, 122444. https://doi.org/10.1016/j.biortech.2019.122444