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Waste treatment of milk using aerobic and anaerobic honeycomb waste processing system to reduce COD, Bod, NH_3-N, TSS, oil, fat and pH

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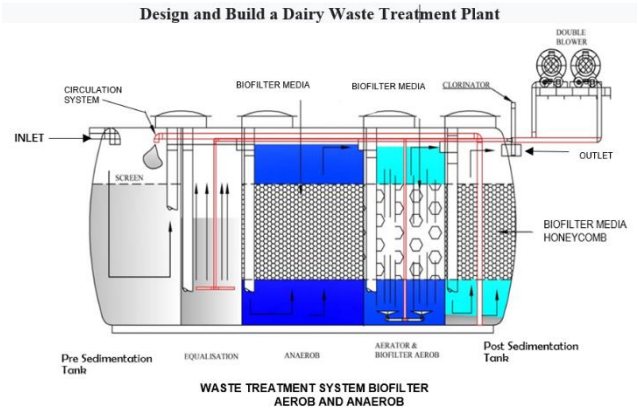
Graphical abstract



Abstract

The dairy industry is one of the industries that continues to grow in Indonesia in line with the large demand for dairy foods. Liquid waste originating from the dairy industry has a special character, namely susceptibility to bacteria. This waste is very easy to decompose and if it is not immediately recycled or controlled it will be very dangerous to the environment around the factory. This research was carried out through the following stages: the seeding process for 12 days, as a stage of the process of bacterial growth and development, marked by a neutral pH, which ranges from 6.9 to 7. All wastewater originating from the production process is channeled into the initial reservoir that has been lye is added which functions to neutralize waste oil. The filtered water enters the aerobic tank, which functions to reduce pollutants in the form of BOD, COD, TSS, Oil and Fat, NH3 - N, and pH by breaking down bacteria without the need for oxygen. The next stage is that the waste is channeled into an aerobic tank made in the form of a honeycomb which is designed to adhere to the valley-breaking bacterial biofilm for the growth of bacteria. This media is also called wasp nest biofilter media. The percentage of reduction in BOD, COD, pH, NH3 - N, Oil and Fat before and after being filtered through the milk waste filtering installation at KPSBU Lembang, West Java. The results of the study were a decrease in BOD, 86.5%, COD: 86.83%, TSS: 78.2%, NH3 - N: 48.23% Fat and Oil: 91.9% and pH in the range 6-9.

Keywords: Milk Liquid Waste, Bamboo Honeycomb Biofilter, Aerobic, Anaerobic

1. Introduction

The dairy industry is one of the industries that continue to grow in Indonesia in line with the huge demand for dairy foods. Liquid waste originating from the dairy industry has a special character, namely susceptibility to bacteria. This waste is easy to decompose and, if it is not immediately recycled or controlled, it will be dangerous to the environment around the factory. Based on the Regulation of the Minister of Environment Number 5 of 2014 concerning Wastewater Quality Standards, that the waste produced by the dairy industry is BOD_5, COD, TSS, Oil and Fat, NH_3 - N, and pH. Most of the main source of liquid waste from the dairy industry comes from dairy products that are wasted during the production process, usually caused by leaks and spills during the production process, such as poor operational systems that occur during the removal of production lines, evaporation machines, filling processes and waste raw materials that damaged. Milk lost during production ranges from 0.1% to 3%.

One of the industries in West Java is a food industry that is engaged in milk processing cooperatives in the form of fresh milk and yogurt which are processed every day and sold directly to consumers. Besides, the industry also serves the marketing of fresh milk from breeders to be sent to the milk processing industry. The dairy industry produces 149,000 kg/day of milk every day with the amount of waste produced is 4000 liters/day. The special feature of liquid waste in the dairy processing industry is that it is easy to grow microorganisms, this causes liquid milk waste to be easily decomposed, so that it can cause environmental pollution in the form of odors and bacterial contamination.

As for the problems faced, it is necessary to find alternative solutions to possible pollution caused by the milk industry in this case in West Java. Researchers offer solutions in the form of a simple, cheap and efficient method of valley milk processing. Such as the research conducted by Wagini R, a processing method with a combination of physical, chemical and biological processes. The process stages include: equalization, anaerobic process, aeration process, activated sludge, sedimentation process, coagulation-flocculation process, sedimentation process, flocation process, light particle deposition process, filtering process with sand and activated charcoal. The regional characteristics of the milk processing industry in West Java are different from other areas, where the temperature in the area is very cold, this causes the rapid decay occurs.

2. Materials and methods

This type of research is a field experimental research with a research design. The research design that will be carried out in this study is an experimental group comparison design, pretest posttest without control without using control. In this design, a comparison of the reduction in the levels of TSS, COD, BOD, NH3 - N, pH, Fat and Oil will be carried out before and after processing in a milk wastewater treatment plant.

Research with experimental research design with pretest posttest design without control can be described as follows:

$$O^1 \ldots\ldots\ldots\ldots\ldots X^1 \ldots\ldots\ldots\ldots\ldots O^2$$

Information:

O1 = Levels of TSS, COD, BOD, NH_3 - N, pH, fat and oil before treatment

X1 = Waste treatment intervention TSS, COD, BOD, NH_3 - N, pH, fat and oil

O2 = levels of TSS, COD, BOD, NH_3 - N, pH, fat and oil after treatment (Figure 1).

The conceptual framework for this research is as follows:

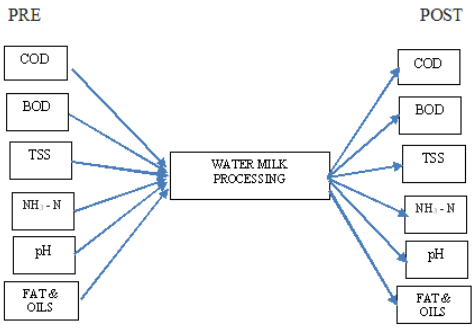
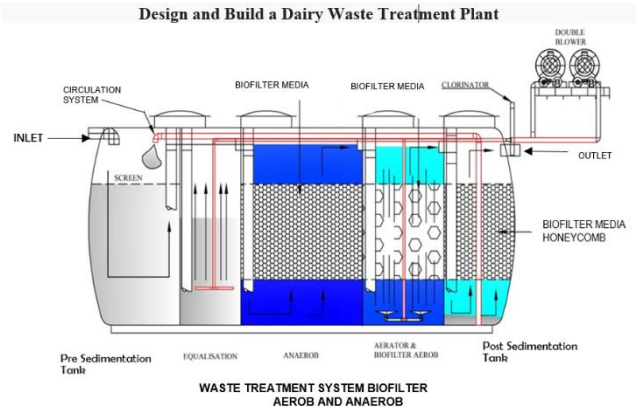


Figure 1. Research concept framework.

2.1. Materials

In conducting this research, the first step is to prepare a device in the form of a tube-shaped reactor as an installation for processing liquid milk waste. The tools and materials needed to design the reactor are: 1). First Sedimentation Tank (Primary Sedimentation Tank), 2). Anaerobic Reactor Tank (Anaerobic Reactor Tank), 3) Aerobic Reactor Tank (Aerobic Reactor Tank), 4) Waste storage tank (Buffer Tank), 5) Filter Tank (Filter Tank) using a filter with bamboo cut media as a medium for growing bacteria naturally anaerobic. 6) The aerobic filter tank uses Henoy Comb PVC or better known as the wasp's nest method. 7) The reactor tube uses a biofilter system with aerobic and anaerobic methods. 8) Furthermore, the liquid milk waste will be flowed into the reactor of the waste treatment equipment for further inspection of BOD, COD, pH, NH3 - N, Oil and Fat.

The following is a picture of a milk wastewater treatment plant:



At the research stage, carried out with the initial process of the seeding stage. After the seeding process for 12 days marked with a neutral pH, which is 6.9 -7 then the running process is carried out for 12 days. Sampling was carried out 4 times, namely the 13th day with sampling points on the influent and effluent reactors. The next step is to collect research data in the form of levels of BOD, COD, TSS, NH_3 - N, Oil and Fat and pH in the processed waste, followed by an analysis of changes in the characteristics of the waste after treatment with an anaerobic biofilter in a reactor using bamboo cut biofilter media.

2.2. Methods

This research is a descriptive study that only looks at the percentage reduction in levels of TSS, COD, BOD, NH_3 - N. pH, fat and oil before and after being processed in the milk liquid waste treatment plant. The population in this research is all liquid milk waste in the milk processing industry in one of the industries in West Java. The amount of milk waste that produces milk is 2000 liters/day. Meanwhile, the number of wastewater samples required for examination of this study is 2 liters for chemical sampling of wastewater.

The sample size of this study is to do one treatment, namely by looking at the decrease in levels of TSS, COD, BOD, NH_3 - N, pH, fat and oil before and after being given treatment through processing the milk waste installation using two repetitions. The sampling technique used is a combined/composite sampling technique. The combined sample is a mixture of two or more samples momentarily into a container to be tested in the laboratory (Anwar, 2005). Where composite sampling is used because the sample to be used is waste water that is not collected and disposed of directly into the water body, so using a time

composite sample. Time composite sample is a mixture of several instantaneous samples taken from the same point with the same volume and time interval and collected in a container to be tested.

The stages of this research are as follows:

1) The initial stage is the seeding process, as a stage for growing anaerobic microorganisms that will be used for research (Indrayanti, 2003). The seeding process was carried out for 12 days, marked with a neutral pH, which is a range of 6.9 -7. After the seeding process has been formed, it will continue with the textile waste processing stage. Sampling was carried out 4 times, namely the 13th day with sampling points on the influent and reactor effluent.
2) The second stage, wastewater from the production process is flowed into a storage tank. The initial reservoir functions to neutralize all substances contained therein by adding lye. Furthermore, in the reservoir that has been filled with the lye mixture, stirring is carried out using an agitator, this is intended so that the waste contained in the reservoir becomes homogeneous.
3) The third stage, all wastewater originating from the wastewater from the storage tank is then flowed into the anaerobic tank. This anaerobic tank functions to reduce pollutants in the form of COD, BOD, TSS, NH_3 - N, oils and fats and pH by breaking down bacteria without the need for oxygen. Bacteria are grown in aeration tanks, using bamboo as a local material. Bamboo can grow various types of microorganisms that can reduce organic matter, this is due to the heterogeneous characteristics of the waste. The remaining organic material that is still present in the wastewater will be broken down biochemically and produce CO_2 gas and new cells. To maintain a constant breeding of bacteria, a sufficient amount of nutrients is needed as food for bacteria.
4) In the fourth stage, the wastewater will be flowed into the aerobic filtering tank which is made in the form of a wasp nest. The function of this wasp nest is as a place to attach waste-decomposing bacteria biofilms to the growth and development of bacteria. Honeycomb contact is a medium specially designed for biological wastewater treatment, where the process of forming bacteria requires oxygen. This media is also known as wasp's nest biofilter media, which is very effective in reducing organic pollutants. The filtered wastewater from the two tanks will be flowed through the effluent.
5) The fifth step was to collect data from the research results, namely the levels of BOD, COD, TSS, NH_3 - N, Fat and Oil and pH in processed waste, followed by analysis of changes in waste characteristics after treatment with anaerobic biofilter in the reactor using bamboo cut biofilter media.

3. Results and discussion

3.1. Results

The results of COD, BOD, TSS, NH_3 - N, fat and oil, and pH, before and after being flowed into the reactor tank, followed by analysis of changes in waste characteristics after treatment with aerobic and anaerobic biofilters in the reactor using bamboo cuttings and wasp nest methods. The results of measurement for the 1st parameter COD, BOD, TSS, NH_3 - N, Fat and Oil, and pH, before and after processing can be seen in Table 1 below:

Table 1. Measurement results 1 levels of COD, BOD, TSS, NH_3 - N, fat and oil, and pH, before and after processing in the reactor tank

No.	Parameter	Levels		NAV (mg/l))
		Influent (mg/l)	Effluent (mg/l)	
1	COD	716	108	100
2	BOD	232.8	32.59	40
3	TSS	187	35	50
4	NH3 - N	2,21	1.42	10
5	Fat and Oil	8.425	0.003	10
6	pH	6.9	7.1	6-9

Table 2. Measurement results 2 levels of COD, BOD, TSS, NH3 - N, fat and oil, and ph, before and after processing in the reactor tank

No.	Parameter	Levels		NAV (mg/l))
		Influent (mg/l)	Effluent (mg/l)	
1	COD	232.8	30.8	100
2	BOD	116.4	15.4	40
3	TSS	144	34.2	50
4	NH_3 - N	0.268	0.108	10
5	Fat and Oil	5.467	1.175	10
6	pH	6.8	7.0	6-9

Based on Table 1, it can be seen a decrease in levels, BOD, TSS, NH_3-N, fats and oils, and pH according to the threshold value based on the Regulation of Minister of Health No. 5/2014 on Wastewater Quality Standards for Parameters, while the COD parameter is still above the threshold value, which is 108 mg/l.

The results of measurement for the second parameter COD, BOD, TSS, NH_3 - N, Fat and Oil, and pH, before and after processing can be seen in Table 2 above.

Based on Table 2 it can be seen that the decrease in levels, BOD, TSS, NH_3 - N, fats and oils, and pH is in accordance

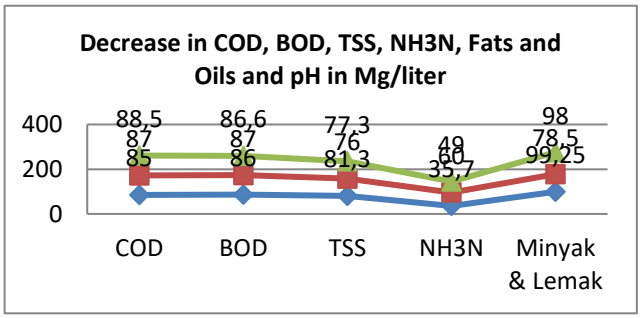
with the threshold value based on the Regulation of Minister of Health No. 5 of 2014 concerning Wastewater Quality Standards.

The results of measurements of the thirds parameter COD, BOD, TSS, NH3 - N, Fats and Oil, and pH, before and after processing can be seen in Table 3 below:

Based on Table 3, it can be seen that the decrease in levels, BOD, TSS, NH3 - N, Fats and Oils, and pH is in accordance with the threshold value based on the Regulation of Minister of Health No. 5 of 2014 concerning Wastewater Quality Standards.

The second measurement was carried out on the 19 th day and the 3rd measurement was carried out on the 24th day, so that the seeding process had run perfectly. At the 2nd and 3rd measurement stages, all parameters are in accordance with the Threshold Value (NAV) according to the Regulation of the Minister of the Environment No. 5 of 2014 concerning Wastewater Quality Standard Parameters (Graph 1).

The following is a graph of the decrease in COD, BOD, TSS, NH3 - N, fat and oil:



Graph 1. Decreased levels of COD, BOD, TSS, NH3 - N, fat and oil.

A recapitulation of the results of measuring the levels of COD, BOD, TSS, NH3 - N, Fat and Oil and pH as much as 3 times the measurement can be seen in Table 4 below:

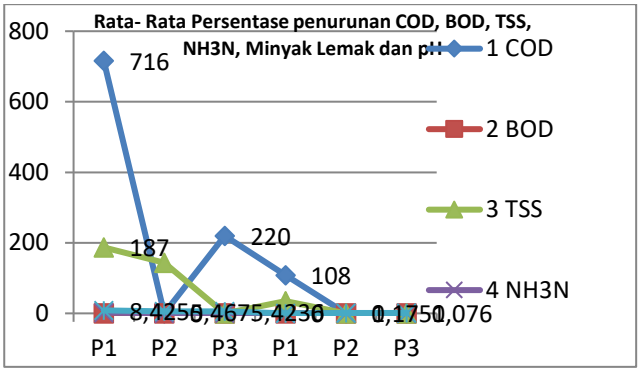
Based on Table 4 above, it can be seen that there is a decrease in levels of COD, BOD, TSS, NH3 - N, Fat and Oil as well as pH for each measurement for three measurements.

The following is the percentage decrease in COD, BOD, TSS, NH3 - N, Fat and Oil levels for 3 measurements:

This research was conducted to see the reduction in the content of BOD, TSS, NH3 - N, Fat and Oil, and pH in milk waste water at milk factory in west java regionwith aerobic and anaerobic biofilter processes in the waste treatment tank using bamboo cuttings in anaerobic process.

3.2. Discussion

The reactor is made of plexy glass with a cover and reactor support. At the bottom of the reactor there is an inlet that aims to enter waste water using a pump. Wastewater that enters the reactor will pass through the biofilter tube aerobically and anaerobically. Wastewater in the reactor is circulated using a pump for 24 hours every day. The reactor is filled with bamboo sticks as a medium for bacterial growth, which is called the seeding process (Graph 2).



Graph 2. Average Percentage Reduction of COD, BOD, TSS, NH3 - N, Fat and Oil and pH of 3 Times Measurements

At the first inspection/measurement stage, it was carried out on day 12, so the seeding process was not fully formed. The seeding process is carried out for 12 days with a marked neutral pH, which is 6.9 -7, this seeding process is a process to grow a biofilm layer. Biofilm is a process of growth and development of microorganisms on the surface of the media and flows through the gaps of the media in a reactor. On the 12th day the microorganisms in the honeycomb reactor were newly formed, but not yet fully formed, the longer the seeding process was carried out, the more perfect the microorganisms would be.

The seeding process is carried out to breed microorganisms so that an adequate amount of biomass is obtained to treat wastewater from milk processing in one of the industries in the West Java Region. Microorganism seeds were taken from bamboo cuttings which were put into a waste treatment tube which was grown aerobically. At this seeding stage, what needs to be considered is the concentration of organic substances (substrate), and VSS. The COD reduction efficiency is strongly influenced by the microbial growth process and the growth of the biofilm layer on the media known as the ripening process. (Azmi *et al*., 2019).

The first stage is acclimatization which is an advanced stage of the seeding process, the acclimatization stage is the stage of adaptation and adjustment of microorganisms that have been formed during the seeding process in milk wastewater. In this study, wastewater from milk processing is carried out continuously (continuously for 2 times a day. The amount of processed milk waste is 4000 liters and is channeled into a sewage treatment plant with the stages of wastewater entering the initial settling basin, then entering the in an anaerobic tank consisting of microorganisms that live without the need for oxygen. After passing through an anaerobic bath, the wastewater enters into an aerobic tube and then flows into a tub/tube containing a tube filled with bamboo which forms as a wasp's suggestion.

Table 3. Measurement results 3 levels of COD, BOD, TSS, NH3 - N, fat and oil, and ph, before and after processing in the reactor tank

NO	PARAMETER	LEVELS		NAV (mg/l))
		INFLUENT (mg/l)	EFFLUENT (mg/l)	
1	COD	220	25.2	100
2	BOD	106.7	14.3	40
3	TSS	143.3	32.2	50
4	NH3 - N	0.341	0.175	10
5	Fat and Oil	5,4236	1,076	10
6	pH	6.8	7.1	6-9

Table 4. Average percentage reduction of COD, BOD, TSS, NH3 - N, oil and fat and ph of 3 times measurements

NO	PARAMETER	LEVELS					
		INFLUENT (mg/l)			EFFLUENT (mg/l)		
		P1	P2	P3	P1	P2	P3
1	COD	716	232.8	220	108	30.8	25.2
2	BOD	232.8	116.4	106.7	32.59	15.4	14.3
3	TSS	187	144	143.3	35	34.2	32.2
4	NH3 - N	2,21	0.268	0.341	1.42	0.108	0.175
5	Fat and Oil	8.425	5.467	5,4236	0.003	1.175	1,076

The honeycomb biofilter is a method of filtering liquid waste by utilizing the artificial presence of microbial groups attached to the media used.(2-3) Microbes attached to the filtering media can decompose organic substances present in the liquid waste.

The decrease in BOD levels during treatment was caused by the process of overhauling organic waste materials by microbes that decompose lactic acid bacteria, molds and protozoa that work together symbiotically to benefit each other and form a continuous pattern of succession during the process of overhauling organic waste liquids. The reduction in organic matter in wastewater causes the oxygen needed by decomposing microbes to decrease, which is indicated by a low BOD value.

Bacteria that come from pure cultures or the environment around the source of the waste to be processed are conditioned to a place with a feed whose concentration gradually resembles the concentration of the waste to be treated. This is an important part of wastewater treatment as an effort to reproduce bacteria according to the required conditions. One way is to use chemicals that have a good composition for the growth process of bacteria. For aerobic bacteria, it is necessary to increase the air flow from the compressor, blower or spray aerator.

The seeding process and the acclimatization of microorganisms are carried out simultaneously, namely by multiplying them in the reactor, by inserting bamboo pieces into the reactor. The reactor is designed to circulate using a pump for 14 days with a contact time of 24 hours. Circulation by pump is circulation at the outlet of the center of the reactor. During the seeding and acclimatization processes, pH was used as the control variable. The changes that occur in pH must be considered carefully, because changes in pH affect bacterial growth in the reactor.

The process of decreasing levels of BOD, TSS, NH3 - N, Fat and Oil, and pH occurs in the aeration process in aerobic and anaerobic tanks, while in the aeration process bacteria begin to grow and develop bacteria multiplied. The growth of these bacteria will cause the food supply in the form of organic material contained in the waste to quickly run out. If this condition continues without any additional food from outside, the bacteria will die and in this process the real waste treatment occurs. According to research by Muhamad Aziz and friends, processing reactors with a biofilter system can reduce BOD levels from 388 mg/l, to 38.33 mg/l, or down 349.67 mg/l (90.27%) and TSS from 196.33 mg/l, to 63.33 mg/l, or a decrease of 133 mg/l (68.59%) in the liquid waste of the dairy industry.

In Aleksandar Kolev Slavov's research, high levels of organic contamination created the conditions for preference for anaerobic digestion rather than aerobic processes in the utilization of milk wastewater even though it is aerobic treatment rarely results in clear flow. This is important novel development, more effective meaning technology to deal with high strength milk waste. Insufficient information on the biodegradation of anaero bic with the temperature phase opens the way for new research on milk wastewater management.

According to research by Amin Goli *et al.*, 2019 stated that the conventional method of treating milk wastewater with aerobic and anaerobic systems can provide the following advantages: 1) Requires little chemical. 2) Requires low energy. 3) Produces less sludge. 4). Greater potential to recover resources. 5) Operations are relatively simple.The limitations of conventional anaerobic and aerobic systems are that they require a large waste treatment room, facilities to process biogas and long HRT (Hydraulic Retention time). Based on this, Amin Goli *et al.* made a bioreactor with a combination of aerobic and anaerobic which is a configuration of the UASB-AFB system as a more economical and environmentally friendly alternative in terms of reducing COD levels in the dairy industry wastewater.

4. Conclusions

The conclusions of this study are:

a. The percentage reduction in BOD in the dairy industry before and after processing is 86.5%.

b. The percentage of COD reduction in the milk industry before and after processing is 86.83%.

c. The percentage reduction in TSS in the dairy industry before and after processing is 78.2%.

d. The decrease percentage of NH3 - N in the dairy industry before and after processing is 48.23%.

e. The pH reduction percentage in the milk industry before and after processing is in the range 6-9.

References

Alrumman S.A., El-kott A.F., and dan Keshk S.M. (2016), Water pollution: source & treatment. *American Journal of Environmental Engineering*, **6**(*3*), Hal. 88–98.

Aziz H., Othman N., Yusuff M., Basri D.R., Ashaari F.A., Adlan M., Othman F., Johari M., and dan Perwira M. (2001). Removal of copper from water using limestone filtration technique: determination of mechanism of removal. *Environmental Geochemistry in the Tropics and Subtropics*, **26**(5), Hal. 395–99. 7.

Effendi. (2008). *Study of Water Quality for Management of Aquatic Resources and Environment.* Yogyakarta: Kanisius.

Filiazati M., et al. (2013). *Domestic Liquid Waste Treatment with Aerobic Biofilter Using Bioball Media and Kiambang Plants Vol 1, No. 1 Environmental Engineering Study Program, Faculty of Engineering*, Tanjungpura University, Pontiana, Chemistry Study Program, Faculty of Mathematics and Natural Sciences, Tanjungpura University, Pontianak.

Goli, et al. (2019). A review on different aerobic and anaerobic treatment methods in dairy industry wastewater. *Jounal Of Environmental Treatment Technique*, **6**(1), 113–141.

Hidayat N. (2016). *Bioprocess Liquid Waste*. Yoyakarta: CV ANDI OFFSET.

Makassar et al., n.d., P.K., Environment J.K., and Wasps M.S. (n.d.). Ability of Wasp Nest Biofilter in Reducing Bod and Cod Levels in Liquid Waste of Hasanuddin University Teaching Hospital Ability Of Wasp Nests Biofilter In Reducing Bod And Cod Conditions In Liquid Waste Hospital Hasanuddin University. 5, 360–366.

Notoatmodjo S. (2010). *Health Research Methodology*. Jakarta: Rineka Cipta.

Osama A., Patil S.S., and Salve K.S. (2015). Characterization of dairy wastewater and its effects on environment. *World Journal of Pharmaceutical Research*, **4**(7).

Slavov A.K. (2016). General characteristics and treatment possibilities of dairy wastewater – a revie, dairy wastewater treatment review. *Food Technology and Biotechnology*, **55**(1), 14–28.

Syarifudin M.A., Narto H.S. (2019), Processing Reactor with Biofilter System to Reduce BOD and TSS of Liquid Waste from the Prima Agro Dairy Industry in Turi, Sleman, Yogyakarta, *Journal of Environmental Health*, **11**(2), 75–79.

Wagini K., and Budi A.S. (2002). Liquid waste management in milk factory. *Human and Environment*, **IX**(March 1, 2002), 23–31.