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Review

Comparison of organic wastewater treatment using anaerobic reactors fixed bed type in Germany and Indonesia

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Abstract
Waste that has a high organic matter content can be treated biologically under anaerobic conditions or using bacteria that can live in an environment without oxygen. One method of wastewater treatment that can reduce high organic content is the Fixed Bed type anaerobic reactor system. The purpose of this research is to compare the treatment of organic wastewater using a Fixed Bed type anaerobic reactor that has been implemented in Germany with that implemented in Indonesia. The method used is a literature study by comparing case studies between the two countries, so the methodology used is a systematic literature review. Based on the results of the discussion, it is known that the organic waste that is processed using an anaerobic reactor carried out in Germany has several differences starting from the sub-stages of the process, and operations to the materials used such as the use of pumps, installation storage tanks, sewage filtration, use of stainless steel and heat exchangers. These differences if applied in Indonesia can cost relatively a lot so they are not suitable for application in Indonesia. Based on the literature study, it was concluded that the anaerobic wastewater treatment solution using a fixed bed type in Indonesia can be a good opportunity and can be imitated by other countries because it has simple equipment, but the reactor efficiency and the resulting percentage of methane production are relatively high. although the required HRT is long, anaerobic catalysts can be used as a solution.
Keywords: anaerobic; fixed bed; Germany and Indonesia; organic waste; wastewater treatment.

1. Introduction

One of the consequences of the industrial of the current life is environmental pollution, which shows its destructive effects in all aspects of human life, including water, soil and air. On the other hand, the development of the industrial sector in Indonesia has both positive and negative impacts. The positive impact that is felt is the creation of jobs, while the negative impact is the emergence of waste disposal or non-product output resulting from every process in the industry.

Industrial wastewater, which is a product of technological progress in the industry, imposes its harmful effects on the water and soil environment day by day (Esty, 2004; Rehbinder & Stewart, 1988). The issue of environmental pollution is becoming more important day by

day (Dietz & Stern, 2002; Anton & Shelton, 2011). Environment and puts human life and other creatures in serious danger (Henda et al, 2023). It is obvious that with the existence of various industries and the widespread environmental pollution, scientific and research steps to control pollution should be accompanied by proper planning and practical measures (Henda et al, 2023).

Wastewater that is directly discharged into the environment without prior treatment can harm the surrounding ecosystem. Therefore, every industry that emits wastewater requires special treatment to reduce these hazardous materials before being discharged into water bodies so that they comply with the wastewater quality standards issued by the government. Wastewaters are one of the factors of environmental pollution and therefore, they should be collected and treated and then returned to the circulation of water in nature (Saravanan et al., 2021; Saatsaz, 2020).

Therefore, we need a wastewater treatment that is able to degrade pollutant and at a low cost. The purpose of this research is to compare the treatment of organic wastewater using a Fixed Bed type anaerobic reactor that has been implemented in Germany with that implemented in Indonesia

2. Methods

This research basically uses secondary information and literature study by identifying the problem in question and comparing between case studies, so the methodology used is Systematic Literature Review, known as SLR. SLR, as the name implies, is a systematic way of collecting, critically evaluating, integrating, and presenting findings from across multiple research studies on a research question or topic of interest.
This paper provides an overview of the SLR method, based on the literature in wastewater treatment. Performing a literature review is a critical first step in research to understanding the state-of-the-art and identifying gaps and challenges in the field.

3. Results and Discussion

Industries that have wastewater with high organic matter, need an appropriate treatment by utilizing the activity of microorganisms. These microorganisms are conditioned in a controlled manner, so that their activity is optimal to degrade the organic matter. The controlled conditions in question are anaerobic conditions where microorganisms or bacteria can live in an environment without oxygen. Anaerobic degradation process is a process of fermenting organic matter by the activity of anaerobic bacteria in conditions without free oxygen and converting it from suspended to dissolved form and biogas (Siddharth, 2006). Anaerobic wastewater treatment can be interpreted as a biochemical process that produces biogas by converting complex organic matter into a renewable energy source (Hagos et al., 2017).
Anaerobic treatment can also be a potential source of bioenergy and can support actions to reduce greenhouse gas emissions released into the air. Bioenergy or biogas produced from the anaerobic digestion process of sludge can be employed as a renewable energy source (Sanaye et al, 2022). Using renewable energies to generate electricity and energy will not only solve the problem of global warming, but since they do not require water (unlike fossil-fuel power plants), it can also help the global water crisis (Izanloo et al., 2022).

3.1 Article Review

In the article by Haner et al. (2022) who conducted a case study in Germany and explained that organic wastewater treatment is carried out using a fixed bed type anaerobic digester. According to Weiland in 1987 this Fixed Bed type reactor is also one of the best methods of

anaerobic treatment to degrade high concentrations of organic wastewater. This statement is also supported by Cakir & Stenstrom (2005), which states that anaerobic treatment becomes more profitable when the influent has a high concentration.
Anaerobic digestion process, as a microbial ecosystem, has different digestion stages which starts with decomposition of complex organic compounds and ends with production of biogas as a final product (Sanaye et al., 2022). The four main stages involved in this process are hydrolysis, acidogenesis, acetogenesis, and methanogenesis (Guven et al., 2018). In each stage a specific group of bacteria works to complete the digestion process of the substrate (Sanaye et al., 2022). Chemical reactions based on the process of degradation of organic compounds with methanogenic bacteria are (Stams et al., 2003):

$4H_2 + HCO_3^- + H^+ \rightarrow CH_4 + 3H_2O$

$Acetate^- + H_2O \rightarrow CH_4 + HCO_3^-$

$Methanol^- \rightarrow 3/4CH_4 + 1/4HCO_3^- + 1/4H^+ + 1/4H_2O$

The wastewater treatment scheme used consists of separators, vacuum pumps, inlet pumps, circulation pumps, large storage tanks, production tanks, and reactors. The volume of the reactor is 34 liter and the storage tank is conditioned at a certain temperature of 4 ◦ C. Based on the conditions for reactor operation, temperatures are divided into two, namely (Metcalf, 2003) mesophilic living at temperatures between 85-1000F (30-380C), and thermophilic living at temperatures between 120-135 0 F (49–570C). The best temperature for bacterial growth is the mesophilic group.
Furthermore, after passing through the storage tank, the wastewater in the form of a liquid phase will be channelled into the reactor by passing through a heat exchanger. The way the heat exchanger works is by heating the wastewater to a temperature of approximately θ=25 ◦ C or mesophilic. The reactor used is made of stainless steel or stainless steel.
Next is the inoculation stage, where the starter material used for the first time is corn silage and pig dung is used as a substrate. Before entering the reactor, pig manure and corn silage were first filtered through a 100 μm filter, so that the acceptable solids content for the reactor was <2%.
Anaerobic biodegradation processes involving inoculum bacteria can affect several parameters including pH, biogas formation, and methane gas (Stronach et al., 2012). Generally bacteria can grow maximum between pH 6-7.5 (Stronach et al, 2012). If the pH is lower than 5.0 and higher than 8.5 then bacterial growth can be inhibited although there are some exceptions of microbes that can live in that pH range.
Anaerobic treatment processes can provide more advantages than aerobic processing (Nurhadi, 2010), including:

- Anaerobic processes do not require energy for aeration, thus reducing costs in the processing process
- The resulting sludge or sludge is less than the aerobic process.
- Pollutants in the form of biodegradable organic matter are almost all converted to biogas (methane gas) which has a high calorific value and can be used as a substitute for energy sources.

Thus, as a result, not only environmental pollution reduces and a cleaner environment is provided, it is possible to increase the biogas produced by anaerobic digestion as well and even to meet all energy needs of wastewater treatment plant (Sanaye et al., 2022).
The results of the degradation of the main components of wastewater disposal will produce methane gas concentrations as follows: 50% CH4 comes from carbohydrates, 68% CH4 comes from fat and 70% CH4 comes from protein (Weiland, 1987). The composition of the biogas produced is highly dependent on the organic matter content of the tofu industrial

wastewater which can be degraded through anaerobic processes, including carbohydrates, fats and proteins. In the case of employing feeding strategies for anaerobic digestion, the objective might be to maximize methane production (Ehlinger et al, 1994), since anaerobic digestion is a complex and nonlinear process, it is essential to tune parameters of feeding strategies to handle specific situations (Gracia et al., 2011).
Biogas production resulting from the fixed bed type anaerobic treatment started at 1.49 L/day on the first day and then stabilized from the 10th day to the end of 147.06 L/day with a COD reduction efficiency of 73%, with methane = 262 L/kgCOD or equivalent to 21% biogas. Hydraulic Retention Time (HRT) = 2 days.

3.2 Implementation in Indonesia

Each country must have different characteristics, so it is not certain that technology that has been successful in one country will also be successful in other countries. The application of anaerobic wastewater treatment technology with fixed bed type reactors in Indonesia has also been applied in several regions.
One example of a case study of tofu industrial wastewater treatment in Indonesia by Prasetyadi et al. (2018) using a fixed bed type anaerobic reactor. Tofu waste has a high organic content, and is processed using a fixed bed type anaerobic reactor which is commonly applied in Indonesia consisting of only one reactor tank and one biogas storage tank or gas holder. In addition, the operation of the wastewater treatment system is also carried out without the use of a pump because it has been designed in such a way that wastewater can enter the reactor with the help of gravity.
The reactor is conditioned at room temperature without a heating or cooling process, so it does not require a wastewater storage tank or heat exchanger. Without the use of wastewater storage tanks, the costs required in procuring equipment will also be much cheaper. In addition, without a heat exchanger, in operational terms it only requires minimal energy and low costs. If calculated as a whole, this can affect the total cost of the entire wastewater treatment process. The anaerobic process carried out in Indonesia without these two tools can still run well because Indonesia is located in the equatorial belt which is mainly tropical climate type, so that Indonesia is suitable and good for bacteria to grow and develop.
The reactor tank and biogas storage area are made of fiberglass because they are easy to shape, resistant to acids, non-corrosive, and strong. When compared to the fixed bed type anaerobic reactor technology carried out by Germany which uses stainless steel, fiberglass is much cheaper and very easy to maintain.
During the inoculation process, 100% cow manure is filled with water in a ratio of 1:1. Cow manure was chosen because it contains poly-bacteria and in it there are methane-forming bacteria. The cow dung that has been mixed with water is then filtered so that there are no large stones or intact undigested grass, but the solids of cow dung are still there because these solids can become organic nutrients for the growth of bacteria. The addition of this water mixture to the cow manure is only meant to make it easier for the cow manure to enter the reactor. At the inoculation stage, the maximum biogas produced is 21,140 liters/day , and 64% of its content is methane gas (Prasetyadi et al., 2018).
Next step is the adaptation stage, where the bacteria that have been attached to the supporting material and the walls of the anaerobic reactor begin to adapt to digest wastewater that has a high enough organic content. The success of bacteria in adapting is marked by the emergence of biogas.
The results showed that the first day produced 9 liters of biogas, and the maximum conditions on day 39 with organic wastewater filling of 7700 liters per day and a COD content of 6.695 kg/m 3 was 35,158 liters of biogas/day with methane gas of 66% and an average the average efficiency for reducing COD is 87.7% (Prasetyadi et al, 2018). This is in

accordance with the theory of Metcalf (2003) which states that the process efficiency of the performance of a Fixed Bed type reactor can reach 75-85%. Hydraulic Retention Time (HRT) = 4.5 days.

Based on data obtained from the Prasetiyadi journal in 2018, biogas produced from tofu wastewater treatment with a fixed bed type anaerobic reactor has been used by the community as many as 40 households as a substitute for gas fuel for cooking. The direct impact of the use of biogas is felt by the community because with the use of biogas, housewives can save their household economy.

Figure 1. Use of biogas for cooking activities

Based on the two previous discuccion, it can be concluded that anaerobic organic wastewater treatment with a fixed bed type reactor applied in Indonesia has good results in several points including:

Table 1. Comparison of Results from Anaerobic Wastewater Treatment Technology using the Fixed Bed type

No	Information	Germany	Indonesia
1	Equipment	Separator, pump, storage tank, reactor	Biogas reactor and tank
2	temperature	Need heat exchangers	Room temperature (mesophilic)
3	inoculation	Chicken manure and cow manure	100% cow manure
4	Reactor stuffing	Using a 100µm filter so that the solids content is <2%.	Not using a filter, but diluted 1:1 with water
5	Methane	21%	66%
6	HRT	2 days	4.5 days
7	material	*stainless steel*	*Glass fibre*
8	COD efficiency	*73%*	*87.7%*

(Analyzed by author, 2023)

The weakness of anaerobic wastewater treatment technology using Fixed Bed reactors in Indonesia is the residence time or HRT of 4.5 days. This can be overcome by using a catalyst, namely peroxydisulfate/zero-valent iron (PDS-ZVI), which is specifically for the anaerobic digestion process.

4. Conclusions

Anaerobic wastewater treatment solutions with a fixed bed type in Indonesia can be a good opportunity and can be imitated by other countries because it has simple equipment

compared to Germany which still uses several tools including the use of pumps, storage tanks, wastewater filters, use of stainless steel in tanks and heat exchangers. Although anaerobic wastewater treatment with a fixed bed type in Indonesia has simple equipment, the reactor efficiency and the resulting methane production percentage are relatively high, even though the required HRT is relatively long, anaerobic catalysts can be used as a solution.

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