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DEVELOPMENT OF EFFICIENT AND ENVIRONMENTALLY FRIENDLY SEPTIC TANKS

Brian Alfandi[1], M. Ali Mukmin, S[2], Ria Rosyati[3], Siti Abadiyah[4]*
[1,2,3,4] Civil Engineering, Faculty of Engineering, University of Muhammadiyah Tangerang
Jalan Perintis Kemerdekaan I No. 33, Tangerang, Banten, 15118, Indonesia
[*1]alfandibrian@gmail.com, [2]abahalitea@gmail.com, [3]riapepro@gmail.com,
[4]abadi_dede01@yahoo.com

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Abstract

In many communities in Indonesia, there are still many areas where their homes do not have a toilet (water closet) that meets hygiene and health requirements. This is caused by many factors, including because there are still many people who live below the poverty line, both economically poor and poor in knowledge (human resources). Procurement of toilets (water closets) which also include a septic tank system with a minimum output that is environmentally friendly and of course cost efficient is very necessary to improve public health. Based on the description above, this research was created in order to provide procurement and development of efficient and environmentally friendly septic tanks. This research is very necessary because of the discovery of an efficient alternative material by using used drums which can be used as septic tanks in Lampung, but it has not deepened the issue of waste output that is safe for the environment. This research was carried out using a constructivist qualitative method with assistance from DIGILIB Digital Library & OPAC UB sources. is at Brawijaya University Malang, where the author is registered as a student in the environmental science doctoral program at Brawijaya University Malang.

Keywords: Septic Tank, Efficient, Environmentally Friendly, constructivist qualitative method

Introduction

The first time a septic tank was used to serve household wastewater was in France around 1870 (McCulloch, 2023). Septic tanks were introduced in the United States in 1884 through the use of two tank chambers using an automatic siphon for occasional waste disposal (Canter & Knox, 2017). Since their introduction in America, septic tank systems have become the most widely used method of waste disposal, with more than 70 million people relying on them (Hersaft, 1976). Around 17 million housing units, or 1/3 of all housing units, dispose of domestic wastewater using septic tank systems. About 25 percent of all new homes being built in the United States use septic tank systems to treat the resulting wastewater before the home is discharged (Canter & Knox, 2017).

Conventional septic tanks are most widely used in Indonesia (Widyarani et al., 2022). In fact, the type of biofilter septic tank which is the latest breakthrough is actually much more efficient, practical and long-lasting. Then, why are conventional septic tanks still widely used in Indonesia? Developer and property practitioner Bambang Eka Jaya said one of the reasons conventional septic tanks are still widely used is because they are affordable. According to him, the septic tank was made by construction workers with a budget that was included in the overall construction of the house (Fadli & Alexander, 2022).

" So, the biofilter septic tank is indeed practical and better, but in terms of costs it is relatively greater," Bambang explained that when someone uses a biofilter septic tank, they must first buy a factory-produced unit. They still must dig the ground to bury the biofilter tool or tank. "So, there are additional costs. In fact, it is not just excavated but also covered with brick around it, and a concrete cover is made so that it can be controlled and sucked up, if necessary," he said. On the other hand, making a conventional septic tank is much easier and more economical. The system used is simpler. Apart from that, even though the biofilter septic tank is much more durable and long-lasting, if it is damaged you must replace the entire device. "If it is damaged, of course it must be replaced as a set, whereas conventional ones can be replaced individually, for example the media and so on," he said (Fadli & Alexander, 2022).

The increasing burden of population and urbanization causes an increasing burden on water consumption(C. He et al., 2021). Water consumption and other operational waste products result in the entry of dangerous foreign objects (pollutants) into the aquatic environment and thus make the water unsafe for consumption(Rathi et al., 2021). The introduction of pollutants such as organic materials and nutrients creates aseptic conditions and problems, such as eutrophication and low dissolved oxygen (DO) content in water(Tonelli & Tonelli, 2020). The creation of an unhealthy ecosystem like that can result in the formation of things that are detrimental to the environment for living things(Malhi et al., 2020). In extreme cases, the impact is that water pollution can also occur in humans because we are in the same food chain as animals (Q. He & Silliman, 2019). The organic matter carried, and the nutrient load is present and proven to be toxic/harmful to humans in many ways. Lack of DO and septic conditions can also result in unavailability of fresh water sources for consumers (Salehi, 2022). In such a worst-case scenario, users will also be forced to use polluted water or pay a high price to get drinking water. To overcome the scarcity created due to relatively higher consumption and increased pollution, wastewater treatment is now an urgent need of the authorities concerned(Arora & Saraswat, 2021).

A septic tank is a basic transitional structure for household waste processing facilities that can utilize sedimentation and anaerobic bacterial fermentation to degrade suspended organic compounds (C. He et al., 2021). The functions of this building include degrading sediment and suspended solid organic compounds (Ji et al., 2022); storage and fermentation of anaerobic bacteria in the sludge at the bottom of the septic tank; drain water from pipes, to prevent blockages in pipes (Huang et al., 2013; Oipeng, 2007; Zhaoyang, 2010). As a demotic waste processing facility without heating and stirring equipment, septic tanks play an important role in reducing environmental pollution (Zawartka et al., 2020; Zhang et al., 2011).

The development of sustainable technologies for domestic wastewater treatment with the added benefits of reducing costs (Stazi & Tomei, 2018) and increasing treatment efficiency is crucial in developing countries (Adegoke & Stenstrom, 2019). This is because domestic wastewater from households is stored in septic tanks with poor treatment quality before going to external channels (Nsiah-Gyambibi et al., 2023).

Since the introduction of septic tanks in 1884 in the United States, septic tank systems, which can be considered conventional systems, are still widely used(Kihila & Balengayabo, 2020), as is also a phenomenon that occurs in Indonesia. Although this type of bio filter septic tank is a new breakthrough that has entered Indonesia.

What kind of septic tank is good for its users and what kind of development is needed to be able to provide environmentally friendly outcomes. In the previous research the use of the MAV system is an integrated approach of macrophytes and earthworms in the vermifiltration process and complex physico-chemical mechanisms (Thamizharasan et al., 2024). The use of several species of macrophytes and earthworms is the hypothesis of this research to examine variations in the influence of their performance with the development of this MAV treatment (Al-Maliki et al., 2021).

Based on this treatment, it is necessary to carry out research to be able to develop a conventional septic tank system which leads us to the development of conventional septic tank systems in Indonesia with environmentally friendly outcomes.

With all that previous research, the author feels it is necessary to carry out research to develop a conventional septic tank system with the use of MAV system based on existing research.

Research Methodology

This research uses a constructivist qualitative method, by providing a description of the previous research using DIGILIB Digital Library & OPAC UB provided by Universitas Brawijaya Malang, and found several related researches, as follows.

1. Vermifiltration as a sustainable natural treatment technology for the treatment and reuse of wastewater: A review. 122 reference includes in this paper
2. Performance evaluation of developed macrophyte-assisted vermifiltration system designed with varied macrophytes and earthworm species for domestic wastewater treatment. 53 reference includes in this paper
3. Research and Evaluate on Wastewater Treatment of Septic Tank. 16 reference includes in this paper

Then from the description and theoretical sources a prescription is taken for the development of a conventional septic tank system with adjustments to regional regulations and the use of used plastic drums from literature and research, as follows.

1. Probolinggo Distrik Regulation Number: 1 tahun 2019 about domestic wastewater management (PEMDA Kabupaten Probolinggo, n.d., p. 1)
2. Utilization of used plastic drum as a material for manufacturing septic tanks (Masykur, 2015). 8 reference includes in this paper
3. Design study of using used drum into a tidal septic tank(Munawar & Suparmi, 2016). 21 reference includes in this paper

Research Results and Discussion

According to research from Sinha et al (2008), Vermifilters are now a promising way of handling, in this case waste water resulting from household work such as washing, cooking, toilets, etc (Saraswat et al., 2022). The application of vermifilters in waste processing has resulted in organic reduction efficiencies of up to 95% and significant nutrient fixation (Tabel 1).

According to reports from, the application of vermifilters in processing domestic waste produces BOD, COD, TDS, and TSS processing efficiencies of orders greater than 90%, 80–90%, 90–92%, and 90–95% respectively.

Meanwhile research reported reductions in COD and BOD of 76% and 67% respectively, while waste from households was treated using the earthworm species Eisenia fetida (Arora et al., 2014).

Research from also observed reduction efficiencies of about 47.3 – 64.7%, 54.7–66%, 7.6–15%, 2–62% for influent COD, BOD, TN, ammonium nitrogen (NH4+-N) (Xing et al., 2010), respectively each. A study from Wang et al (2016) stated that the vermifilter used in domestic wastewater treatment had achieved BOD, COD and SS reduction efficiency of 84%, 81% and 94% respectively. In line with that research Liu et al (2013) also obtained COD, BOD, and NH4+-N reduction efficiency of up to 67.6%, 78% and 92.1% using ceramsite as a filter media during processing of rural household waste (Furlong et al., 2014). Vermifilter has also been applied to human waste(Banerjee et al., 2024). Another study stated a COD reduction of around 87% for vermicomposting human waste.

Table 1. Application of Vermifiltration in Treating Domestic Wastewater. BOD = Biochemical oxigen need; COD = Chemical oxigen need; TN = Amount of Nitrogen; TP = Total Fosfor;
$NH4^+$-N = Amonium Nitrogen.

SI. No	Types of wastewater	Earthworm species	Organics removal (%)	Nutrient removal (%)	References
1	Municipal wastewater	Eisenia fetida,	BOD 88	NH_4^+-N 86,	Kumar et al. (2016)
		Eudrilus eugeniae	BOD 70		
2	Municipal wastewater	Eisenia fetida,	COD 47.3–64.7, BOD 54.7–66	TN 7.6–14.9, NH_4^+-N 2-62	Xing et al. (2010)
3	Municipal wastewater	Eisenia fetida,	BOD > 90, COD 80-90	-	Sinha et al., (2008a,b)
4	Municipal wastewater	Eisenia fetida,	BOD 75.9, COD 66.7	-	Arora et al. (2014c)
5	Rural domestic wastewater	Eisenia fetida,	COD 78, BOD 98.4	NH_4^+-N 90.3, TP 62.4	Wang et al. (2010a,b)
6	Municipal sewage sludge	Eisenia fetida,	COD 53.01, BOD 61.06		Li et al. (2013b)
7	Municipal wastewater	Eisenia fetida,	COD 83.5, BOD 81.3	TN 32.4, NH_4^+-N 55.6 TP 38.6	Wang et al. (2016)
9	Municipal wastewater sludge	Eisenia fetida,	COD 48.5–53.5	-	Zhao et al. (2010)
10	Rural domestic wastewater	Eisenia fetida,	COD 67.6, BOD 78	NH_4^+-N 92.1	Li et al. (2013a)
11	Human faeces	Eisenia fetida,	COD 87	-	Furlong et al. (2014)
12	Human faeces	Eisenia fetida,	COD 88-90	-	Furlong et al. (2015)

From these references, research (Arora & Saraswat, 2021) provides a description of how vermifiltration performs in the efficiency of reducing nutrients, organics, solids and pathogens, then adds several research results with the addition of macrophyte plants.

Table 2. Application of Vermifilter with the Help of Macrophytes in Several Types of Waste Water

SI. No	Types of wastewater	Earthworm species	Plant species	COD removal (%)	Nitrogen removal (%)	Phosphorus removal (%)	HLR ($m^3/m^2.d$)	References
1	Synthetic wastewater	Eisenia fetida	Acorus calamus	86.7	TN 85.6	83.05 TP	0.056	Zhao et al. (2014a,b)
2	Domestic sewage	Eisenia fetida	Phragmites australis	94.8	NH_4^+-N 97.1	95.6	1	Wang et al. (2010a,b)
3	Domestic wastewater	Eisenia fetida	Lolium perenneL.	94.2	TN 58.2 NH_4^+-N 93.3	-	0.36, 1.08, 0.36, 0.36, 0.54	Wang et al. (2015)
4	Swine waste water	Pheretima peguana	Typha angustifolia	> 90	> 90	-	0.08	Nuengjamnong et al.
5	Urban watewater	Perionyx sansibaricus	Cyprus rotundus	90	-	PO_4^{3-} 98.3	-	Tomar and Suthar (2011)
6	Domestic wastewater	Eisenia fetida	Phragmites australis, Typha augustifolia, Canna indica	86.9	TN 76.6	TP 74	14 L/d	Xu et al. (2013a)
7	Sludge	Eisenia fetida	Canna indica	62 - 81	-	TP 72 - 80	-	Chen et al. (2016)
8	Domestic sewage	Eisenia fetida	Penstemon campanulatus	81.3	NH_4^+-N 98, TN 60	TP 98.4	1	Wang et al. (2011)
9	Synthetic domestic watewater	Eisenia fetida	Canna indica, Iris japonica, Acorus calamusL., Phragmites australis, Zizania caducifolia, Typha angustifolia	70 - 88	TN 84 - 93 NH_4^+-N 80 - 92	TP 84 - 89	-	Xu et al. (2016)
10	Synthetic domestic watewater	Eisenia fetida	Phragmites austrail, Typha augustifolia, Canna indica	-	TN> 95, NO_3- > 90, 58.2 NH_4^+ > 95	-	14 L/d	Xu et al. (2013b)
10	Dairy industry wastewater	Eisenia fetida	Canna indica	75.8	TN 42.6, NH_4^+-N 73.2	-	0.65	Samal et al. (2017a)
11	Dairy industry wastewater	Eisenia fetida,	Canna indica	73, 62.6, 43.9	NH_4^+-N 68.3, 55.2, 31.6, TN 37.8, 28, 18.8	TP 61.1, 49.3, 38.3	0.3, 0.6, 0.9	Samal et al. (2018)

COD: Chemical Oxygen Demand; TN: Total Nitrogen; TP: Total Phosphorous; NH_4^+-N: Ammonium Nitrogen; NO_3^--N: Nitrate-Nitrogen; PO_4^{3-}–P: Phosphate Phosphorous.

From the two applications in this research, the following conclusions were obtained; This meta review in-depth explains the mechanisms involved in vermifiltration and the contribution of earthworms in processing waste. This research details the mechanisms and actions involved in pathogen removal, of particular interest. The analytical performance of the vermifilter proves its efficacy in handling pollutants supplied to the system. This research provides impetus for the application of vermifilters on a field scale and discusses the influence of various factors on their performance. In attempting to take vermifiltration from the 'lab to the field', associated limitations are discussed in this review. The efforts made by previous researchers in addressing the limitations associated with vermifiltration have also been reviewed. In this study, a detailed analysis of changes in the vermifilter mechanism after adding macrophytes was carried out. From the analysis carried out, it can be concluded that vermifilter with the help of macrophytes is a very good alternative compared to vermifilter alone, which is the conclusion of the research.

This research develops a domestic wastewater treatment vermifiltration system with the help of Macrophyte (MAV). The MAV system is an integrated approach of macrophytes and earthworms in the vermifiltration process and complex physico-chemical mechanisms (Samal et al., 2017). The use of several species of macrophytes and earthworms is the hypothesis of this research to examine variations in the influence of their performance with the development of this MAV treatment(Vidal et al., 2023). This research aims to evaluate the performance of the treatment development of MAV with three variations of macrophyte species (Eichhorniacrassopes, Pistiastratiotes and Spirodelasp.) and two variations of worm species. soil (Eiseniafetida and Eudriluseugeniae) was used as a treatment development for this MAV system (Nsiah-Gyambibi et al., 2023).

Sewage samples were collected every 48 hours within two weeks for physico-chemical, pathogen and worm analysis. The contents (N total, NH3, NO3-N and P tot) in wastewater are high, respectively (>50 mgL-1,>5mgL-1,>1mgL-1and>20mgL-1). Results revealed that the developed MAV system was effective in removing solids (>60%), nutrients (>60%) and pathogens (>90%). In most cases, there were no significant differences between the selected macrophytes and earthworms in treatment performance. The results showed that the selected macrophytes combined with earthworm species were suitable when used in the development of the MAV system. Developing MAVs with a variety of selected species of macrophytes and earthworms not only contributes to wastewater treatment(Islam et al., 2023), but also improves worm farming. Eudriluseugeniae showed higher biomass gain (5–10% more) compared to Eiseniafetida (Nsiah-Gyambibi et al., 2023).

Domestic wastewater from septic tanks in Ghana is poorly treated before discharge. The MAV system developed in this research can function as a secondary treatment system for household septic tanks. This is because the results of this research have revealed that domestic wastewater developed with the MAV System is effective in removing solids and nutrients, (>60%) and pathogens (>90%) originating from domestic wastewater. Thus, the combined effect of macrophytes and earthworms in a MAV system provides ideal conditions that reduce solids, nutrients, and pathogens from wastewater. The presence of macrophytes in advanced MAVs not only contributes to wastewater treatment, but also increases system aeration which encourages the development of vermiculture for vermifiltration in vermi beds (Opitz et al., 2021). In addition to the biomass gain where Eudriluseugeniae recorded significantly higher values than Eisenia foetida, vermi cultivation of the two earthworm species was equally efficient in the vermifiltration process. In future research, more attention is needed to test the robustness of the developed MAVs under harsh conditions such as high HLR (> 0.5 m3 m-2 d-1), high intensity contamination, cold climate, extreme pH and toxicity sodium (Nsiah-Gyambibi et al., 2023).

The research was conducted at the Environmental Engineering Laboratory located in Kumasi in Ghana and was carried out in April and May, setup up schematic diagram in figure 1.

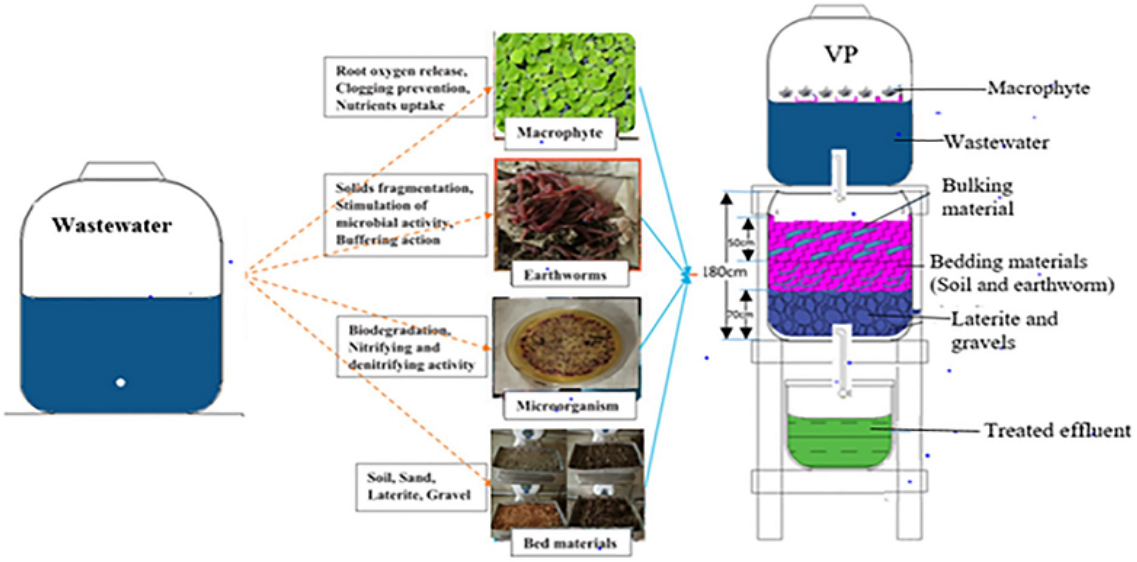

Figure 1. Research Schematic Diagram

Septic tanks as domestic waste processing units play an important role in handling environmental pollution (Widyarani et al., 2022). Domestic waste quality variation indices and pollutant removal rates were analysed after treatment in septic tanks (Srivastava et al., 2008), research was carried out on septic tanks in Chaohu city located in Anhui Province, P R China. The results showed that the COD, BOD5, SS and TN removal rates were 41.23%, 32.86%, 30.07% and 10.54% respectively, increasing NH3-N and TP concentrations.

The removal rate of COD and BOD5 increased with increasing temperature, however, there was no significant change in the removal rate of N and P. In addition, the biodegradability of wastewater was retained in the septic tank. The results have provided a comprehensive evaluation of septic tanks and their selection techniques.

In this previous research which conducted in August, October, November and December 2010, selected septic tanks were monitored for 4 periods, each period took 24 hours.

Table 3. The Pollutan Removal Rate Of Selected Septic Tank In Kangle Residential Area

Index	Inflow (mg/L)					Effluent (mg/L)					Removal Rate (%)
	Period 1	Period 2	Period 3	Period 4	Average	Period 1	Period 2	Period 3	Period 4	Average	
COD	385,24	470,28	369,51	484,06	427,27	238,38	296,50	267,07	344,54	286,87	32,86
BOD_5	126,44	190,07	152,99	248,96	179,62	57,70	103,20	85,46	175,82	105,55	41,23
SS	30,70	70,50	72,00	46,17	54,84	15,13	46,50	59,08	32,67	38,35	30,07
TN	70,61	58,72	61,39	154,68	86,35	77,12	69,4	68,09	94,4	77,25	10,54
NH_3-N	44,63	43,06	39,77	60,92	47,1	41,89	54,8	60,12	62,63	54,86	-14,15
TP	5,42	5,86	7,12	8,5	6,73	5,12	5,38	11,58	6.93	7,25	-7,17

The percentage of removal rate with the application of the MAV system for COD is the lowest 47.3% - 64.7% while for BOD the lowest is 54.7% - 66%, whereas if you do not use MAV which was developed according to table 3, then the percentage removal rate for COD is 32 .66% and BOD of 41.23%.

Then, from the description of the theoretical source, a prescription or recommendation for the framework of thought that can be drawn is that the application of MAV system development in conventional septic tanks provides a positive contribution according to the parameters mentioned above.

To develop the application of septic tank media in the field, we will review whether there are certain requirements for the use of septic tank materials, in this case Pemerintah Republik Indonesia through Peraturan Daerah Probolinggo Nomor 1 Tahun 2019 tentang Pengolahan Air Limbah Domestik provide regulations in Part Two. Purpose of Article 3. Domestic wastewater management aims to:

a. realizing the implementation of SPALD that is effective, efficient, environmentally friendly, and sustainable.
b. improving quality domestic wastewater services.
c. improve public health, healthy living behaviour, and environmental quality.
d. protect raw water quality from domestic wastewater pollution.
e. encourage efforts to utilize domestic wastewater processing results.
f. provide legal certainty in the implementation of SPALD.

From examples of existing regulations, it turns out that there are no specific restrictions on the type of material for septic tanks(Srivastava et al., 2008). Then we review research on making septic tanks using used plastic drums which are often found on the market in general (Masykur, 2015). The size and volume of a septic tank is not influenced by soil type, soil absorption capacity, or groundwater level (Adegoke & Stenstrom, 2019). The water that comes out of the septic tank still must be processed in an absorption field, absorption well or filter (Beal et al., 2005). Advantages of Using Plastic Drums as Material for Making Septic Tanks
1. Plastic drums are more durable/permanent because they are resistant to chemical solutions
2. Waterproof/leak-proof plastic drum
3. Plastic drums are easy to get
4. Plastic drums are cheap
5. Easy to work with
6. Can be made in various shapes to suit land conditions
7. Brick masonry can be more economical

Then we look again at the research (Munawar & Suparmi, 2016), with research results, as follows;
1. The used drum designed as compartment A can function as a Septic Tank and Compartment B as an IPAL so that it can change the physical form of fesses and reduce the quality of wastewater.
2. TSS levels in compartment A were 178 mg/l while in Compartment B were in the range between 45 mg/l to 310 mg/l.
3. BOD levels in compartment A were 281 mg/l while in Compartment B were in the range between 72 mg/l to 846 mg/l.
4. High TSS and BOD parameters are possible due to the non-optimal functioning of microorganisms in degrading organic materials contained in faecal waste.
5. Low TSS and BOD parameters are possible because microorganisms are more optimal in degrading organic materials contained in faecal waste.

According to the Minister of Environment Regulation number 112 of 2003 concerning Domestic Waste Quality Standards, the minimum BOD and TSS parameters are 100 mg/l, while from the research results in compartment A it is 178 mg/l to 132.5 mg/l (average) or around 25.56% removal rate for TSS and in compartment A 281 mg/l to 387 mg/l (average) or around -37.72% (minus) removal rate for BOD..

Conclusion

The conclusion that can be studied from the discussion above is that a prescription or recommendation for the framework of thought can be drawn that the application of the MAV system developed can be applied to used drum media because there are no restrictions on the type of material for septic tanks according to the rules explained and a MAV system developed is indeed needed for can reduce the COD or TSS parameters from the removal rate which is only 25.56% which can be increased to 47.3% to 64.7% while the reduction in BOD parameters from the removal rate - 37.72% (minus) can be increased to 54.7% up to 66%, so that the goal of getting an efficient and environmentally friendly septic tank can be achieved.

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