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A Study on The Effective Use of Microorganisms using Different Amounts of Mudball and Wastewater Retention Time

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Abstract: Wastewater treatment is important before water sources are polluted where it needs to be treated to prevent water pollution before the water returns to the environment. Inadequate sewage systems cause rivers to be polluted and make them open sewers, which are discharged directly into the river which will affect the environment, human health and quality of life. Therefore, a study on the Use of Effective Microorganisms using different amounts of mudballs and wastewater retention times was carried out. This was to see the potential of treating wastewater from oxidation ponds using Effective Microorganisms (EM) mudballs as a treatment method. The scope of this study was to determine the organic matter present in wastewater samples and EM mudballs that act to treat wastewater taken from oxidation ponds and analyzed in the laboratory. The data obtained was analyzed according to a certain number of days for a month using EM mudballs as treatment materials. Five parameters were analyzed including pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO) and Ammonia Nitrogen (AN). The process of determining the appropriate dose of EM mudballs for treatment can be determined by using 1 to 4 EM mudballs. The retention time for the treatment period was monitored for a month, on days 7, 14, 21 and 28. The wastewater study process was carried out using an aquarium as a prototype. The results of the study showed that the use of 1 EM mudball was sufficient for the short-term treatment process, on day 7. In this study, the use of 4 mudballs was determined as the best dose because it had the highest BOD, COD and AN removal effectiveness. Bacterial growth determination could be detected from day 1 to day 28. Therefore, it can be concluded that this treatment process has the potential to be utilized because the parameters that were tested could be removed effectively.

Keywords: Wastewater, retention time difference, organic matter, wastewater sample

1. Introduction

In more advanced civilizations, knowledge about the importance of managing sewage waste more systematically is increasingly emphasized so that problems related to it can be avoided. Treating wastewater from polluting water sources is very necessary to prevent such pollution before the water returns to the environment. Inadequate sewage systems cause rivers to be polluted and turn them into open sewers, which are discharged directly into rivers, which will affect the environment, human health and quality of life. In Malaysia, for example, since its incorporation in 1994, Indah Water Konsortium (IWK) has been responsible for improving sewage services in this country by emphasizing the need for environmentally safe sewage disposal practices, the use of correct technology in managing sewage waste, and being environmentally friendly. The increase in population has also led to an increase in the number of sewage plants throughout Malaysia (DOE, 2010). In addition, the discharge of effluent water is often associated with water pollution problems, especially when wastewater is discharged into rivers, lakes and the sea. Wastewater that is discharged is feared to pollute water quality, aquatic life and the environment.

There are various treatment methods that have been introduced, for example the Hi-Kleen treatment process and oxidation ponds and applied to treat this wastewater from polluting the environment, whether the treatment system operates conventionally, namely through physical, chemical and biological treatment techniques. EM Mudball used has several advantages which are low cost, easy to use, effective and safe. EM Mudball is not only used in waste treatment, but can also be used as a multipurpose product, for example for organic fertilizer. EM used in water treatment can improve the quality and environment of water.

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Through the fermentation process it will bind nutrients from being taken by other species such as algae for example, reduce sludge and ammonia, increase oxygen solubility (DO) and turbidity. The treatment carried out gave positive results and the following are also the parameters that are often tested using EM such as very effective, can reduce sludge content, safe method and reduces impact on the environment. This technological change is intended to overcome the weaknesses that exist during the treatment processes also to upgrade treatment services to be able to produce waste that is safe for the environment. Most treatments offer chemical methods, for example sewage treatment centres also use bacterial decomposition techniques for the disposal of waste materials, which ultimately are feared to have a negative impact on the environment (Dewan Kosmik, October 2002). Increased awareness of the importance of preserving the environment has provided other alternatives in providing treatment methods with the goal of maintaining sustainability values in all aspects. Among the methods that have been used in maintaining sustainability values are Effective Microorganism (EM) technology, Garbage Enzyme and sawdust bio-mixture. However, in this research, the treatment chosen is the treatment known as EM mudball.

In considering the aspect of environmental sustainability, Effective Microorganism (EM) is one of the products for the solution process in wastewater treatment, whether domestic waste or industrial waste. The use of EM is becoming more widespread throughout the world (Freitag, 2000). EM was used as a restoration method in shallow Konin Lake (Western Poland) where severe cyanobacterial water blooms were observed. The study lasted for 5 years: 2011–2015, covering the treatment period (2013–2015) and two previous years. EM application initiated positive changes in the ecosystem by means of excessive organic matter decomposition and increased diversity of phytoplankton, although cyanobacteria blooms were still present due to high nutrient content (Safwat.M, 2021). In addition, there are also non-governmental organizations (NGOs) and environmentalists who have run campaigns to promote its use. The use of EM is one of the alternatives used in wastewater treatment. Although the use of EM in Malaysia is widespread, the appropriate EM doses are not specifically determined for a type of treatment. The problem of not having a guide in the dosage of excessive EM use is feared to have an impact on the environment. Further clarification of the specific environmental effects caused by excessive doses of microbes, whether it causes eutrophication, ecosystem imbalance or decreased air quality, has yet to be determined because this study proves that the use of EM is from organic materials without involving chemicals. This is because, Sangakkara, 2002 stated that excessive microbial content in wastewater to be treated can affect the quality of wastewater released in the water drainage, which will have a negative impact on the environment. This can indirectly help in finding solutions to problems related to doses in oxidation pond wastewater. There are two objectives studied in this study, namely, to determine the effectiveness of the use of EM Mudball and to study the effectiveness of EM MudBall with differences in detention time over a certain period. The advantage of EM is that its process of fermentation is natural and not chemically engineered or genetically synthesized. Consequently, EM technology is not only eco-friendly but also plays the actual role of protecting the environment. This is because EM is safe and organic (M. Safwat,2021).

1.1 Scope of Study

In the scope of this study, the oxidation pond is the sampling area. Wastewater from the oxidation pond is obtained. A visit to the study area is carried out to observe the oxidation pond to find out the cause, the conditions around the pond area also the type of influent that is discharged. The purpose of this study is to ensure that the EM mudball used in the treatment of wastewater from the sewage can reduce the values of the parameters measured in this experiment. The laboratory experiment involves analyzing wastewater samples from the sewage to obtain parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), acidity and alkalinity (pH), ammonia nitrogen (AN) and dissolved oxygen (DO). This study aims to see the effectiveness of using EM Mudball as an alternative to assist the treatment method of wastewater from the oxidation pond and to find out the appropriate dosage to be used in the treatment of wastewater from the oxidation pond in maintaining the concept of environmental sustainability.

2 Literature Review

There are two types of EM to be used, namely liquid EM and solid EM. EM produced in liquid form will use brown sugar or molasses which acts as food for this EM so that it remains alive and active before being poured into water. In this research, EM Mudball was used. It is a mixture of 70% soil and 30% organic matter. Organic matter here means materials that do not involve any type of chemical and can be decomposed. EM Mudball will be added to water and it will continue to settle for the reproduction of anaerobic bacteria (Zarina, 2010). If the use of EM liquid in a large area and flowing causes EM liquid not to have time to treat the wastewater. EM used in water treatment can improve the quality and environment of water. Through the fermentation process, it will bind nutrients from being taken by other species such as algae for example, reduce sediment and ammonia, increase dissolved oxygen (DO) and turbidity (Azwita, 2009). Photosynthetic bacteria (PSBs) in the EM solution are natural bacteria that can carry out the purification process. Soil balls containing the so-called effective microorganisms (EM) have been applied to improve water quality of small ponds, lakes, and streams worldwide. Refer to Gun- Seok Park et. all, 2016, the application of 0.75 % of hardener to the soil balls exerted almost neutral pH (pH 7.3) which caused up to a fourfold increased hardness of the soil ball. EM mudball also improved the water quality due to a significant reduction in dissolved oxygen, total phosphorus, and total nitrogen

contents. Table 1 shows studies that have been conducted by several researchers using EM as a wastewater treatment. The treatments carried out gave positive results and the following are the parameters that are often tested using EM. After that, the mud balls are thrown into the river with the aim of improving the quality of the river water. This technique has been tried in countries such as Malaysia, Singapore and South Africa (Fadjari et. all, 2016) In theory, the "Mud Balls" act as adsorbents to remove turbidity, while the heterotrophic EM microorganism community degrades organic pollutants. The mud balls help in reducing suspended solids, turbidity and COD, and increase the DO level of the river water.

Table 1: List of Researchers who use EM in wastewater treatment

No.	Researcher Name		Parameter (value after 5 days of treatment)				Treatment
			pH	COD (mg/l)	BOD (mg/l)	TSS (mg/l)	
1	Gede Ngurah Widinna, 2004	before	4.0	105	35	37.8	EM
		after	7.44	89	28	29	
2	S.Monica et al, 2011	before	7.8	570.4	374.5	486.6	
		after	7.3	99.8	55.9	43.3	
3	Sivanan Dongyai et al, 2011	before	4.0	-	100	-	
		after	5.5	-	47.73	-	

3. Methodology

3.1 Treatment Using Static System

A total of five samples were carried out with one sample as a control and the other 4 samples having different numbers of mudballs. The 2nd sample had 1 mudball, the 3rd sample had 2 mudballs, the 4th sample had 3 mudballs and the 5th sample had 4 mudballs. These doses were determined to find the best dose to treat the wastewater. The tests were conducted on the parameters which were acidity and alkalinity (pH), biochemical oxygen demand (BOD), Chemical oxygen demand (COD), dissolved oxygen (DO) and Ammonia nitrogen (AN).

3.2 Preparation of EM Mudball

The equipment and materials used in the process of producing EM mudball are activated EM liquid, soil (such as clay), brown sugar, water, mixing container and digital weighing device. The EM liquid is activated using a ratio of 50:50: 900 where 50 ml of EM liquid, 50 grams of brown sugar and 900 ml of water. The fermentation process is left for a week at a temperature of less than 40ºC. The EM mudball manufacturing process has the following measurements in table 2:

Table 2: Ingredients according to the measurements for making EM Mudball

No	Material	Quantity
1	EM liquid	1 liter
2	Rice Bran	340 g
3	Clay	670g

(a) (b)

Fig.1: (a) Mudball material mixture (b) Completed mudball

3.3 Preparation of Wastewater Treatment Model

The process of determining the appropriate dose using EM Mudball in water treatment where the experiment was conducted based on the use of an aquarium as a model. The purpose of using an aquarium was to determine the optimal dose of EM Mudball according to the ratio of the area to be treated and easy to control. For the purpose of this study, the optimal dose of EM mudball in treating wastewater was determined based on tests on aquarium containers. The optimal dose was identified through the improvement of the water quality level through the experiments conducted. To facilitate the calculation of the dose ratio, an aquarium that can fill 16 liters of water was used in this experiment. The steps involved in preparing the oxidation tank wastewater treatment model are:

1. A total of two aquarium containers were used, one for control and the other for the experiment.
2. One aquarium was left as a control. While the other went through the treatment process using EM mudball treatment
3. Each sample was taken in the aquarium for the experiment for BOD, COD, DO and pH.
4. During the experiment, the oxidation pond wastewater was aerated for each mudball that was put into the aquarium

3.4 Instrument

Several instruments were used for this experiment. The use of instruments also depends on the parameters studied. Table 3 shows the instruments used.

Table 3: List of parameters and tools used in the experiment

Parameter	Equipment
pH	Meter pH
DO	DO meter
BOD	DO meter
COD	Spectrophotometer HACH DR 2800
Ammonia Nitrogen	spectrophotometer HACH DR 2800

4. Results and Discussion

4.1 Introduction

The overall results of the study obtained from the treatment process using Effective microorganism (EM) mudball were carried out at the laboratory work stage. The initial characteristics of the oxidation pond are very important in determining the percentage of chemical removal efficiency. The development of the pH of the oxidation pond during the treatment process was also studied. All the graphs shown were analyzed by considering all the initial and final concentrations of COD, BOD, DO, pH and ammonia nitrogen samples to determine the respective removal efficiency. Therefore, the appropriate mudball dosage value, detention time for treatment effectiveness and bacterial growth in the sample can be determined after each stage is carried out.

The study of the analysis of the removal efficiency of the oxidation pond wastewater was carried out continuously from the beginning to the end of the research. This means that the mudball dosage value needs to be determined first followed by determining the effectiveness of the mudball with the detention time used in this stage. All the results presented with the graphs are related to the use of the EM mudball that has been tested. Therefore, it can be clearly understood about the effect of the parameters that have been tested, especially on the removal efficiency depending on the respective parameters.

4.2 Analysis of wastewater treatment results in different detention times

For the results of wastewater treatment samples for a long-term period, the purpose was to see the effectiveness of using mudballs whether the number of mudballs affected the treatment of wastewater. The number of mudballs used was 1-4 in wastewater treatment and left for a period of 28 days. The volume of wastewater put into the aquarium was 16 liters and an aeration system was used.

Based on figure 3, the BOD reading value within a month was obtained where with the use of several mudballs. The BOD reading for the use of 1 mudball began to increase on the 14th day to the 28th day, which was from 59.67 mg/l to 61.67 mg/l. This shows that the use of 1 mudball was not effective in the long term. For the use of 2 mudballs, within a week the BOD reading showed a decrease of 21.33 mg/l but on the next day the BOD reading increased again, from 41 mg/l to 45.33 mg/l. For the use of 3 mudballs, the BOD reading showed a decrease on the 14th day but increased on the next day, with a reading of 47.67 mg/l. This shows that the use of 1 to 3 mudballs is not very effective in a long detention time. This is because the microbes in the treated wastewater have died due to running out of food.

For the use of 4 mudballs, it is more effective in a long detention time because there are still microbes to treat the wastewater. The BOD reading obtained on the 14th day decreased to 48.67 mg/l when compared to the BOD reading on the 7th day. On the 21st day, the BOD reading obtained was 39 mg/l. This proves that the use of 4 mudballs is more effective in a detention time of one month.

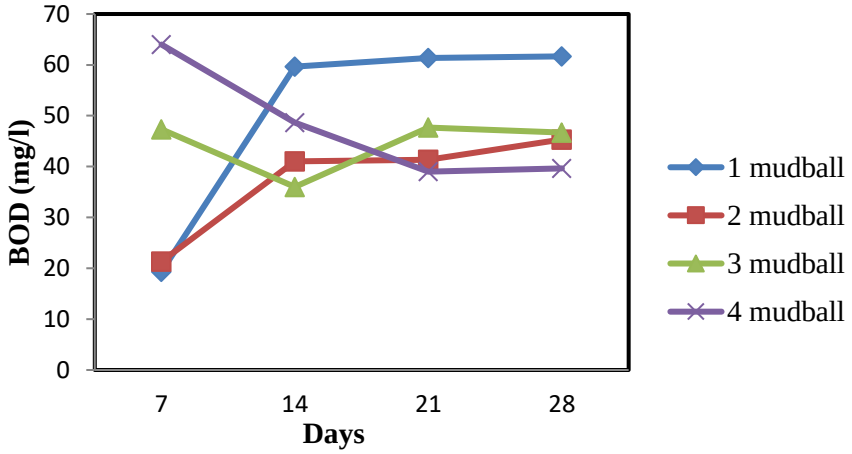

Fig. 3: BOD value graph for a month with the use of 1 mudball to 4 mudballs

Referring to figure 4, the COD value for a month was obtained. The use of 1 mudball showed that the COD reading obtained was 58 mg/l on day 7. The BOD reading began to increase on day 14 to day 28, from 189 mg/l to 195 mg/l. This shows that the use of 1 mudball is not effective in the long term because the COD reading value continued to increase. With the use of 2 mudballs, within a week the COD reading obtained was 64 mg/l but on day 14 to day 28 the COD reading increased from 125 mg/l to 138 mg/l. For the use of 3 mudballs, the COD reading showed a decrease on day 14, which was 111 mg/l but on day 21 it increased, with a COD reading value of 144 mg/l. On day 28, the COD reading increased again to 144 mg/l. This shows that using 1 to 3 mudballs is not very effective in long detention times. This is because the microbes in the treated wastewater have died due to running out of food. Using 4 mudballs is more effective in long detention times because there are still microbes to treat the wastewater. The COD reading obtained on day 7 was 195 mg/l. On day 14, the COD reading decreased by 48 mg/l compared to the BOD reading on day 7. On day 21 and day 28, the COD reading obtained was 118 mg/l and 119 mg/l. This shows that using 4 mudballs proved to be more effective in reducing COD readings during a one-month detention period during treatment.

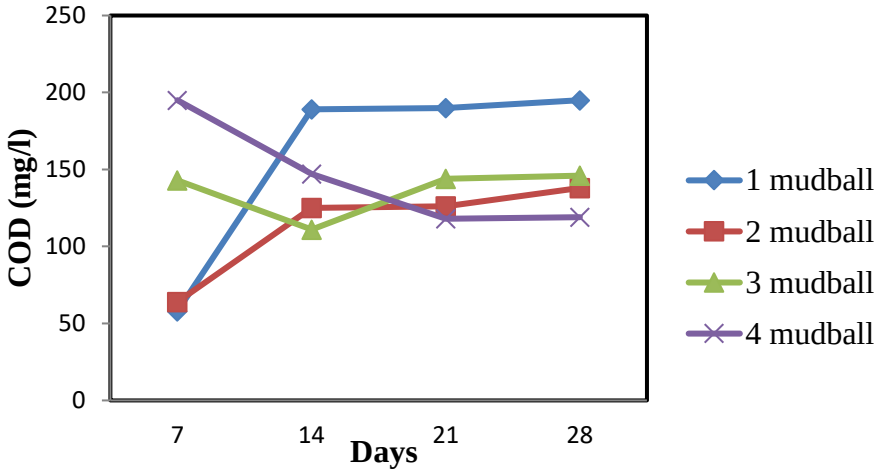

Fig.4: COD value graph for a period of one month with the use of 1 mudball to 4 mudballs

Referring to figure 5, the DO value for a period of one month has been obtained. The use of 1 - 4 mudballs shows that the DO reading obtained is between 6.12 mg/l - 7.44 mg/l. The DO reading obtained is not very different. The DO reading for the use of 1 mudball on the 7th day and the 14th day obtained is 6.54 mg/l and 7.41 mg/l. On the 21st day and the 28th day, the DO reading decreased slightly, namely 7.15 mg/l and 7.1 mg/l. For the use of 2 mudballs, the data obtained on the 7th day and the 14th day are 6.12 mg/l and 7.44 mg/l. Meanwhile on the 21st and 28th day the DO reading

decreased slightly, namely 7.16 mg/l and 7.09 mg/l. The DO reading for the use of 3 mudballs on the 14th day showed an increase. The DO reading on the 7th day was 6.75 mg/l while on the 14th day it was 7.44 mg/l. On the 21st and 28th day the DO reading was 7.15mg/l and 7.11 mg/l. For the use of 4 mudballs, the reading obtained was the highest value of the DO reading, namely on the 14th day, which was 7.4 mg/l. While on the next day the same reading was obtained, namely 7.2 mg/l.

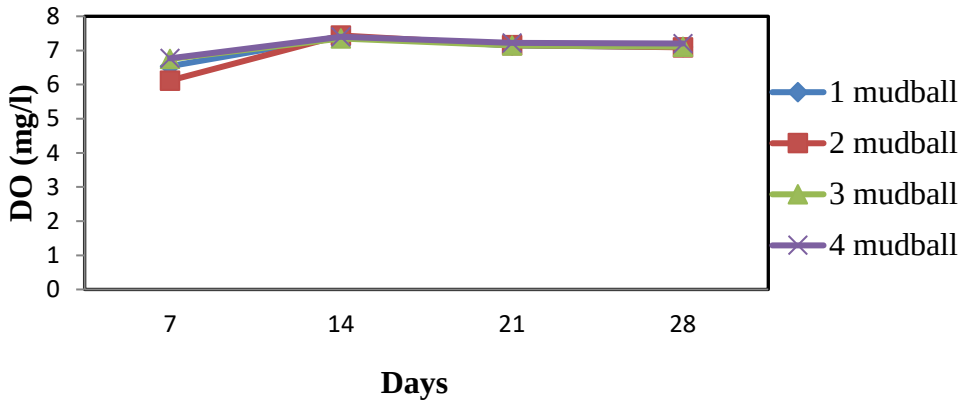

Fig. 5: Graph of DO values for a period of one month with the use of 1 mudball to 4 mudballs

Based on figure 6 below, the ammonia nitrogen (AN) reading value for a period of one month was obtained with the use of several mudballs. The AN reading for each mudball use decreased every week. For the use of 1 mudball, the reading on the 7th day was 3.11 mg/l. Then on the 14th day, the AN reading decreased by 2.44 mg/l. The AN reading the following week was 0.6 mg/l. This shows that the use of 1 mudball is effective in reducing the AN reading. For the use of 2 mudballs, for a period of one week the AN reading showed a decrease from 2.11 mg/l to 0.4 mg/l. With the use of 3 mudballs, the AN reading also showed a decrease every week from 1.07 mg/l to 0.42 mg/l. Although overall this AN treatment showed a decrease in AN reading, the use of 4 mudballs was the lowest reading obtained on day 28, which was 0.31 mg/l. This indicates that the use of mudballs in wastewater treatment for AN parameter can reduce AN reading.

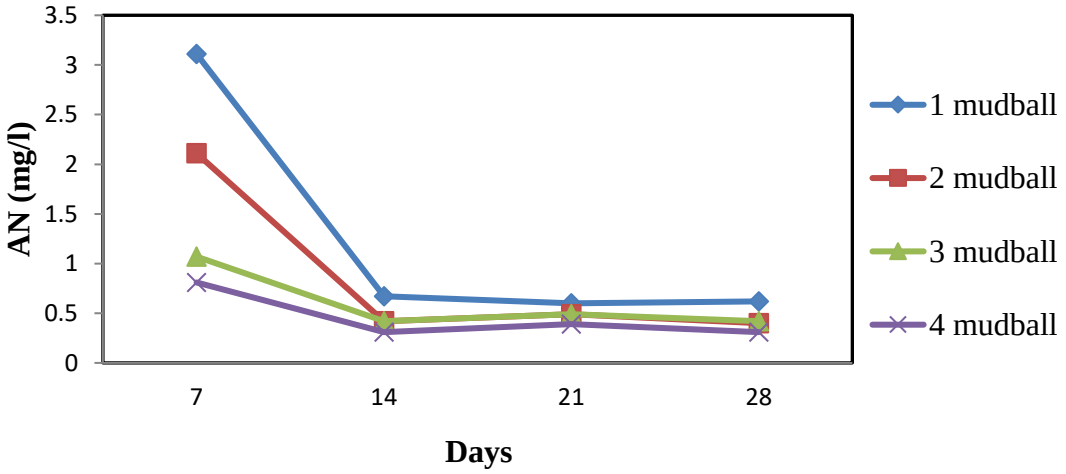

Fig. 6: Graph of ammonia nitrogen values for a period of one month with the use of 1 mudball to 4 mudballs

Based on figure 7, the pH value for a period of one month has been obtained. The use of 1 - 4 mudballs shows that the pH reading obtained is between 7.213 to 7.88. For the use of 1 mudball, the pH value obtained is neutral, namely on the 7th and 14th day is 7.441 and 7.232. While on the 21st and 22nd day, the reading obtained is 7.222 and 7.213. For the use of 2 mudballs, the data obtained on the 7th and 14th day is 7.499 and 7.314. While on the 21st and 28th day the pH

reading is 7.4 and 7.46. This shows that this wastewater is neutral. The pH reading for the use of 3 mudballs on days 7 to 28 shows that this wastewater is slightly alkaline.

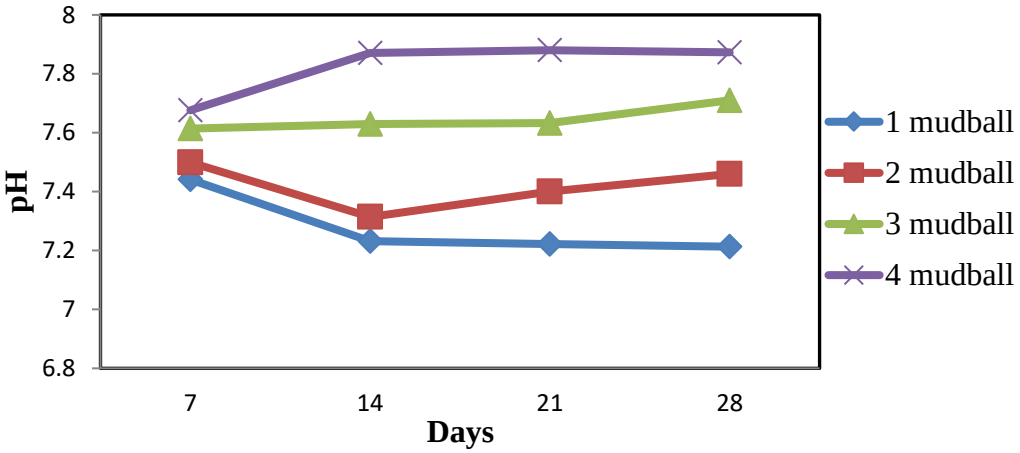

Fig. 7: pH value graph for a period of one month with the use of 1 mudball to 4 mudballs

5 Conlcusion

In this study, the use of different amounts of mudballs for the treatment of sewage wastewater was carried out. The results of the experiments conducted for parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD) and ammonia nitrogen (AN) can determine the removal efficiency during the operation under study. In addition, the values of acidity and alkalinity (pH) and dissolved oxygen (DO) can be increased through this treatment process. Overall, it can be concluded from this study that the use of EM mudballs can be one of the useful methods for the treatment of wastewater effluent.

The experiments conducted provide evidence that:

- EM mudballs can reduce COD, BOD and AN reading to a better level.
- From the analysis obtained, it has been shown that the use of one mudball is sufficient for a week of treatment. The level of removal efficiency with one mudball is suitable for this treatment. The use of many mudballs can accelerate the reduction process in just three days. The removal efficiency on days 4 to 7 for the use of all mudballs in this experiment reaches from 80% to 98%.
- Experiments conducted to study the effectiveness of EM mudballs with differences in retention time in this study obtained the best retention time on day 7 with the use of 4 more effective mudballs. The removal efficiency obtained from the analysis for each parameter reaches up to 97% removal.
- The use of mudballs also acts as a pH neutralizer because the pH obtained for each treatment process has increased slightly from the initial pH.
- The use of mudballs also acts as a helper in increasing DO where the DO reading obtained for each treatment process has increased higher than the initial DO.

In this study, after studying the potential of EM mudball in treating sewage wastewater, it can be used in future waste technology because based on the analysis results, it brings benefits in terms of low cost and effectiveness in treating sewage wastewater. Therefore, it is proposed to conduct further studies for treatment of various other wastewaters is carried out using EM mudball as a treatment material before wastewater is discharged.

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