Efficiency of the *Tubifex sp* in Reduction The Sludge of WWTP in Hospital

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Abstract

The volume of wastewater from the activities of Prof. Dr. Margono Soekarjo Hospital in 2020 reached ± 13,684 - 42,178 liters per month with a BOR of 56.97 - 98.38%. Suspended Solid measurements obtained sludge production in the aeration bath up to 300 mg/l/day. A biological approach is being used to reduce sludge by utilizing aquatic worms. The *Tubifex sp* worm method can reduce sludge biomass by predationing bacteria and organic particles resulting from the decomposition of organic matter by bacteria. This type of research is a experiment with a pre-test - post-test group design with a variation of the worm to sludge ratio was 0.4; 0.6; and 0.8. The measurement of sludge biomass was carried out before processing and after processing the contact time was 5 days, 10 days and 15 days. Measurement of sludge biomass before treatment was 100 grams and after treatment with a ratio of 0.4 was 6 - 76 grams, in treatment with a ratio of 0.6 was 11 - 62 grams, while treatment with a ratio of 0.8 was 19-57 grams. The efficiency value of *Tubifex sp* at a ratio of 0.4 was 24-94%, at a ratio of 0.6 was 38-90% and at a ratio of 0.8 was 43-81% in reducing the sludge biomass of WWTP Prof. Dr. Margono Soekarjo hospital. It is concluded that the use of variations in contact time and ratio in treatment with *Tubifex sp* worms is efficient to reducing sludge biomass with a sig value at a sig 0,000 contact time variation, worm ratio variable value sig 0,000 and a combination of the ratio variable and contact time sig 0,000. The value of Adjusted R Squared 0.945 means that the contact time, worm ratio and the interaction between contact time and worm ratio have an effect on reducing sludge biomass by 94.5%. It is recommended to carry out related further research to the application of this treatment on a field scale.

***Keywords**: WWTP sludge, Sludge Biomass, Tubifex sp, Contact Time*

1. Introduction

Hospitals are health service institutions that provide individual health services in a plenary manner that provides inpatient, outpatient, and emergency services[1]. The activities of the hospital produce waste be it solid waste, liquid waste or gas. Liquid waste containing chemical substances will not be able to be neutralized properly so it is very dangerous for residents around the hospital. [2].

From the negative impacts, hospitals need to conduct environmental health efforts aimed at protecting the public from environmental pollution sourced from liquid waste. So the waste is very detrimental to the environment so it is necessary to do sludge treatment before disposal into the environment.

Sludge processing is carried out both mechanically, physically and chemically. The use of these methods requires large energy, extensive land and the addition of chemicals that will increase processing costs [3]. The cost of investment for sludge processing is about one-third of the total cost of IPAL. So it takes an alternative treatment that can reduce mud at a cheaper cost one of them with a biological approach [4].

A biological approach began to be used to reduce sludge by utilizing aquatic worms. This method is increasingly in demand due to low energy consumption and is able to reduce pollutants [5]. The method underlies the ecological theory of reducing sludge production by expanding the food chain or strengthening microfauna predators in waste treatment systems[4]. Some aquatic worm species of the *Aeolosomatidae, Tubificidae, Naididae and Lumbriculidae* groups are natural predators that have the ability to reduce sludge [6]

The ability of *Lumbriculidae* aquatic worms in reducing sludge has been studied by Hendrickx[7] and shows that the total suspended solid (TSS) reduction rate in worm-containing reactors is three times greater than that of wormless reactors. The addition of aquatic worms in sludge can also decrease chemical oxygen demand (COD), total nitrogen (TN) and total phosphorus (TP) in sludge by 42%, 39% and 12% used by worms as nutrients for the formation of new biomass. [3]

2. Material and Methode

The type of research used is pre experiment research with pre test post test group design. The free variables in this study were the ratio of *Tubifex sp* worms to sludge which is 0.4; 0,6; and 0.8 and contact times of 5 days, 10 days and 15 days. The bound variable in this study is the reduction of waste sludge in the reactor. The control variables in this study were temperature, pH and dissolved oxygen levels in the reactor.

Tubifex Sp worms used in this study have gone through a cleansing process using running water for 24 hours to remove pollutants found in the body of the worm colony used. WWTP sludge used in this study was taken from the remaining sludge of the aeration process of WWTP Prof. Dr. Margono Soekarjo Hospital

The treatment of each variation in the ratio of worms to sludge is carried out as many as four repetitions. By preparing 100 grams of sludge in each experiment so that the entire mud used is 3.9 Kg of sludge. The reactor in this penetrating has a length of 20cm, width of 20cm and height of 20cm and mud compartment with a size of Length 15 cm, width 15cm and height 15cm. the study conducted measurements of sludge biomass before treatment and after treatment. In addition, researchers also performed temperature, pH and dissolved oxygen measurements on the water used in the study.

3. Result and Discussion

a. Sludge Biomass

The expected treatment of sludge using *Tubifex sp* worms is done with three variations of the ratio of worms to sludge which is 0.4; 0,6; and 0.8. The amount of sludge used in each test is 100 grams. Testing was conducted with a variety of contact times of 5 days, 10 days and 15 days. The result of the decrease in sludge biomass is presented in table 1

Table 1. Average Decrease in WWTP sludge biomass by *Tubifex sp*

Ratio	Before (gram)	After 5 Days (gram)	After 10 Days (gram)	After 15 Days (gram)
0,4	100	67,5	26	7,25
0,6	100	49,2	14,7	13,5
0,8	100	40,5	19,7	21,2
Control	100	100	90	90

Based on table 1 average of sludge biomass measurement results at 4 replication times with a ratio of 0.4 i.e. 7.25 – 67.5 grams. The highest test result was 76 grams on the fourth replication 5 days with a difference of 24 grams of biomass before treatment. The lowest yield was 6 grams at a ratio of 0.4 to 15 days with a difference of 94 grams of biomass prior to treatment. The ratio of 0.6 between 13.5 – 49.2 grams. The highest biomass at a ratio of 0.6 replication was the third 5-day contact time with a difference of 38 grams, while the lowest biomass at a ratio of 0.6 replication first contact time was 10 days with a difference of 90 grams from before treatment. At a ratio of 0.8 treatment results with a ratio of 0.8 indicates biomass yields between 21.2 – 40.5 grams. The highest biomass at the ratio of 0.8 replication first contact time 5 days with a difference of 43 grams, while the lowest biomass at the ratio of 0.4 replication second and fourth contact time 10 days with a difference of 81 grams. As well as an increase in biomass at a contact time of 15 days.

Sludge biomass at a ratio of 0.4 fourth replication with a contact time of 5 days obtained high results can be caused by the lag phase (adaptation phase) of *Tubifex sp* worms to adjust to the new environment reaches 15 days so that at a ratio of 0.4 fourth replication with a contact time of 5 days worms are still not able to adapt to the maximum with the available reactor conditions. The decrease in reactor temperature from 28 -23 ^{O}C, pH from 7.5 – 7.3 and Dissolved Oxygen 7.77 – 7.68 mg/l had no effect on the life of *Tubifex sp* worms. it does not affect the life of *Tubifex sp* worms especially at a ratio of 0.4 fourth replication with a contact time of 5 days because it is still within the temperature limit, pH for the best growth of *Tubifex sp* worms as well as dissolved oxygen levels greater than the optimal dissolved oxygen levels for the life of *Tubifex sp* worms.

High sludge biomass at a ratio of 0.6 replication of the three 5-day contact time can be caused by the adaptation phase (lag phase) of *Tubifex sp* worms that have not been running optimally which is 15 days. So the consumption of sludge by worms is still not able to reach the maximum level of consumption. In addition, it can also be caused by feces produced by *Tubifex sp* worms. *Tubifex sp* worm droppings show better precipitating ability compared to real waste sludge [3]. The increase in sludge biomass at a ratio of 0.8 to a contact time of 15 days can be caused by impurities produced by *Tubifex sp* worms as well as death from tubifex sp worms. This is characterized by the appearance of a foul smell in the reactor as well as the change of water to murky and gray. The death of *Tubifex sp* worms can be caused by a lack of food sources in the reactor.

The best growth of Tubifex sp worms is in environments with temperatures between 12-27º C. The pH range in tubifex sp worm habitat ranges from 5.5-8.0 [8]. The spread of tubifex sp worms is determined by oxygen levels. At water oxygen levels of 1.7 mg/l and current speeds of 300 to 600 ml/min, the growth of worm populations is the highest [8].

Tubifex sp worms usually feed on bacteria and organic particles remodeled by bacteria. Then the bacteria needs N-organic and C-organic for its growth. Carbon is used as a source of energy and nitrogen as a source of protein for the development and growth of microogranism. High N-organic values will lead to an increase in the bacterial population in the reactor so that the amount of food availability of *Tubifex sp* worms increases [8].

b. Biomass Reduction Efficiency

The results of the calculation of the efficiency value of the decrease in sludge biomass after treatment with *Tubifex sp* worms are shown in table 2

Table 2 *Tubifex sp* Worm Efficiency in reducing WWTP sludge

Ratio	Efficiency		
	5 Days (%)	10 Days (%)	15 Days (%)
0,4	32,50	74,00	92,75
0,6	50,75	83,75	86,50
0,8	59,50	80,25	78,75
Kontrol	0	10	10

The results of the research on the reduction of sludge biomass in WWTP of Prof. Dr. Margono Soekarjo hospital has been conducted measurements and calculations of efficiency measured from the results of reduction before and after treatment is then divided by the results before treatment and multiplied by 100%. Based on table 2 shows the average efficiency value of *Tubifex sp* worms in lowering the biomass of WWTP Sludge of Prof. Dr. Margono Soekarjo hospital using a ratio of 0.4 at a contact time of 5 days of 32.5%, a 10-day contact time of 92.75% and a 15-day contact time of 92.75%. *Tubifex sp* worm efficiency in reducing the biomass of WWTP sludge in Prof. Dr. Margono Soekarjo Hospital using a ratio of 0.6 on the treatment of 5-day contact time is 50.75%, 10-day contact time is 83.75%, and 15-day contact time is 86.5%. While the efficiency of *Tubifex sp* worms in lowering the biomass of WWTP sludge in Prof. Dr. Margono Soekarjo hospital using a ratio of 0.8 at the contact time of 5 days is 59.5%, the contact time is 10 days which is 80.25% and the contact time is 15 days which is 78.75%.

Tubifex sp worm efficiency in reducing the biomass of WWTP sludge in Prof. Dr. Margono Soekarjo hospital by using three variations of time and three variations of the ratio of worms is quite maximal. This can be seen from the efficiency of the reduction of WWTP sludge biomass in Prof. Dr. Margono Soekarjo hospital reached 32.5 – 92.75%. Experiments on decreasing sludge biomass using *Tubifex sp* worms have high potential to reduce the amount of biomass (up to 75%) [3].

Factors that affect the process of sludge reduction with *Tubifex sp* worms include the ratio of worms to sludge, contact time, sludge biomass, temperature, pH and dissolved oxygen. Of these factors there are the most affecting factors, namely the ratio of worms to sludge, contact time and the combination of the ratio of worms to sludge with contact time. The ratios used in this study were 0.4, 0.6, and o.8. At a ratio of 0.8 the sludge reduction process occurs rapidly, but the production of faeces from *Tubifex sp* worms also takes place faster than other ratios. Other products produced during the sludge reduction process are phases secreted by worms due to metabolic processes. As well as a lack of foodstuffs can trigger death in *Tubifex sp* worms [9].

c. Analysis of the influence of ratio variations, and contact time to mud reduction rates

Table 3 Statistical analysis results of influence of ratio variation, contact time to sludge reduction rate

Variable	F	*P*	Inf
Contact time	72,859	0,000	Sig.
Ratio	111,042	0,000	Sig.
Combination of Ratio and Contact Time	10,029	0,000	Sig.

Statistic analysis is performed to determine whether there is a statistically significant difference between two or more groups of independent variables on dependent variables.

The significance of the effect of the ratio of worms to sludge can be seen in table 3 with a value of $p = 0.000 < 0.05$ (α) then Ho is rejected which means the ratio of worms to sludge can decrease the biomass of sludge meaningfully or in other words there are differences in sludge biomass at different worm ratios. The significance of the effect of contact time on sludge is also equal to the ratio of $p = 0.000$ value, meaning Ho is rejected, meaning there is a difference in contact time with sludge biomass.

The third result was the interaction between the two treatments, namely the ratio of worms to sludge and contact time, judging by the value p = 0.000<0.05, so that Ho was rejected meaning that the interaction of the two independent variables also had an effect on the decrease in sludge biomass.

Statistical analysis using Factorial Anova in Table 3 obtained *adjusted R Squared* value of 0.945 means contact time, worm ratio and interaction between contact time and worm ratio influenced by 94.5% decrease in sludge biomass (0.945x100%), the remaining 5.5% was influenced by other variables. The following factors to be aware of include the ratio of worms to sludge, increased digestion of endogenous sludge as a result of increased sludge age, oxygen concentration or temperature, accumulation of sludge in reactors, carrier materials (in full-scale experiments) and worms (in the case of simple-scale experiments)[5].

Decreased sludge biomass with *Tubifex sp* worms using ratio and contact time provides a slowdown in the occurrence of collisions or intercations between the sludge of WWTP in Prof. Dr. Margono Soekarjo hospital with *Tubifex sp* worms. so that there is a predation process in the IPAL sludge with *Tubifex sp* worms. Determination of contact time in lowering sludge biomass is long enough that the process of reducing sludge biomass by *Tubifex sp* worms is quite maximal. The right contact time and ratio allows the process of predation of sludge biomass by tubifex sp worms to take place better.

4. Conclusion

Based on the results and discussions that have been described about the efficiency of *Tubifex sp* worms in reducing the sludge of WWTP, it can be concluded as follows:

a. The results of sludge production measurement from WWTP of Prof. Dr. Margono Soekarjo Hospital with Suspended Solid (SS) measurement. in 2020 reached 0 – 300 mg/l/day with the volume of sludge used for this study amounting to 100 grams/treatment.
b. The measurement of WWTP Sludge biomass of Prof. Dr. Margono Soekarjo Hospital after processing with *Tubifex sp* ratio of 0.4 contact time of 5 days, 10 days and 15 days is 64 - 76 grams, 20 - 31 grams, and 6 - 8 grams. Processing with *Tubifex sp* ratio of 0.6 contact time 5 days, 10 days and 15 days is 40 – 62 grams, 10 – 19 grams and 11 – 17 grams. While processing with *Tubifex sp* ratio of 0.8 contact time 5 days, 10 days and 15 days is 31 - 57 grams, 19 - 21 grams and 20 - 23 grams.
c. The results of Anova Factorial analysis on the contact time variable show a sig value of 0.000 < 0.05; variable ratio indicates a sig value of 0.000 < 0.05 and a combination of variable ratio and contact time indicates a sig value of 0.000 < 0.05. Anova Factorial test results with a sig value of < 0.05 mean there is an influence between variable ratio, variable contact time as well as a combination of variable ratio and contact time to decreased sludge biomass. Also obtained adjusted R Squared = 0.945 means contact time, worm ratio and interaction between contact time and worm ratio effect on the decrease of mud biomass by 94.5%.
d. *Tubifex sp* efficiency to reduce waste sludge biomass in WWTP of Prof. Dr. Margono Soekarjo Hospital, the lowest efficiency average yield is 32.5% with a ratio of 0.4 at the contact time of 5 days. While the highest average efficiency result is 92.75% with a ratio of 0.4 at 15 days contact time.

5. Acknowlegdement

a. Further research is needed on the development of *Tubifex sp* worms during the reduction process. It aims to monitor the breeding of worms during the treatment process.
b. Further research is needed on the process of stool production by *Tubifex sp* during the treatment period. It aims to know exactly the reduction of sludge carried out by *Tubifex sp* without the addition of sludge biomass from worm faeces.
c. Further research is needed related to the application of this treatment on a field scale.

6. References

1. Indonesia KKR. PERMENKES REPUBLIK INDONESIA NOMOR 3 TAHUN 2020 TENTANG KLASIFIKASI DAN PERIZINAN RUMAH SAKIT. 2020;(3):1–80.
2. Subekti S. Pengaruh Dan Dampak Limbah Cair Rumah Sakit Terhadap Kesehatan Serta Lingkungan. J Univ Pandanaran [Internet]. 2011;1–6. Available from: http://jurnal.unpand.ac.id/index.php/dinsain/article/download/139/136
3. Hendrickx TLG. Aquatic worm reactor

for improved sludge processing and resource recovery. 2009.
4. Vebriane W, Moesriati A, Purnomo A. KONSENTRASI NITROGEN DAN FOSFOR DALAM PROSES REDUKSI LUMPUR LIMBAH EFFECT OF AQUATIC WORM ON NITROGEN AND PHOSPHORUS CONCENTRATION DURING WASTE SLUDGE REDUCTION PROCESS. 2014;
5. Basim Y, Farzadkia M, Jaafarzadeh N, Hendrickx T. ENVIRONMENTAL HEALTH Sludge reduction by lumbriculus variegatus in Ahvas wastewater treatment plant. 2012;1–5.
6. Buys BR, Klapwijk A, Elissen H RW. Development of a test method to assess the sludge reduction potential of aquatic organisms in activated sludge. Bioresour Technol; 2008.
7. Elissen HJH, Mulder WJ, Hendrickx TLG, Elbersen HW, Beelen B, Temmink H, et al. Bioresource Technology Aquatic worms grown on biosolids : Biomass composition and potential applications. 2010;101:804–11.
8. Astutik W. PERBEDAAN MEDIA KOTORAN AYAM, KOTORAN SAPI, AMPAS TAHU, DAN LIMBAH MEDIA JAMUR TIRAM TERHADAP PERTUMBUHAN CACING SUTRA (Tubifex tubifex L.) DAN PEMANFAATANNYA SEBAGAI BUKU ILMIAH POPULER. Fak Kegur dan Ilmu Pendidik Univ Jember. 2016;
9. Rahman R, Moesriati A, Arief J, Hakim R. PERBANDINGAN TINGKAT REDUKSI LUMPUR LIMBAH DENGAN MENGGUNAKAN CACING AKUATIK Tubifex sp. DAN Lumbriculus sp. 2012;(2012).