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# DOMESTIC WASTEWATER TREATMENT USING VERMIFILTER COMBINED WITH *CANNA INDICA*

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## ABSTRACT

Untreated domestic wastewater can pollute the aquatic ecosystem. Vermifilter integrated with the *Canna indica* plant is one of the technological alternatives that can be used to treat domestic wastewater. One of affecting the performance of vermifilters is the vermibed media. **Aim:** This study aims to examine the effect of vermibed material on the concentration of COD, TP, DO, and the pH value of domestic wastewater treated with vermifilter combined with *Canna indica* plants. **Methodology and Results:** The research was conducted on a laboratory scale with a continuous system using a plastic reactor dimension of 59 x 38 x 29 cm, which is filled with sand filter media, coconut fiber, gravel, and vermibed. The vermibed reactor consists of 4 reactors including reactor 1 (R1) vegetable vermibed, reactor 2 (R2) sawdust, reactor 3 (R3) banana peel, and reactor 4 (R4) cow dung. The results showed that at the end of the research, the best performance is showed by reactor R2 that able to decrease COD 94.81%, TP 92.07%, DO increase 320.00%, pH 6.30±0.10. Vermibed sawdust (R2) can lower COD, TP and raise DO higher to treat domestic wastewater by combining vermifilter with *Canna indica* plant. **Conclusion, significance, and impact study:** Vermifilter with *Canna indica* plant is an effective wastewater treatment in reducing COD, TP, increasing DO and pH value. This treatment is easy processing of operation and maintenance, does not require large land, can be done on an individual scale, and is environmentally friendly.

## MANUSCRIPT HISTORY

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## KEYWORDS

- *Canna indica*
- Vermifilter
- Vermibed

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## 1. INTRODUCTION

The majority of domestic waste is discharged directly into sewers without treatment, so it is feared that it can cause pollution of rivers, lakes, and other surface waters (Va *et al.,* 2018). Domestic waste includes organic substances, pathogenic bacteria, heavy metals, nitrogen, and phosphorus. Untreated domestic waste can pollute the aquatic ecosystem (Hamad, 2020; Nurhayati *et al.,* 2019). Office building wastewater in one city contains Chemical Oxygen Demand (COD) 106 mg/L - 432 mg/L, Dissolved Oxygen (DO) 3.2 mg/L, and Total phosphate (TP) 3.66 mg/L (Va et al., 2018). Domestic waste treatment should use easy processing of operation and maintenance, does not require large land, can be done on an individual scale, and is environmentally friendly (Adugna *et al.,* 2019; Samal *et al.,* 2018b).

One alternative to treat domestic waste is to use vermifilters combined with aquatic plants. This technology is cost-efficient, and does not cause odors (Lourenço & Nunes, 2017), does not form sludge, is sustainable, is more efficient in degrading chemical and biological contaminants. (Samal *et al.,* 2017b). Vermifilter produces vermicompost, useful as agricultural compost, and worm biomass as animal feed and fish (Bhat *et al.,* 2020)

Vermifilter is a technology that combines the activity of earthworms and microbial to decompose waste (Kumar & Ghosh, 2019; Rustum *et al.,* 2020). Earthworms encourage an increasing number of microbes in the vermifilter reactor (Samal *et al.,* 2017) that will decompose organic substances, solids, heavy metals by eating, absorbed through the skin of walls, and decomposed by worms (Patil & Munavalli, 2018; Singh *et al.,* 2019). The incorporation of vermifilter with aquatic plants can increase the degrading of organic substances. Plants' roots can be overgrown with microbes (Samal *et al.,* 2018a).

In recent years, many studies on wastewater treatment using vermifilter combined with plants, including the treatment of liquid waste milk industry with vermifilter plant *Canna indica* with Hydraulic Loading Rate (HRL) 0.3 $md^{-1}$ can reduce $BOD_5$ 90.34% and COD 85.59 while in HRL 0.6 $md^{-1}$and BOD 85.75% and COD 79.64% (Samal *et al.,* 2018b). Treatment of Cattle farm wastewater with vermifillter and plants can reduce COD 68.3% - 78.1%; Total Nitrogen (TN) 39.1% - 44.0%; Total Phosphate (TP) 51.1-58.3% (Singh *et al.,* 2021). The milk waste treatment using a combination of vermifilter and *Canna indica* plants can decrease COD 83.2%, TN 57.3% (Samal *et al.,* 2018a).

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Worm density, Hydraulic Retention Time (HRT), Hydraulic Loading Rate (HLR), worm growth media (vermibed), type of flow, and levels of treated wastewater pollutants affect the performance of vermifilter (Singh *et al.,* 2018). Vermibed is at the very top layer of the vermifilter. Media growing worms often use wood powder, bark, peat, straw (Lourenço & Nunes, 2017), garden soil, cow dung (Rustum *et al.,* 2020), vermicompost (Samal *et al.,* 2018b), sawdust (Adugna *et al.,* 2019), Filter media often use gravel and sand (Koslengar *et al.*, 2020). The filter media serves as an adsorbent, where bacterial colonies and filtration media grow. Vermibed serves as the food of earthworms and microbes, so it grows and develops well, as well as a place of growth of aquatic plants (Singh *et al.,* 2019).

There have been many studies that discuss the performance of vermifilter, among others about HLR (Samal *et al.,* 2018b), HRT (Rustum *et al.,* 2020), the combination of vermifilter with aquatic plants (Samal *et al.,* 2018a). There is little research on the effect of worm growing media (vermibed) on the performance of vermifilter combined with the *Canna indica* plants. This study aims to compare four (4) vermibed materials (cow dung, banana midrib, vegetables, and sawdust) to decrease COD, Total phosphate (TP), pH value, and Dissolved Oxygen (DO) in domestic sewage treatment using vermifilter combined with *Canna indica* plants.

## 2. RESEARCH METHODOLOGY

### 2.1 Domestic Wastewater and Vermibed Material

The wastewater used is wastewater from the drainage of Karangrejo Sawah Wonokromo District Surabaya City, of East Java, Indonesia. The research was conducted in the dry season so that domestic waste is not mixed with rainwater runoff. The worm used was the earthworm *Lumbricus rubellus (L. rubellus)*. Vermibed vegetables using a mixture of mustard and cabbage (50%; 50%). Vermibed sawdust comes from teak wood. Vermibed banana peel from banana *Musa paradisiaca* L. Vermibed cow dung comes from beef cow dung. Vermibed material mixed with garden soil in a ratio of 1:3. The filter media used is gravel (⌀ ±3 cm), quartz sand (⌀ ±0.5 cm), coconut fiber. The height of each filter media is 5 cm. the average porosity of gravel, sand and coconut fiber is 64.67%. All vermifilter ingredients come from the area around Surabaya.

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## 2.2 Vermifilter Reactor Design

The study was conducted with a completely randomized design on four variations with three repetitions on a laboratory scale. The vermifilter reactor use plastic boxes with dimensions of 59 x 38 x 29 cm. Fill the media into each reactor in order from bottom to top, namely gravel (⌀ ± 3 cm, height 5 cm), quartz sand (⌀ ± 0.5 cm, height 5 cm), coconut fiber (5 cm high), and vermibed (10 cm high). Reactor 1 (R1) contains vegetable vermibed, R2 sawdust, R3 banana peel, and R4 cow dung. Spreading *L.rubellus* worm 4-6 cm long as many as thirty (30) tails and *Canna indica* plants is ±20 cm as many as six pieces into each vermibed. Figure 1 shows the vermifilter reactor.

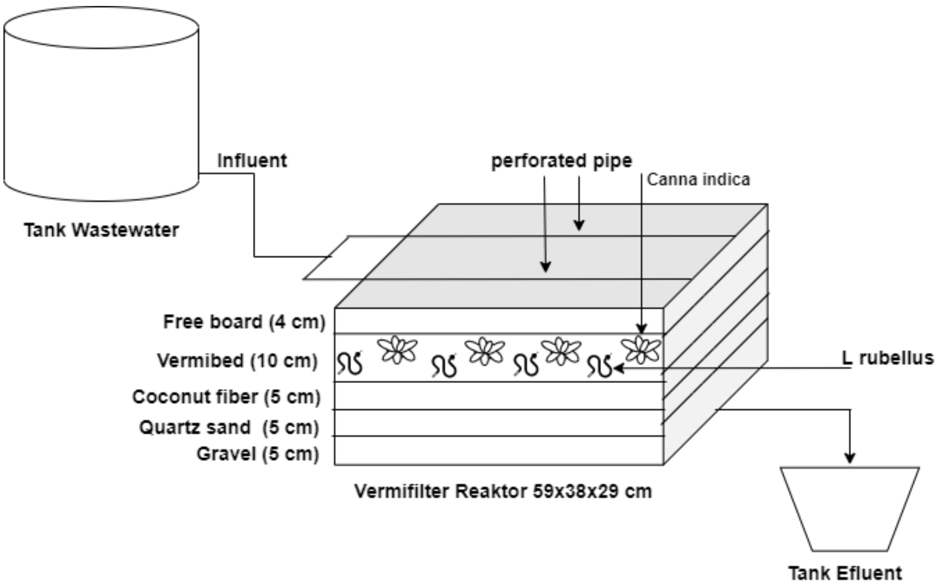


**Figure 1** Vermifilter reactor

Before being used as a vermibed, cow dung is dried for seven days to remove ammonia. Ammonia content in cow dung can cause poisoning (Anggada *et al.,* 2019). Soak the sawdust for 24 hours to remove sap and dirt. Cut the banana peel to a size of 1-2 cm to ferment for three weeks. Blending Mustard vegetable waste and cabbage into porridge, fermented for seven days (Nurdiansyah *et al.,* 2018). Mixing vermibed material with garden soil in a ratio of 1: 3 (Samal *et al.,* 2018b). Clean the filtration media of the dirt by washing using clean water and drying using sunlight.

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The processing seeding and acclimatization of filtration media in batch by using domestic wastewater for seven days until it forms a layer of biofilm and reaches stable condition (Rahmadyanti *et al.,* 2020; Singh *et al.,* 2021). Acclimatization test of worms and *Canna indica* plants simultaneously for each reactor by spreading 30 worms and six plants for three days. Continuously flow domestic wastewater to the vermibed and maintain humidity between 42-60%. During acclimatization, worms get food from vermibed material and domestic wastewater. Acclimatization is successful if the plant grows buds. The worms remain in the growing media, did not come out of the vermibed, and did not swarm (Nurdiansyah *et al.,* 2018)

## 2.3 Vermfilter Operation

Drain wastewater from the reservoir to each reactor using perforated PVC pipes. Wastewater drips evenly to the vermibed surface. Flowing wastewater continuously with a discharge of 0.133 ml/second. The wastewater will be decomposed by worms, passing through the filter media out through the effluent pipe. During the study maintained Hydraulic Retention Time (HRT) for ±3 days, and Hydraulic Loading Rate (HLR) BOD5 0.099 kg BOD5 m-3 day-1. Analysis of COD, TP, temperature, pH, and DO on days 0, 3, 6, 9, 12, 15. COD analysis method SNI 6989.2:2009, TP SNI 06.6989.31:2005, DO SNI 06-6989.14-2004, pH SNI 6989.11:2019. The data is expressed in the mean ± standard deviation.

## 3. RESULT AND DISCUSSION

The provided Table 1 depicts the performance of the vermifilter on COD, TP, DO, and pH during the study. The initial waste for COD and pH parameters has not met the quality standard, referring to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68 of 2016, concerning Domestic Waste Quality Standards. The disposal of wastewater into rivers without being treated is harmful to the health of living things, damages aquatic life, causes a foul odor, and damages aesthetics (Nurhayati *et al.,* 2019). After 15 days treatment the concentrations of COD and TP in the domestic wastewater were through fall in furthermore, the concentration of DO and pH was through increased. The COD concentration and pH of all reactors have met the quality standards.

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**Table 1** Characteristics of domestic wastewater

| Parameter | Unit | Quality Standards* | Influent | Effluent | | | |
|---|---|---|---|---|---|---|---|
| | | | | R1 (Vegetable) | R2 (Sawdust) | R3 (Banana peel) | R4 (Cow dung) |
| COD | mg/L | 100 | 590.67±1.15 | 47.33±2.31 | 30.67±3.06 | 38.67±4.16 | 49.33±1.15 |
| TP | mg/L | - | 11.56±0.058 | 1.51±0.01 | 0.92±0.01 | 1.95±0.09 | 1.56±0.06 |
| DO | mg/L | - | 2.17±0.06 | 8.60±0.17 | 9.10±0.36 | 8.80±0.00 | 7.93±0.12 |
| pH | - | 6-9 | 4.31±0.01 | 6.5±0.10 | 6.3±0.01 | 6.06±0.11 | 6.31±0.03 |

**Referring to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68 of 2016 Concerning Domestic Waste Quality Standards)*

## 3.1 COD Concentration

Table 2 shows the COD concentration during the study. The removal of COD concentration occurs due to the symbiotic process of earthworms with bacteria and plants in decomposing organic substances (Samal *et al.,* 2017b, 2018b). Earthworms in vermibed will eat, absorb through the skin, digest and excrete organic substances in wastewater (Singh *et al.,* 2019). Organic complex substances are degraded into simpler organic substances so that microbes are easy to decompose (Samal *et al.,* 2017b; Singh *et al.,* 2021). Mucus from the worm's body increases the number of aerobic microbes in the reactor (Singh *et al.,* 2019). The movement of the worms in the vermibed will burrowing and tunnels, making it easier for oxygen to enter the vermibed. This condition is very favorable so that aerobic conditions are maintained, and microbes in the filter media can grow well and degrade optimally (Samal *et al.,* 2018b). Earthworms and aerobic microbes degrade organic substances in the wastewater. Plants cause vermibed to be protected from direct sunlight, plant roots will form pores, making it easier for oxygen to enter the media, avoiding blockages, and as a place for microbes to live (Samal *et al.,* 2017b). Plant roots can add oxygen through the process of convection and diffusion (Samal *et al.,* 2017a).

The results of this study are higher than research studies on wastewater treatment of the dairy industry with a vermifilter and *Canna indica* plants with an HRL of 0.3 $md^{-1}$, which can reduce COD 85.59% (Samal *et al.,* 2018b). wastewater treatment of Cattle farms with vermifilter and plants can reduce COD 68.3% - 78.1% (Singh *et al.,* 2021).

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**Table 2** Removal COD concentrations

| Day | COD Concentrations (mg/L) | | | |
|---|---|---|---|---|
| | R1/Vegetable | R2/Sawdust | R3/Banana peel | R4/ Cow dung |
| 0 | 590.67±1.15 | 590.67±1.15 | 590.67±1.15 | 590.67±1.15 |
| 3 | 201.33±2.31 | 219.33±1.15 | 273.33±4.16 | 320.67±1.15 |
| 6 | 188.00±3.46 | 141.33±6.11 | 195.33±5.03 | 153.33±5.77 |
| 9 | 128.67±8.08 | 109.33±1.15 | 94.67±8.08 | 101.33±2.31 |
| 12 | 53.33±7.02 | 50.67±1.15 | 62.67±5.77 | 64.67±5.03 |
| 15 | 47.33±2.31 | 30.67±3.06 | 38.67±4.16 | 49.33±1.15 |

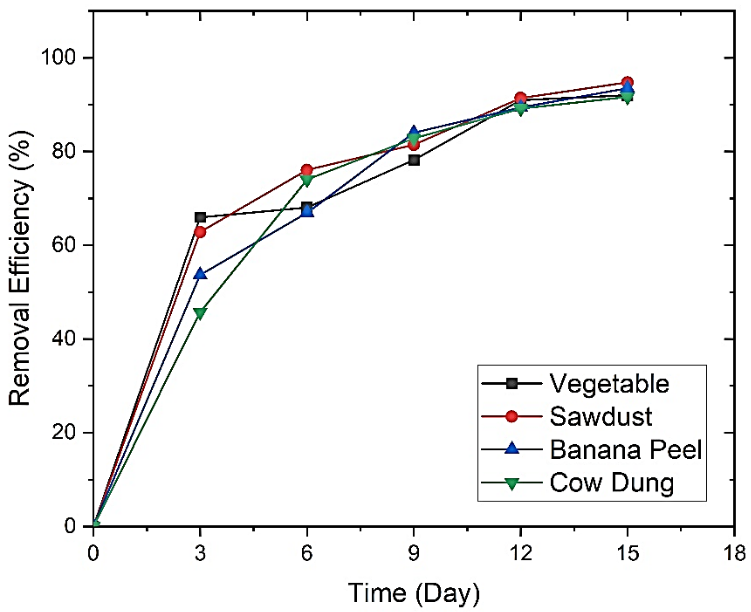


**Figure 2** Removal COD concentration

Figure 2 shows that the removal COD from the 3rd to 15th day increased. The high removal of COD occurs due to the increasing number of microbes that are symbiotic with worms and *Canna indica* roots (Singh *et al.,* 2021). On the 15th day, all reactors can reduce COD, R1 91.99%; R2 94.81%; R3 93.45%, and R4 91.65%. COD concentration at the end of the reactor R1 47.33±2.31 mg/L; R2 30.67±3.06 mg/L; R3 38.67±4.16 mg/L and R4 49.33±1.15 mg/L. On the 15th day of COD decrease in all reactors was > 91%, COD concentration was < 100 mg/L and met the quality standard. The highest COD reduction was in reactor R2, with an efficiency of 94.81%

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reduction in R2 and a COD concentration of 30.67±3.06 mg/L.

## 3.2 DO Concentration

DO is the main factor in vermifilter, DO also helps in oxidizing degradable compounds (Samal *et al.,* 2017a; Singh *et al.,* 2021). Table 3 shows that all reactor concentration of DO from the 3rd to 15th day has increased. The increase in DO occurs due to the decrease in COD during the vermifiltration process. Increased DO due to organic matter decomposed by earthworms and microbes. Earthworms and microbes require to DO in degrading organic matter, so the smaller the organic matter, the smaller the DO required (Manyuchi *et al.,* 2019). The high DO is also due to the movement of worms in digging and making tunnels in the vermibed. The tunnel functions as a capillary and allows oxygen to enter the vermibed. Earthworms and microbes utilize dissolved oxygen to degrade pollutants. Degradation of organic matter due to the symbiosis of earthworms with microbes and *Canna indica* (Singh *et al.,* 2019).

On the 15th day, the DO concentration in reactor R1 was 8.63±0.17; R2 9.10±0.36; R3 8.80±0.00; R4 7.93±0.12. Figure 3 shows that DO increase in reactor R1 296.92%; R2 320.00%; R3 306.15%, R4 266.15%. The highest increase in DO occurred in reactor R2 with vermibed sawdust. An increase of 320.00% and a final DO concentration of 9.10±0.36 mg/L. Coarse fibrous sawdust has a high porosity so that the aeration process occurs well. Vermibed with high porosity will increase worm activity. Worms will eat and excrete organic substances into smooth substances (Singh *et al.,* 2019). This research is almost the same as research on wastewater treatment of pigs with a vermiiflter that can increase DO> 345.5% (Manyuchi *et al.,* 2019).

**Table 3** DO Concentrations

| Day | DO Concentrations (mg/L) | | | |
|---|---|---|---|---|
| | R1/Vegetable | R2/Sawdust | R3/Banana peel | R4/ Cow dung |
| 0 | 2.17±0.06 | 2.17±0.06 | 2.17±0.06 | 2.17±0.06 |
| 3 | 2.67±0.15 | 3.13±0.12 | 3.27±0.23 | 3.75±0.12 |
| 6 | 3.23±0.06 | 3.47±0.06 | 3.93±0.06 | 4.23±0.25 |
| 9 | 5.33±0.15 | 7.43±0.12 | 5.70±0.00 | 5.43±0.12 |
| 12 | 7.87±0.23 | 8.27±0.25 | 7.60±0.00 | 7.73±0.25 |
| 15 | 8.60±0.17 | 9.10±0.36 | 8.80±0.00 | 7.93±0.12 |

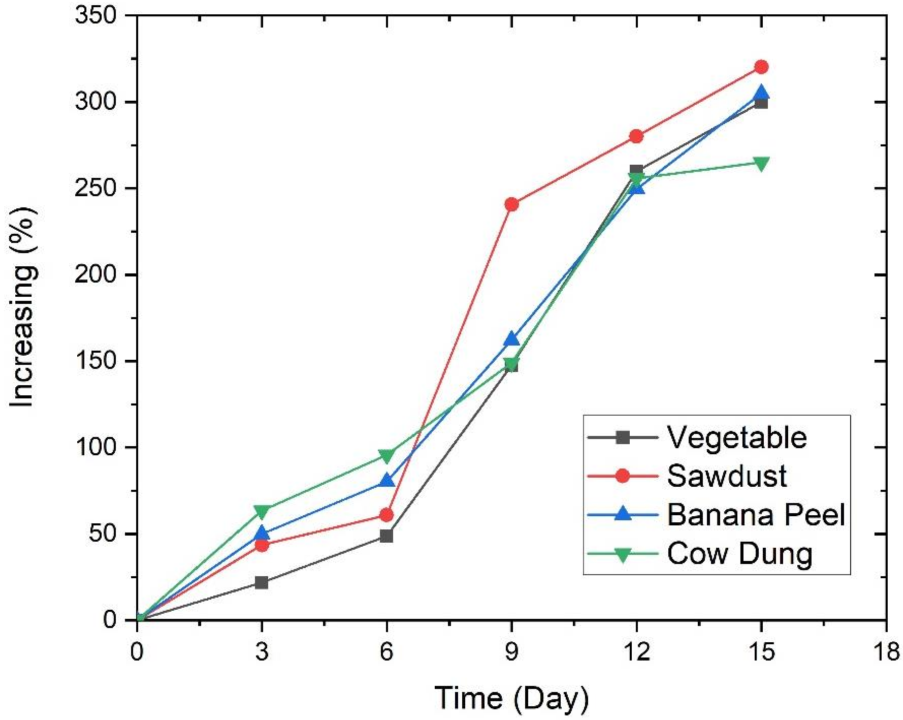


**Figure 3** DO increasing

## 3.3 Total Phosphate (TP) Concentration

Table 4 shows the concentration of TP decreased from the 3rd to 15th day. The concentration of TP on the 15th day in reactor R1 was 1.51±0.01; R2 0.91±0.01; R3 1.95±0.09; R4 1.56±0.06. Figure 4 shows the removal TP. On the 15th day, the R1 reactor can reduce TP by 86.95%; R2 92.07%; R3 83.14%; R4 86.46%. The removal in TP on the 15th day in the four reactors was between 83-92%. The removal TP is not as large as the decrease in COD because the activity of worms and microbes also causes phosphate mineralization so that the phosphate concentration increases (Samal *et al.,* 2017b).

TP removal occurs due to physical, chemical, and biological processes, adsorption, desorption in the filter media, precipitation from phosphorus complex reactions, mineralization, fragmentation, and absorption of plants in the vermifilter (Khan *et al.,* 2020; Samal *et al.,* 2017a; Vera-Puerto *et al.,* 2020). Earthworms and heterotrophic microbes degrade organic phosphorus to phosphate (Nurhayati *et al.,* 2019; Singh *et al.,* 2021). *Canna indica* plants will absorb Phosphorus as one of the nutrients needed for their growth (Wimbaningrum *et al.,* 2020).

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**Table 4** Total phosphate concentrations

| Day | Total Phosphate Concentrations (mg/L) | | | |
|---|---|---|---|---|
| | R1/Vegetable | R2/Sawdust | R3/Banana peel | R4/ Cow dung |
| 0 | 11.57±0.06 | 11.57±0.06 | 11.57±0.06 | 11.57±0.06 |
| 3 | 2.26±0.03 | 2.11±0.05 | 3.69±0.02 | 3.04±0.05 |
| 6 | 2.12±0.10 | 1.5780.02 | 3.40±0.01 | 2.38±0.03 |
| 9 | 1.78±0.12 | 1.24±0.04 | 2.70±0.02 | 2.56±0.07 |
| 12 | 1.46±0.01 | 0.94±0.01 | 2.57±0.04 | 2.35±0.05 |
| 15 | 1.51±0.01 | 0.92±0.01 | 1.95±0.09 | 1.56±0.06 |

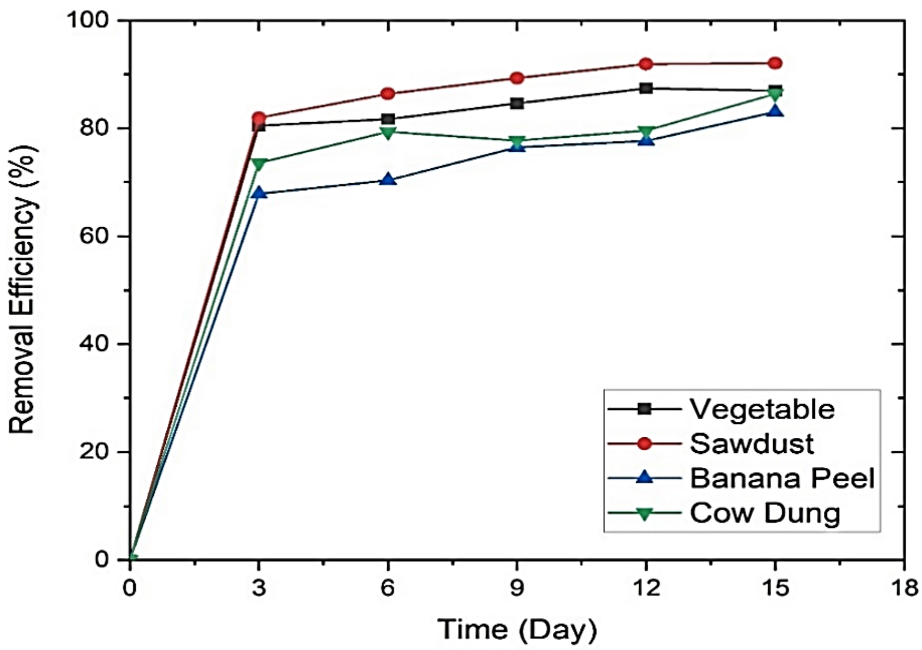


**Figure 4** Removal total phosphate

## 3.4 Degree of Acidity (pH)

The early wastewater pH affects the survival of bacteria and earthworms, which will degrade organic substances (Singh *et al.,* 2019). The optimal pH for worm growth is 6.2-9.7 (Adugna *et al.,* 2019). PH wastewater before treatment 4.31±0.01. At the beginning of the study, the pH was below the optimal pH of worm growth, the worms were able to neutralize it by releasing calcium (Singh *et al.,* 2019).

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Table 5 shows the 3rd to 9th day the pH of the wastewater increased. On the 9th to 15th day, the pH is stable, neutral, is between 6.10-6.50. The pH conditions are suitable for the living conditions of the worms. The increase in pH occurs because the vermifilter degrades nitrogen in the waste into ammonia. The addition of ammonia will increase the pH (Singh *et al.,* 2019).

This research is almost the same as the treatment of waste distillation with a vermifilter can increase the pH from 4.0 to 7.02 (Kannadasan *et al.,* 2019). Domestic waste treatment with vermifilter raises the pH from 6.5 to 8.6 (Adugna *et al.,* 2019). Treatment of domestic waste with a vermifilter, the pH value increases to neutral pH (Ghasemi *et al.,* 2020).

**Table 5** pH Value in reactor treatment domestic waste

| Day | Total Phosphate Concentrations (mg/L) | | | |
|---|---|---|---|---|
| | R1/Vegetable | R2/Sawdust | R3/Banana peel | R4/ Cow dung |
| 0 | 11.56±0.06 | 11.56±0.06 | 11.56±0.06 | 11.56±0.06 |
| 3 | 2.28±0.04 | 2.10±0.04 | 3.70±0.20 | 3.04±0.06 |
| 6 | 2.12±0.10 | 1.57±0.01 | 3.41±0.01 | 2.37±0.70 |
| 9 | 1.78±0.11 | 1.24±0.04 | 2.7±0.20 | 2.56±0.05 |
| 12 | 1.46±0.01 | 0.94±0.01 | 2.57±0.04 | 2.75±0.06 |
| 15 | 1.51±0.01 | 0.91±0.01 | 1.95±0.09 | 1.57±0.06 |

## 3.5 Effect of Vermibed on COD, DO, TP and pH

Vermibed serves as food for worms and microbes, so it grows well (Samal *et al.,* 2018b). The organic matter contained in vermibed becomes a food source for worms and microbes (Singh *et al.,* 2018). The combination of vermiiflter with *Canna indica* plants can use vermibed from a mixture of mustard and cabbage vegetables, sawdust, banana peel, cow dung. Cow dung contains high levels of nitrogen and organic substances so that earthworms like it (Dani *et al.,* 2017). Cabbage contains 1.5% protein and 65-80% water content (Rusad & Santosa, 2016). Mustard greens contain high fiber, water, carbohydrates, fat, and protein. Worms like these two vegetables because they are odorless (Nirigi *et al.,* 2019; Sitompul *et al.,* 2017). Sawdust contains coarse fibers so that the vermibed is well aerated. Teak sawdust contains 60% cellulose, 28% lignin, and 12% other substances (Mufti *et al.,* 2021). Judging from the efficiency of decreasing COD, TP and increasing DO, the best reactor R2 is vermibed from teak sawdust.

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## 4. CONCLUSION

The results of this study are higher than research studies on wastewater treatment of the dairy industry with a vermifilter and *Canna indica*. Vermifilter with *Canna indica* plant is effective in reducing COD, TP, increasing DO and pH value. At the end of the research, the best performance is showed by reactor R2 that able decrease COD 94.81%, TP 92.07%, DO increase 320.00%, pH 6.30±0.10. Vermibed sawdust (R2) is able to decrease COD, TP and raise DO higher to treat domestic wastewater by combining vermifilter with *Canna indica* plant.

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## REFERENCES

Adugna, A. T., Andrianisa, H. A., Konate, Y., & Maiga, A. H. 2019. Fate of Filter Materials and Microbial Communities during Vermifiltration Process. *Journal of Environmental Management*. 242(February): 98-105. https://doi.org/10.1016/j.jenvman.2019.04.076.

Anggada, R. D., Sucahyo, & Hastuti, P. 2019. Earthworms (Lumbricus rubellus) Growth and Compost Compositions in Media Enriched with Food Waste and Tofu Industrial Waste. *Buletin Anatomi dan Fisiologi*. 4(2): 182-191.

B, P. J. 2018. Wastewater Treatment by Vermifiltration : A Review. *International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)*. VII(I): 186-190.

Bhat, S., Vig, A., Li, F., & Ravindran, B. 2020. *Earthworm Assited Remediation of Effluents and Wastes* (Issue July). Springer Singapore. https://doi.org/https://doi.org/10.1007/978-981-15-4522-1.

Dani, I. R., Jarmuji, J., Pratama, A. W. N., & Nugraha, D. A. 2017. Collaboration of Cow Feses and Sheed as Media on Response Earthworm's (Pheretima, sp). *Jurnal Sain Peternakan Indonesia.* 12(3): 308-316. https://doi.org/10.31186/jspi.id.12.3.308-316.

Ghasemi, S., Mirzaie, M., Hasan-Zadeh, A., Ashrafnejad, M., Hashemian, S. J., & Shahnemati, S. R. 2020. Design, Operation, Performance Evaluation and Mathematical Optimization of a Vermifiltration Pilot Plan for Domestic Wastewater Treatment. *Journal of Environmental Chemical Engineering*. 8(1): 103587. https://doi.org/10.1016/j.jece.2019.103587.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 3, page 281-295, October 2022
*Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023*

Hamad, M. T. M. H. 2020. Comparative Study on the Performance of Typha Latifolia and Cyperus Papyrus on the Removal of Heavy Metals and Enteric Bacteria from Wastewater by Surface Constructed Wetlands. *Chemosphere*. 260: 127551. https://doi.org/10.1016/j.chemosphere.2020.127551.

Kannadasan, N., Dharshini, Eabinezer, S., Natarajan, N., Krishnamoorthy, R., & Sri Sakthi Priyadarshini, R. 2019. Potential of Distillery Effluents for Safe Water Through Vermifiltration. *Journal of Applied and Natural Science*. 11(4): 768-777. https://doi.org/10.31018/jans.v11i4.2112.

Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68 of 2016 concerning Domestic Waste Quality Standards. http://neo.kemenperin.go.id/files/hukum/19 Permen LHK th 2016 No. P.63 Baku Mutu Air Limbah Domestik.pdf

Khan, N. A., El Morabet, R., Khan, R. A., Ahmed, S., Dhingra, A., Alsubih, M., & Khan, A. R. 2020. Horizontal sub Surface Flow Constructed Wetlands Coupled with Tubesettler for Hospital Wastewater Treatment. *Journal of Environmental Management.* 267(May): 110627. https://doi.org/10.1016/j.jenvman.2020.110627.

Koslengar, M., Konate, Y., & Karambiri, H. 2020. Blackwater Processing via Vermifiltration: Worm-based Toilet (Wormlet) in the Arid Context of Burkina Faso. *African Journal of Science, Technology, Innovation and Development*. 12(3): 273-286. https://doi.org/10.1080/20421338.2020.1755105.

Kumar, C., & Ghosh, A. K. 2019. Fabrication of a Vermifiltration Unit for Wastewater Recycling and Performance of Vermifiltered Water (Vermiaqua) on Onion (Allium Cepa). *International Journal of Recycling of Organic Waste in Agriculture*. 8(4):405-415. https://doi.org/10.1007/s40093-019-0247-9.

Lourenço, N., & Nunes, L. M. 2017. Is Filter Packing Important in a Small-Scale Vermifiltration Process of Urban Wastewater? *International Journal of Environmental Science and Technology*. 14(11): 2411-2422. https://doi.org/10.1007/s13762-017-1323-1.

Manyuchi, M. M., Mupoperi, N., Mbohwa, C., & Muzenda, E. 2019. Treatment of Wastewater using Vermifiltration Technology. In *Water Conservation, Recycling and Reuse: Issues and Challenges.* pp. 215-230. https://doi.org/10.1007/978-981-13-3179-4_12.

Mufti, Aulia Anas, Harliyanti, P., & Lisafitri, Y. 2021. The Effectiveness of Earthworms, Cow Dung and EM4 on Teak Sawdust Composting. *Jurnal SEOI.* 3(1): 1-11.

Nirigi, E., Sucahyo, S., & Oktulseja, J. La. 2019. Effects of Adding Probiotics on Worm Growth and Quality of Compost Produced. *BIOEDUSAINS: Jurnal Pendidikan Biologi dan Sains*. 2(2): 179-187. https://doi.org/10.31539/bioedusains.v2i2.532.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 3, page 281-295, October 2022
*Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023*

Nurdiansyah, I., Bahrie, B., & Banu, L. S. 2018. The Influence of the Composition of Maintenance Media to Cocoon Productivity and Hatching of the Eartworm Eggs (Lumbricus Rubellus). *Jurnal Ilmiah Respati Pertanian*. 12(1): 763-769.

Nurhayati, I., Ratnawati, R., & Sugito. 2019. Effects of Potassium and Carbon Addition on Bacterial Algae Bioremediation of Boezem Water. *Environmental Engineering Research*. 24(3): 495-500. https://doi.org/10.4491/EER.2018.270.

Patil, Y. M., & Munavalli, G. R. 2018. Greywater Treatment by Vermifilter: A Low-Cost Option for Rural Sanitation in India. *International Journal of Recent Trends in Science and Technology.* 26(2): 21-29. https://doi.org/https://doi.org/10.26611/202622.

Rahmadyanti, E., Wiyono, A., & Firmansyah, G. A. 2020. Integrated System of Biofilter and Constructed Wetland for Sustainable Batik Industry. *International Journal of GEOMATE*. 18(70): 138-148. https://doi.org/10.21660/2020.70.61681.

Rahmatullah, F., Sumarni, W., & Susatyo, E. B. 2013. Potensi Vermikompos dalam meningkatkan Kadar N dan P pada Limbah IPAL PT. Djarum. *Edaj*. 2(3): 0-5.

Rusad, R. E., & Santosa, S. 2016. Utilization of Vegetables Waste of Cabbage Brassica Oleracea and Papaya Fruit Carica Papaya as Feed Lumbricus Rubellus Earthworms. *Jurnal Biologi*. 1*(*1): 8-15. robin.e.r.b10@gmail.com.

Rustum, R., Shebin, A. K., & Adeloye, A. J. 2020. Dairy Wastewater Treatment Option for Rural Settlments by Vermi-Biofiltration. *International Journal of GEOMATE*. 18(67): 33-38. https://doi.org/10.21660/2020.67.5641.

Samal, K., Dash, R. R., & Bhunia, P. 2017a. Performance Assessment of a Canna Indica Assisted Vermifilter for Synthetic Dairy Wastewater Treatment. *Process Safety and Environmental Protection*. *111*: 363-374. https://doi.org/10.1016/j.psep.2017.07.027.

Samal, K., Dash, R. R., & Bhunia, P. 2017b. Treatment of Wastewater by Vermifiltration Integrated with Macrophyte Filter: A review. *Journal of Environmental Chemical Engineering*. 5(3): 2274-2289. https://doi.org/10.1016/j.jece.2017.04.026.

Samal, K., Dash, R. R., & Bhunia, P. 2018a. Design and Development of a Hybrid Macrophyte Assisted Vermifilter for the Treatment of Dairy Wastewater: A Statistical and Kinetic Modelling Approach. *Science of the Total Environment*. 645: 156-169. https://doi.org/10.1016/j.scitotenv.2018.07.118.

Samal, K., Dash, R. R., & Bhunia, P. 2018b. Effect of Hydraulic Loading Rate and Pollutants Degradation Kinetics in Two Stage Hybrid Macrophyte Assisted Vermifiltration System. *Biochemical Engineering Journal*. 132: 47-59. https://doi.org/10.1016/j.bej.2018.01.002.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 3, page 281-295, October 2022
*Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023*

Singh, R., Bhunia, P., & Dash, R. R. 2018. COD Removal Index - A Mechanistic Tool for Predicting Organics Removal Performance of Vermifilters. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2018.07.272.

Singh, R., D'Alessio, M., Meneses, Y., Bartelt-Hunt, S. L., Woodbury, B., & Ray, C. 2021. Development and Performance Assessment of an Integrated Vermifiltration based Treatment System for the Treatment of Feedlot Runoff. *Journal of Cleaner Production.* 278(2021): 123355. https://doi.org/10.1016/j.jclepro.2020.123355.

Singh, R., Samal, K., Dash, R. R., & Bhunia, P. 2019. Vermifiltration as a Sustainable Natural Treatment Technology for the Treatment and Reuse of Wastewater: A review. *Journal of Environmental Management*. 247(June): 140-151. https://doi.org/10.1016/j.jenvman.2019.06.075.

Sitompul, E., Wardhana, I. wisnu, & Sutrisno, E. 2017. Study of Identification of Ratio C / N Processing Waste Organic Mustard Greens, Cassava Leaves and Goat Dung using the Composition of Variation Vermicomposting. *Jurnal Teknik Lingkungan*. 6(2): 1-12.

Sulistia, S., & Septisya, A. C. 2020. Analysis Of Domestic Wastewater Quality in Office Space. *Jurnal Rekayasa Lingkungan*. 12(1): 41-57. https://doi.org/10.29122/jrl.v12i1.3658.

Va, V., Setiyawan, A. S., Soewondo, P., & Putri, D. W. 2018. The Characteristics of Domestic Wastewater from Office Buildings in Bandung, West Java, Indonesia. *Indonesian Journal of Urban and Environmental Technology*. 1(2): 199-214. https://doi.org/10.25105/urbanenvirotech.v1i2.2826.

Vera-Puerto, I., Saravia, M., Olave, J., Arias, C., Alarcon, E., & Valdes, H. 2020. Potential Application of Chilean Natural Zeolite as a Support Medium in Treatment Wetlands for Removing Ammonium and Phosphate from Wastewater. *Water (Switzerland).* 12(4): 1-15. https://doi.org/10.3390/W12041156.

Wimbaningrum, R., Arianti, I., & Sulistiyowati, H. 2020. Effectivenes of Lembang Plant (Typha angustifolia L.) in the Constructed Wetland in Decreasing Levels of TSS, BOD and Phosphate of Firm Laundry Wastewat. *Berkala Sainstek.* 8(1): 25-28.