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WATER QUALITY OF TUBIFEX WORM CULTURE IN VERTIQUA TECHNOLOGY

Kualitas Air Budidaya Cacing Sutra Pada Teknologi Vertiqua

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ABSTRACT

Tubifex sp. culture is an important source of natural feed with high nutritional value for fish larvae and juveniles. The dependence on natural harvesting results in unstable availability, highlighting the need for an efficient cultivation system capable of maintaining water quality. This study aimed to evaluate the water quality of *Tubifex* sp. cultured using Vertiqua technology integrated with a recirculating system and a Biofical Filter. The experiment was conducted from November 2025 to January 2026 at the Bossbaster experimental pond, Sukabumi Regency, Indonesia. Observed parameters included temperature, pH, dissolved oxygen (DO), ammonia, nitrite, nitrate, phosphate, alkalinity, turbidity, and odor indicators. Temperature, pH, and DO were measured daily, while the remaining parameters were analyzed at the beginning, middle, and end of the culture period. The results showed that the average temperature (26.4°C), pH (7.45), alkalinity (105.8 mg/L), nitrate (4.65 mg/L), phosphate (0 mg/L), and turbidity (0 NTU) remained within acceptable ranges for *Tubifex* culture. However, dissolved oxygen (3.51 mg/L), ammonia (1.515 mg/L), and nitrite (0.236 mg/L) exceeded the recommended water quality standards. Despite these limitations, the Biofical Filter integrated into the Vertiqua system maintained relatively stable water quality, reduced odor, and minimized organic waste accumulation throughout the culture period. Therefore, Vertiqua technology has considerable potential for *Tubifex* culture on limited land, although further optimization of the filtration system is required to improve dissolved oxygen and reduce ammonia and nitrite concentrations.

Keywords: Biofical Filter, Tubifex Culture, Vertiqua, Water Quality, Worm Culture

ABSTRAK

Budidaya cacing sutra (*Tubifex* sp.) merupakan salah satu alternatif penyediaan pakan alami bernilai nutrisi tinggi bagi larva dan benih ikan. Ketersediaan cacing sutra yang masih bergantung pada hasil tangkapan alam menyebabkan pasokannya berfluktuasi sehingga diperlukan teknologi budidaya yang mampu menjaga produktivitas sekaligus mempertahankan kualitas air. Penelitian ini bertujuan menganalisis kualitas air pada budidaya cacing sutra menggunakan teknologi Vertiqua yang dilengkapi sistem resirkulasi dan Biofikal Filter. Penelitian dilaksanakan pada November 2025 hingga Januari 2026 di kolam percobaan Bossbaster, Kabupaten Sukabumi. Parameter yang diamati meliputi suhu, derajat keasaman (pH), oksigen terlarut (DO), amonia, nitrit, nitrat, fosfat, alkalinitas, kekeruhan, serta indikator bau. Suhu, pH, dan DO diukur setiap hari, sedangkan parameter lainnya dianalisis pada awal, pertengahan, dan akhir penelitian. Hasil penelitian menunjukkan bahwa suhu rata-rata 26,4°C, pH 7,45, alkalinitas 105,8 mg/L, nitrat 4,65 mg/L, fosfat 0 mg/L, serta kekeruhan 0 NTU masih berada pada kisaran yang mendukung budidaya cacing sutra. Sebaliknya, kadar oksigen terlarut rata-rata 3,51 mg/L, amonia 1,515 mg/L, dan nitrit 0,236 mg/L belum memenuhi baku mutu yang direkomendasikan. Meskipun demikian, sistem Biofikal Filter pada teknologi Vertiqua mampu mempertahankan stabilitas kualitas air, mengurangi bau, serta mengendalikan akumulasi bahan organik selama pemeliharaan. Teknologi Vertiqua berpotensi diterapkan sebagai sistem budidaya cacing sutra pada lahan terbatas, namun masih memerlukan optimalisasi sistem filtrasi untuk meningkatkan kualitas air terutama pada parameter DO, amonia, dan nitrit.

Kata kunci: Biofikal Filter, Budidaya Cacing Sutra, Kualitas Air, *Tubifex* sp., Vertiqua

INTRODUCTION

Cacing Silk worms (*Tubifex sp.*) are a type of natural feed that plays a crucial role in aquaculture, particularly during the larval and fry stages of fish development. This is because *Tubifex sp*. possesses a size suitable for the larval mouth opening, movement that stimulates a feeding response in fish, and a nutritional profile that supports the growth and survival of fish fry (Febrianti *et al*., 2019). Beyond serving as a protein source, silk worms contain fats, minerals, and other nutrients that contribute to enhanced growth, survival, and development in fish fry (Batubara *et al*., 2023). Consequently, the demand for silk worms continues to rise alongside the expansion of fish hatchery operations in Indonesia.

To date, the high demand for silk worms is primarily met through harvesting from natural habitats. This reliance makes silk worm availability highly dependent on environmental factors and seasonal changes, thereby preventing a guaranteed, continuous supply of this natural feed for hatchery operations (Nurfitriana *et al*., 2024). Dependence on natural sources leads to fluctuations in availability, driven by changing environmental conditions, water pollution, and seasonality. As a result, the supply of silk worms has been unable to consistently meet the needs of fish farmers. Therefore, developing silk worm cultivation technology is a vital strategy for ensuring a sustainable supply of natural feed and reducing exploitation pressure on natural populations (Wang *et al*., 2021).

The success of silk worm cultivation is heavily influenced by water quality. Parameters such as temperature, pH, dissolved oxygen (DO), ammonia, nitrite, nitrate, and phosphate determine the comfort level of the organisms and the metabolic activity of microorganisms within the culture medium. High-density culture systems often experience an increase in organic matter, which can lead to the accumulation of toxic nitrogenous compounds if not properly managed (Chen *et al*., 2022). Uncontrolled changes in water quality can induce physiological stress in cultured organisms by disrupting metabolic processes, osmoregulation, and other physiological activities; this leads to reduced growth rates and feed utilization efficiency, as well as an increased risk of mortality when environmental conditions fall outside the organisms' tolerance ranges (Long *et al*., 2019).

Salah One innovation developed to address these issues is Vertiqua (Vertical Aquaculture) technology, which employs a multi-tiered cultivation system featuring water recirculation and a Biofikal Filter. This system is designed to optimize limited land use while maintaining water quality through physical and biological filtration and phytoremediation processes. The Biofikal Filter consists of sand, charcoal, rice husks, and water spinach (*Ipomoea aquatica*); these components filter suspended particles, absorb pollutants, and facilitate the transformation of nitrogen compounds, thereby stabilizing the cultivation environment. This technology is expected to enhance water use efficiency and create more controlled cultivation conditions compared to conventional systems (Badiola *et al*., 2018).

Research on water quality within the Vertiqua system remains relatively limited, particularly regarding its application in the cultivation of sludge worms (*Tubifex sp*.). Most previous studies in Indonesia have focused on increasing sludge worm production through the use of various cultivation media, supplementary feeding, and rearing environment management; however, research into a cultivation system's ability to maintain stable water quality parameters requires further development. Evaluating water quality is crucial because parameters such as temperature, pH, dissolved oxygen (DO), ammonia, nitrite, nitrate, and organic matter influence the growth and reproduction of sludge worms. Therefore, testing the effectiveness of the recirculation system and the Biofikal Filter is necessary to determine their capacity to create cultivation conditions that meet the biological needs of sludge worms (Suharyanto *et al*., 2020).

This study aims to analyze water quality in sludge worm (*Tubifex sp*.) cultivation using Vertiqua technology equipped with a recirculation system and a Biofikal Filter and to evaluate the suitability of each water quality parameter against the quality standards used as cultivation benchmarks. Water quality analysis was conducted to assess the capacity of the recirculation and filtration system to maintain stable culture conditions, as water quality management utilizing physical, biological, and plant-based filters can help reduce organic matter accumulation and control nitrogen compounds that influence cultivation success. The findings of this study are expected to serve as a foundation for developing silk worm cultivation technology that is more efficient, water-saving, and sustainable, and suitable for implementation on limited land (Jubaedah *et al*., 2023).

RESEARCH METHODS

Time and place

The research was conducted over a period of 58 days, from November 21, 2025, to January 17, 2026, at the Bossbaster Experimental Pond in Kampung Legoknyenang, Muaradua Village, Kadudampit District, Sukabumi Regency, West Java.

Tools and materials

Table 1. Tools and Materials

Equipment	Amount	Quantity	Description
Plastic container (60 cm long, 40 cm wide, 15 cm high)	9	Piece	Research medium
Bucket	3	Piece	Research medium
Pump	3	Piece	Research medium
PVC piping	10	m	Research medium
Cooler box	1	Piece	Coolant
Sample bottle	3	Bottle	Water sample container

DO meter	1	Piece	Water quality measurement
pH meter	1	Piece	Water quality measurement
Materials	**Amount**	**Quantity**	**Description**
Charcoal	3	kg	Research medium
Rice husks	3	Bag	Research medium
Sand	6	kg	Research medium
Water spinach (kangkung)	6	Bunch	Research medium
Mud			
Water	90	Liter	Research media
Tubifex worm inoculum	90	Gram	Research media
Equipment	**Amount**	**Volume**	**Description**
Plastic storage box (60 cm long, 40 cm wide, 15 cm high)	9	Piece	Research media
Bucket	3	Piece	Research media
Pump	3	Piece	Research media
PVC pipe	10	m	Research media
Cooler box	1	Piece	Research media

Research Design

This study employed a Completely Randomized Design (CRD) because the conditions of each experimental unit were relatively homogeneous. The treatment consisted of the Vertiqua cultivation system equipped with a Biofikal Filter, with three replicates. The CRD was selected as it is suitable for research conducted under relatively uniform environmental conditions (Hanafiah, 2016). The study utilized a CRD with a single treatment the Vertiqua cultivation system equipped with a Biofikal Filter and three replicates (Masaniku *et al*., 2023). Each replicate utilized a single Vertiqua unit arranged vertically and equipped with a water recirculation system. Analysis was conducted using a quantitative descriptive approach based on mean observation values, which were then compared against water quality standards for *Tubifex* (silk worm) cultivation as referenced by Effendi (2022), Samsundari (2013), and Boyd (1990).

Research Procedure

The cultivation units consist of plastic containers stacked in three tiers and interconnected via a water recirculation system. Each container is equipped with PVC pipe inlets and outlets. Water is circulated using an aquarium pump to maintain a stable flow rate in each container throughout the rearing period. Fine mud collected from fish culture ponds and subsequently passed through a fine mesh serves as the culture medium for the tubifex worms. After filtration, the mud is allowed to settle for one day before the worm inoculum is introduced. The recirculation system then operates continuously throughout the rearing period. Daily inspections of the water lines, pump, and reservoir tank are conducted to ensure proper water flow and prevent system blockages.

Observation Parameters

The water quality parameters monitored included temperature, pH, dissolved oxygen (DO), alkalinity, ammonia, nitrite, nitrate, phosphate, turbidity, and odor. Measurements of temperature, pH, DO, and odor were conducted daily using a thermometer, pH meter, and DO meter, whereas ammonia, nitrite, nitrate, phosphate, alkalinity, and turbidity were analyzed at the beginning, midpoint, and end of the study at BBPBAT Sukabumi using spectrophotometry (for ammonia, nitrite, nitrate, and phosphate), acid-base titration (for alkalinity), and a turbidimeter (for turbidity).

Data Analysis

Observational data were analyzed using descriptive quantitative methods by calculating the mean value for each water quality parameter based on three replicates. These mean values were then compared against water quality standards to evaluate the suitability of the culture environment. The study employed a Completely Randomized Design (CRD) with a single treatment and three replicates, while differences between the mean values and the reference standards were assessed using a One-Sample t-test at a 95% confidence level ($\alpha = 0.05$) (Sugiyono, 2022).

RESULTS

Water Quality for Silkworm Cultivation in the Vertiqua System

Water quality measurements taken during the study indicate that while some parameters met the quality standards for *Tubifex sp*. culture, others fell outside the recommended ranges. These findings demonstrate that water quality stability is a critical determinant of success in *Tubifex sp*. culture, as parameters such as temperature, pH, dissolved oxygen (DO), ammonia, nitrite, and organic matter each have optimal ranges that influence the growth and survival of the cultured organisms (Putri *et al*., 2022).

Table 1. Average water quality parameters for silk worm culture in the Vertiqua system.

Parameters	Average Score	Quality standards	Description
Temperature (°C)	26.4	20–26	Not yet met
pH	7.45	6,5–8,0	Met
DO (mg/L)	3.51	>5	Not yet met
Alkalinity (mg/L)	105.80	≤200	Met
Ammonia (mg/L)	1.515	≤0,20	Not yet met
Nitrite (mg/L)	0.236	≤0,06	Not yet met
Nitrate (mg/L)	4.65	≤10	Met
Phosphate (mg/L)	0.00	≤0,02	Met
Turbidity (NTU)	0	≤25	Met

Parameters	Average Score	Quality standards	Description
Odor	Odorless	Odorless	Met

Temperature

During the study, the average water temperature in the Vertiqua system was 26.4°C. This value slightly exceeded the upper limit of the water quality standard for silk worm cultivation, which is 20–26°C.

pH

During the study, pH values ranged from 7.1 to 7.6, with an average of 7.45. This range falls within the recommended quality standards for silk worm cultivation.

Dissolved Oxygen (DO)

Dissolved oxygen concentrations ranged from 1.4 to 5.2 mg/L, with an average of 3.51 mg/L. These values remain below the recommended quality standard of more than 5 mg/L.

Odor Indicator

Observation results indicate that the water in all Vertiqua units remained odorless throughout the maintenance period.

Alkalinity

Alkalinity values during the study ranged from 94.26 to 119.67 mg/L, with an average of 105.80 mg/L, remaining below the maximum limit of 200 mg/L.

Ammonia

Ammonia concentrations ranged from 0.48 to 2.43 mg/L, with an average value of 1.515 mg/L—higher than the quality standard used as a reference.

Nitrite

Nitrite levels during the study ranged from 0.107 to 0.366 mg/L, with an average of 0.236 mg/L. These values exceeded the water quality standard used as the reference for the study.

Nitrate

Nitrate values ranged from 3.97 to 5.05 mg/L, with an average of 4.65 mg/L. These concentrations remain below the standard quality threshold.

Phosphate

The analysis results indicate that the phosphate concentration during the study was 0 mg/L, thereby remaining within water quality standards.

Turbidity

The water turbidity value in the Vertiqua system was 0 NTU, indicating clear water conditions throughout the study.

DISCUSSION

Temperature

The study results indicate that the average water temperature in the Vertiqua system was 26.4°C, slightly above the upper limit of the standard quality range for *Tubifex* worm culture (20–26°C). Nevertheless, the relatively small temperature difference suggests that the Vertiqua system was still capable of maintaining relatively stable thermal conditions throughout the study.

The rise in temperature is thought to be influenced by the intensity of solar radiation striking the culture containers. The absorption of solar radiation by the media and water led to an increase in thermal energy, thereby raising the water temperature. This finding aligns with the thesis, which states that light intensity is a primary factor influencing changes in water temperature.

Temperature is a crucial parameter as it affects the metabolic activity of aquatic organisms. Temperatures exceeding the optimal range can increase oxygen demand, accelerate the decomposition of organic matter, and impact water quality stability. Therefore, the use of shade netting or shading structures for the Vertiqua installation should be considered to keep the temperature within the optimal range.

Degree of Acidity (pH)

An average pH value of 7.45 indicates that the Vertiqua system is capable of maintaining near-neutral water conditions. This value falls within the standard quality range for silk worm culture, thereby supporting the organisms' physiological activities during the rearing period.

The pH stability is attributed to the recirculation system and the Biofikal Filter, which maintain a balance of biological processes within the culture medium. Furthermore, the relatively high alkalinity provides buffering capacity against pH changes, resulting in minimal acidity fluctuations throughout the study.

Dissolved Oxygen (DO)

The average dissolved oxygen (DO) value of 3.51 mg/L indicates that oxygen levels in the Vertiqua system remain below the reference quality standard (>5 mg/L). This low dissolved oxygen concentration suggests that oxygen supply and distribution within the culture medium are not yet optimal; DO is a critical parameter influencing organism metabolic activity, microbial respiration, and the decomposition of organic matter within the culture system (Effendi, 2022).

Based on observations made during the study, the low DO value is likely linked to the accumulation of worm mucus and organic matter, which hindered water flow in the inlet channel and consequently reduced the efficiency of oxygen mixing and input into the system. Furthermore, increased respiratory activity by the cultured organisms and organic-matter-decomposing microorganisms likely heightened dissolved oxygen consumption, leading to a decline in DO levels within the rearing medium (Mulyadi *et al*., 2021).

Odor Indicator

Throughout the study, all Vertiqua units maintained an odor-free culture medium. This indicates that the use of the Biofikal Filter effectively helps reduce the accumulation of organic matter and decomposition by-products derived from both uneaten feed and the metabolic waste of the cultured organisms that could otherwise generate odors. A filtration system combining mechanical and biological processes enhances the breakdown of organic matter through the removal of suspended particles and the activity of decomposer microorganisms; this suppresses odor-causing compounds and maintains greater stability in the culture environment (Badiola *et al*., 2018). The absence of odor in the Vertiqua system also demonstrates effective organic waste management, as excessive accumulation of organic matter in culture systems typically leads to water quality deterioration and the formation of decomposition by-products such as ammonia and hydrogen sulfide that can be detrimental to the cultured organisms (Boyd *et al*., 2020).

Alkalinity

The average alkalinity value of 105.8 mg/L indicates that the water conditions in the Vertiqua system possess sufficient buffer capacity to maintain pH stability throughout the study. Alkalinity is a crucial parameter in aquaculture systems, as it plays a role in maintaining water chemical balance and providing an inorganic carbon source that supports the activity of microorganisms particularly nitrifying bacteria during the transformation of nitrogen compounds (Effendi, 2022).

Stable alkalinity levels support the activity of decomposer and nitrifying bacteria, thereby mitigating pH fluctuations caused by organic matter decomposition. This demonstrates that the Vertiqua filtration system helps maintain water quality balance by regulating biological and chemical processes within the culture medium (Preena *et al*., 2021).

Ammonia

The average ammonia concentration of 1.515 mg/L remained above the quality standard used as a benchmark for *Tubifex* worm (silk worm) cultivation. High ammonia levels indicate that the accumulation of nitrogenous waste derived from organism metabolism and residual organic matter persisted throughout the rearing period. Ammonia is a nitrogenous compound toxic to aquatic organisms when accumulated in high concentrations; consequently, controlling this compound is crucial for maintaining water quality in the cultivation system (Effendi, 2022).

Nevertheless, the use of a bio-filter in the Vertiqua system is believed to contribute to mitigating ammonia increases through the filtration of organic matter and the activity of decomposing microorganisms. Water spinach (*Ipomoea aquatica*) used in the phytoremediation component also possesses the ability to absorb dissolved nitrogen from the water; however, this capacity is influenced by plant biomass, growth rate, and the waste load entering the system. The high ammonia concentration observed in this study indicates that the amount of nitrogen generated exceeded the absorption capacity of the plants and the biological processes within the filtration system (Sitompul *et al*., 2021).

Nitrite

The average nitrite level of 0.236 mg/L remained above the reference quality standard. This high nitrite concentration indicates that the conversion of ammonia to nitrate via nitrification was ongoing, as nitrite is an intermediate compound formed during the oxidation of ammonia by nitrifying bacteria. High levels of nitrite accumulation must be controlled, as they can disrupt the physiological processes of aquatic organisms and degrade the quality of the culture water (Kordi & Ghufran, 2020).

Nevertheless, the absence of excessive nitrite accumulation indicates that the biofilter system remained capable of supporting nitrifying bacteria in oxidizing nitrite to nitrate. The presence of porous filter media provided a substrate for the growth of nitrifying bacteria, thereby helping to maintain the balance of nitrogen transformation processes within the culture system. This condition was further supported by nitrate levels remaining within a safe range throughout the study (Jubaedah *et al*., 2023).

Nitrate

The average nitrate value of 4.65 mg/L remains below the standard quality threshold used as a reference. This indicates that the nitrification process within the Vertiqua system is functioning effectively, with ammonia and nitrite compounds being oxidized into nitrate a form with lower toxicity to the cultured organisms. Nitrate is a relatively stable form of inorganic nitrogen in aquatic environments and serves as an indicator of successful nitrogen waste management in aquaculture systems utilizing biofilters (Effendi, 2022).

The low nitrate concentration in the Vertiqua system is also likely linked to nitrogen uptake by water spinach (*kangkung*), which acts as a phytoremediation component within the Biofikal Filter. Aquatic plants can utilize nitrate as a nutrient source for growth; thus, their presence helps reduce dissolved nitrogen accumulation and maintains water quality stability within the aquaculture system (Nugroho *et al*., 2021).

Phosphate

A phosphate concentration of 0 mg/L indicates that the Vertiqua system was able to maintain phosphate levels at a very low point throughout the study. Low phosphate levels in the water can reduce the risk of excessive nutrient enrichment (eutrophication), which can trigger uncontrolled algal growth and degrade the quality of the culture water (Effendi, 2022).

These low phosphate conditions are likely attributable to a combination of mechanisms within the Biofikal Filter: the filtration of organic matter, phosphorus utilization by microorganisms, and nutrient uptake by water spinach (*Ipomoea aquatica*) through phytoremediation. Aquatic plants are known to absorb phosphorus in the form of phosphate to support growth; thus, their presence helps reduce the accumulation of dissolved phosphate within the culture system (Irianto & Triweko, 2021).

Turbidity

A turbidity value of 0 NTU indicates that the water in the Vertiqua system remained highly clear throughout the study. This condition demonstrates the effectiveness of the filtration process within the Biofikal Filter in reducing suspended particles and fine organic matter present in the culture medium. Low turbidity levels indicate a relatively low concentration of suspended solids, thereby supporting a more stable culture environment (Pratama *et al*., 2022).

The Biofikal Filter utilizing a combination of sand, charcoal, rice husk charcoal, and water spinach functions through physical filtration mechanisms that trap solid particles, as well as biological filtration driven by microbial activity and nutrient uptake by the plants. Carbon-based filter media, such as charcoal and rice husk charcoal, are known to enhance water quality by adsorbing organic matter and pollutants, while aquatic plants absorb dissolved nutrients, helping to maintain the stability of the culture environment (Fauzia *et al*., 2021).

CONCLUSION

Research results indicate that the Vertiqua technology is capable of maintaining several water quality parameters for *Tubifex sp*. (sludge worm) culture specifically pH, alkalinity, nitrate, phosphate, turbidity, and odor within ranges that meet established standards. The recirculation system, integrated with a Biofikal Filter, effectively maintains water quality stability and reduces the accumulation of organic matter that could otherwise degrade the culture medium.

However, certain parameters namely temperature, dissolved oxygen (DO), ammonia, and nitrite did not meet the reference standards. These findings suggest that the Vertiqua system requires further optimization, particularly regarding aeration, water circulation efficiency, and biological filtration performance, to boost dissolved oxygen levels and minimize nitrogen compound accumulation during the culture process.

Overall, the Vertiqua technology shows promise for *Tubifex* sp. cultivation in space-constrained areas due to its ability to maintain relatively stable water quality conditions. Nevertheless, further development of the filtration system and maintenance protocols is necessary to achieve optimal water quality and enhance cultivation productivity.

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