Application of sludge collector in super-intensive Vannamei shrimp farms

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Abstract: The solid organic waste load that is formed during the vannamei shrimp cultivation process is a problem that must be overcome because it triggers water quality deterioration and the emergence of shrimp disease. The sludge collector is designed to accommodate a load of the solid waste easily removed from the pond environment during the cultivation process. This study evaluates the performance of two types of pond outlets on water quality and shrimp production performance. Two concrete pond plots with an area of 1000 m² each were used in this study. The treatments applied are the Sludge Collector and Central Drain solar model as outlet facilities located in the middle of the pond. The stocking density of the fry is 500 PL/m² and is maintained for 92 days. According to the feeding program, 38-36% crude protein content is given eight times daily. The water exchange was carried out in the morning and evening. The application of additives in the form of lime, molasses, and probiotics into the ponds was adjusted to the needs and development of pond water quality conditions. The parameters measured consisted of water quality, total bacteria, total hematocyte count, prophenoloxidase (proPO), growth, survival rate, production, feed conversion ratio, and analysis of shrimp production costs. Data is analyzed using descriptive statistics. The study results show that the Sludge Collector application in super-intensive ponds has better water quality (total ammonia nitrogen, nitrite, nitrate, and total suspended solid performance due to the cleaner sludge disposal system to maintain water quality conditions suitable for the life of vannamei shrimp. This response is in line with the performance of THC and proPO in shrimp in Sludge Collector ponds that have a lower stress level than in Central Drain ponds. The sludge Collector application resulted in an 8.25% higher gain than the Sludge Collector treatment with a larger shrimp size.

1. Introduction
Super-intensive vannamei shrimp cultivation is the orientation of a future culture system with the principle of low volume high density so that it does not require a large area of cultivation so that it is easy to control, resulting in high shrimp productivity and competitiveness. A controlled cultivated environment and area with good cultivation management are expected to become a productive, profitable, and sustainable vannamei shrimp cultivation system [1].

Super-intensive shrimp farming is faced with the problem of increasing waste load along with the maintenance period. The resulting waste load will lead to a decrease in the quality of aquaculture and threaten the feasibility of habitat for shrimp life and growth [1,2]. Even the critical period of high-density vannamei shrimp cultivation is in the Day of Culture (DOC)-40 to 50 range due to an increase in the accumulated load of organic waste at the bottom of the pond [3].
One of the causes of the decline in the quality of the pond water environment is the discharge of wastewater during operations which contains high concentrations of nutrients from organic waste as a consequence of the input, which results in feed residue and feces that are dissolved into the water to be discharged into the surrounding waters [4]. Shrimp culture waste load can reach 12.6-21 kgN and 1.8-3.6 kgP per tonne of shrimp production at a feed conversion ratio (FCR) of 1.5 and will increase as shrimp productivity and FCR improves [5, 6].

Super-intensive shrimp pond wastewater with a stocking density of 750 - 1,250 PL/m² contains an average of total suspended solid (TSS) 798-924 mg/L, Total Organic Matter (TOM) 81,227-88,641 mg/L; total nitrogen (TN) 9,8389-14,4260 mg/L; and total phosphate (TP) 7.8770-11.8720 mg/L [7]. This value has exceeded the threshold limit of the permitted pond wastewater standard so that it has the potential to harm the environmental quality of the water bodies receiving the waste load.

The management of shrimp culture still focuses on water quality management, and few people pay attention to solid waste management or semi-moist shrimp farming [8]. Meanwhile, the environmental impact of shrimp farming is closely related to the discharge of aquaculture wastewater into the environment. Suwoyo et al. [9] reported that solid waste from super-intensive pond culture contains high nutrients such as total N 0.58%, P2O5 3.33%, K2O 0.8%, C-organic 9.94%, pH 6.73, water content 16.36%, and C/N ratio 17.14.

One kilogram of shrimp produced can produce 500 grams of organic waste at a stocking density of 30 PL/m² with a production rate of 7 tons/ha [10] and can even reach 2 kg sediment/kg of shrimp produced at a stocking density of 1000 PL/m² with a production rate 10 tonnes/0.1 ha [1]. Therefore, control and management of solid waste in ponds are essential for the success of shrimp farming. One of the efforts that can be done is to collect solid waste in a concentrated place called the Sludge Collector (SC). The availability of SC in the pond will facilitate solid waste disposal so that the pond bottom is cleaner from organic matter sediment formed during the cultivation process. Kawahigashi [11] states that constructing a shrimp toilet (ST) is one of the best ways to control and overcome EMS / AHPNS, vibrosis, and viral diseases in vannamei shrimp farming. ST increases the concentration efficiency and removes sediment and sludge (feces, uneaten feed, shrimp carapace, algae, and biofloc) from the bottom of the pond.

The cleanliness of the SC function is determined by the design and pattern of water flow in the pond produced by the paddlewheel layout as a current driver. The success of SC as a means of supporting pond operations is expected to guarantee the quality of the pond water environment in prime condition to support the life and growth of shrimp. Maintaining pond water quality in prime condition will increase the success of the super-intensive and fruitful shrimp farming business on shrimp income and production. The existence of SC is expected to be one of the cheapest and most environmentally friendly alternative options to solve the problem of solid waste load during the shrimp farming process. This study aims to evaluate the pond sludge collector (SC) to improve the performance of the central drain of shrimp ponds in the waste disposal process for shrimp ponds on water quality and shrimp culture performance.

2. Materials and Methods

2.1. Research Location
The research was carried out at the Experimental Pond Installation (EPI) Research Institute for Coastal Aquaculture and Fisheries Extension (RICAFE) in Punaga Village, Mangarabombang District, Takalar Regency, from June - October 2020.

2.2. Sludge Collector Design
The Sludge Collector (SC) is built in the center of the pond and functions as a central drain, in a circular shape with a diameter of 6 m so that it has an area of about 28 m², equivalent to 3% of the pond area. The shape of the SC is made of a cone with a slope angle of 23° and a depth of 0.5 m, and a storage volume of 6.6 m³. The bottom of the SC connected to the discharge pipe leading to the
The collector drain serves to dispose of sludge from the pond. The exhaust pipe is equipped with a filter (Figure 1 and Figure 2). The wheel's layout is arranged so that the current generated is in the form of a circle centered on the center of the pond so that it can direct the movement of sludge towards the SC section.

![Figure 1. Sludge Collector design scheme for super-intensive shrimp ponds](image1)

![Figure 2. Central drain design scheme for super-intensive shrimp ponds](image2)

2.3. SC applications in shrimp farming

There were two units of concrete ponds, each measuring 1,000 m² used for the trial of enlargement of vannamei shrimp. Pond preparation included cleaning, adjusting the wheel's position, washing the pond with a 60 ppm chlorine solution, rinsing the walls and bottom of the pond, filling one meter of water, sterilizing water using chlorine at a dose of 30 ppm, fertilizing and growing natural food. The pond preparation period took about 7-10 days.

PL-10 vannamei shrimp fries were obtained from a commercial hatchery equipped with a disease-free certificate [12]. The fries were stocked at a density of 500 PL/m² in ponds equipped with SC (SC treatment) and ponds equipped with central drain (CD Treatment). SC has a sludge basin with a volume of 28 m³ that facilitates the sludge disposal process. In contrast, the CD is not equipped with a sludge basin and only relies on pipes that serve to suck the sludge in the central area of the drain.

The shrimp were given commercial feed (38-36% crude protein) with the feed dosage referring to the standard feeding program during the rearing process. The feeding frequency was six times a day,
given at 07:00; 10:00 am; 13:00; 16:00, 19:00, and 22:00. The sludge disposal, concentrated in the middle of the pond, was carried out before feeding in the morning, afternoon, and evening. The addition of new water to the ponds was carried out in the morning and evening, as the volume of water decreases. The application of additives in the form of lime, molasses, and probiotics into the ponds was adjusted to the needs and development of pond water quality conditions.

2.4. Measured parameter
In situ water quality monitoring was carried out twice a day in the morning and evening. The measured parameters consist of temperature, salinity, pH, and dissolved oxygen using the YSI Professional Pro DO meter. Meanwhile, the parameters of total organic matter (TOM), total suspended solid (TSS), total ammonia nitrogen (TAN), nitrite, nitrate, phosphate, alkalinity were carried out once a week and analyzed in the laboratory. While the total plate count (TPC) and total vibrio bacteria (TVB) were carried out every two weeks and analyzed in the laboratory. Shrimp immunity monitoring was carried out at the end of the study by taking hemolymph samples to analyze Total Hematocyte Count (THC) and prophenoloxidase (proPO).

Shrimp growth monitoring was carried out once a week with an individual weight weighing approach with a digital weighing device with a capacity of 500 grams and an accuracy level of 0.1 grams. Shrimp weight growth data was used as a reference in determining daily feed dose adjustments. At the end of the study, the harvest was carried out, and the shrimp production, the number of living shrimps, were calculated using the sampling method approach and the size of the shrimp (ind./kg).

2.5. Data analysis
The obtained data were shown in the table and figure, which was an analyzed statistic descriptively.

3. Result

3.1. Water quality
In situ water quality parameters of temperature, salinity, pH, and dissolved oxygen in the CD and SC plots were relatively the same (Table 1). In situ quality measurements daily in the morning (07: 00-08: 00) and evening (17: 00-18: 00) illustrate the relatively similar dynamics. There was an increase in salinity from 33.4 to 38.4 ppt due to stocking in June, which already entered the dry season, and harvesting in September at the peak of the dry season. The same thing is that the water temperature parameter is in the range 23 - 29.7 °C, experiencing quite large daily fluctuations because at the experimental location in July-August, there is a "bedding" season, low temperature at night and very low tide fluctuation, with strong winds, affect increasing the salinity of water due to high evaporation.

A drop in water pH below 8 begins at DOC-80 and is usually followed by a decrease in alkalinity below 100 ppm. Decreasing pH and alkalinity values will lead to environmental conditions that can affect the development of shrimp disease. Found a correlation between decreasing water pH and alkalinity with the emergence of EHP in ponds that had previously been infected with EHP [13]. This condition also occurred in the CD and SC plots.

| Plot | Parameter                  | Minimum | Maximum | Mean  | sd  |
|------|----------------------------|---------|---------|-------|-----|
| CD   | Temperature (°C)           | 23.0    | 29.7    | 26.3  | 1.1 |
|      | Salinity (ppt)             | 33.4    | 38.4    | 36.8  | 1.3 |
|      | pH                         | 7.5     | 9.0     | 8.4   | 0.4 |
|      | Dissolved oxygen (ppm)     | 3.7     | 6.1     | 4.8   | 0.4 |
|      | Temperature (°C)           | 23.4    | 29.8    | 26.4  | 1.1 |
| SC   | Salinity (ppt)             | 33.7    | 38.1    | 36.6  | 1.2 |
|      | pH                         | 7.6     | 9.1     | 8.5   | 0.3 |
|      | Dissolved oxygen (ppm)     | 3.6     | 5.7     | 4.8   | 0.5 |
TAN content in the CD plot ranged from 0.0856-2.9667 ppm and started to increase in concentration to a maximum of 2.9667 ppm in the middle of the second month of maintenance (Table 2 and Figure 1). The same pattern occurred in the SC plot, reached a peak of 2.4611 ppm, but in the first week of the second month, it experienced a drastic decrease (Figure 2) until DOC-21 sludge disposal has not been carried out so that it had an impact on increasing TAN values in the first month due to accumulation of organic matter from feed residues, feces, and dead plankton. However, probiotic administration and sludge disposal started after DOC-21 can control the rate of increased TAN. In mid-July, the value of TAN experienced a drastic decline. The TAN values in the SC plot were lower than those in the CD plots, both in the range and average values (Table 2). The applied Sludge Collector was quite helpful in removing the sludge. Checking the bottom of ponds around SC, which was carried out regularly, proved no sludge buildup in SC's holding area. The T-test of water quality parameters shows that both SC and CD treatments are not significantly different (p>0.05). However, the parameters of TAN, nitrite, nitrate, phosphate, TOM, and alkalinity in SC pond have lower average values than CD pond (Table 2).

The nitrite and nitrate content dynamics in both CD and SC plots had a relatively similar pattern, increasing in the second month, then stagnant during the third month of maintenance with relatively small fluctuations (Figures 3 and 4). The applied water quality management was able to control the nitrite and nitrate content in the third month of maintenance. The nitrite and nitrate content in SC plots tended to be lower than CD plots, and it was suspected that there was a positive role for the sludge removal mechanism through SC, which was more effective than the CD.

**Table 2. Water quality parameter average score in CD and SC ponds (n=25)**

| Score | TAN (ppm) | Nitrite (ppm) | Nitrate (ppm) | Phosphate (ppm) | TOM (ppm) | Alkalinity (ppm) | TSS (ppm) | C/N | N/P |
|-------|-----------|---------------|---------------|-----------------|-----------|------------------|-----------|-----|-----|
| **Central Drain (CD)** | | | | | | | | | |
| Min | 0.0856 | 0.0063 | 0.1038 | 0.0926 | 30.03 | 90.45 | 45 | 11 | 1 |
| Max | 2.9667 | 3.8399 | 4.0976 | 1.3628 | 68.19 | 150.75 | 240 | 369 | 33 |
| Avg | 1.4076 | 2.0776 | 2.2087 | 0.8454 | 51.98 | 124.14 | 151 | 49 | 8 |
| sd | 1.0426 | 1.7342 | 1.7089 | 0.4585 | 11.63 | 19.91 | 53 | 87 | 8 |
| **Sludge Collector (SC)** | | | | | | | | | |
| Min | 0.0778 | 0.0051 | 0.0994 | 0.0564 | 26.27 | 86.43 | 69 | 10 | 1 |
| Max | 2.4611 | 3.9856 | 3.9163 | 1.4666 | 68.82 | 144.72 | 237 | 360 | 57 |
| Avg | 0.9965 | 1.5889 | 1.7170 | 0.7189 | 49.12 | 121.46 | 167 | 52 | 11 |
| sd | 0.8333 | 1.7208 | 1.6277 | 0.4570 | 12.57 | 16.80 | 46 | 90 | 13 |

*The same letter on the same row indicated no significantly different (p<0.05). Data of NH3-N, NO2 and NO3 were transformed by log10(x+1); whereas data of TSS were transformed by log10 (x) prior to T-student analysis.*

Phosphate levels in the water were relatively stable in the first month of maintenance, then increased in the second and third months with a range of 0.0926-1.3628 (0.8454±0.4585) ppm in the CD plot and 0.0564-1.4666 (0.7189±0.4570) ppm in the DC plot (Table 9). The phosphate dynamics in the two plots had a relatively similar pattern, but the average level in the SC plot was lower than that in the CD plot (Figures 1 and 2).

The alkalinity of the cultivation media also experienced relatively the same dynamics between the CD and SC plots, where in the first week of September, it decreased below 100 ppm and resulted in a decrease in the pH of pond water below 8. The periodic addition of lime increased the alkalinity value of the water in the third month in the CD and SC plots (Figure 3).
Figure 3. Water quality dynamics vannamei shrimp pond in CD plot

Figure 4. The dynamics of water quality for vannamei shrimp ponds in the SC plot

TOM increased from the beginning of stocking to harvest with values ranging from 30.03-68.19 (51.98±11.63) ppm in the CD plot and 26.27-68.82 (49.12±12.57) ppm in the SC plot. Up to DOC-21, the sludge had not been disposed of so that it had an impact on increasing TOM in both CD and SC plots, then it decreased in the second month and increased again at the beginning of the third month and then decreased again until harvesting age in DOC-92 (Figure 5). TOM dynamics appeared to be inversely proportional to alkalinity, where when TOM increased, the alkalinity value tends to decrease, and vice versa.
3.2. Bacterial Development

The pattern of total bacterial change (TPC) in both the CD and SC plots was relatively the same from the beginning of stocking to harvest. The range of TPC in the CD plot was between 3.08x10^3-1.3x10^6 cfu/mL, and the SC plot was between 1.2x10^4-1.2x10^6 cfu/mL (Figure 6). Meanwhile, the total value of vibrio bacteria (TBV) in the CD plot was between 3.5x10^1-2.6x10^4 cfu/mL, and in the SC plot it was between 4.5x10^1-2.1x10^4 cfu/mL (Figure 7). From the second to the third month of maintenance, the TBV value in the CD plot was higher than the TBV value in the SC plot. The average value of the TBV/TPC ratio in the CD plot was 7.9±9.1% higher than the ratio in the SC plot, which was 4.0±5.1%. However, the ratio of both was still below 10% and categorized as relatively safe. (Figure 8). From the second month of rearing until harvest, the TBV ratio in the CD plots tended to be higher than in the SC plots.
3.3. Disease development and shrimp immunity
During the experiment, protozoa attacked shrimp that caused hemocytosis in both CD and SC plots in the first month (Table 3). In the second month of monitoring, positive for Enterocytozoon hepatopenaei (EHP) in the first week of August and positive for EHP and White Spot Syndrome Virus (WSSV) in the third month the first week of September. Simultaneous EHP and WSSV attacks can trigger high enough fatalities that destroy crops. Considering the shrimp's size and the shrimp's health condition, it was decided to harvest at DOC-92. The disease caused relatively low survival and shrimp production at 58.20% and 3.731 kg (CD plot) and 50.91% and 3.833 kg (SC plot). SC application resulted in higher growth performance due to relatively better water quality conditions compared to CD plots. However, simultaneous EHP and WSSV attacks cannot be overcome.
Table 3. Disease development of shrimp in CD and SC ponds

| Month | CD | SC |
|-------|----|----|
| First | Protozoa which cause hemocytosis, was found in the first month and decreased in the second and third months, not even found at the end of the third month | Protozoa which cause hemocytosis, was found in the first month and decreased in the second and third months, not even found at the end of the third month |
| Second | Positive EHP (W-1, August) | Positive EHP (W-1, August) |
| Third | Positive EHP and WSSV (W-1, September) | Positive EHP and WSSV (W-1, September) |

The total hemocyte count (THC) in white vannamei shrimp in the SC plot was higher than in the CD plot (Figure 7A). The highest hemocytes were obtained in the SC plot at 27.6 x 106 cells/mL and the CD plot at 9.25 x 106 cells/L. The results of the ProPO measurement in the SC plot of 0.12 Abs were higher than that of the CD plot of 0.05 Abs (Figure 7B).

![Figure 9](image.png)

Figure 9. Content of THC (A) and ProPO (B) in shrimp in CD and SC plots

3.4. Growth, survival rate, production, and feed conversion ratio

A study of the pond sludge removal system between Central Drain (CD) and Sludge Collector (SC) had been carried out with the growth performance shown in Figure 10. Up to DOC-40, the growth pattern of shrimp between CD and SC treatments was relatively the same, and then there was a difference in harvest time at DOC-92. Growth in the SC plot reached 15.03±3.01 g/ind, which was higher than the CD plot at 12.82±2.76 g/ind. The daily weight gain of shrimp fluctuated during rearing, but it was seen that after DOC-40 rearing, shrimp weight gain in the SC plot was higher than in the CD plot. At the end of maintenance in the third month, the Average Daily Growth (ADG) of shrimp experienced a drastic decrease in the CD plot compared to the SC plot (Figure 11). Appetite in the CD plot decreased, indicated by the remaining feed on the tray after 2 hours of feeding.
Shrimp size diversity tends to decrease during rearing. At harvest time, the diversity of shrimp weights indicated by the coefficient of variation (CV) in the SC plot was 19.10% lower than the CV value in the CD plot of 21.50% (Figure 12). This indicated that the weight of shrimp size in the SC plot was relatively more uniform than in the CD plot.

Shrimp survival in the SC treatment plot was 50.91% lower than in the CD plot, 58.20% (Table 4). EHP disease in both plots at the end of the study was indicated by white cotton's presence in the shrimp's body segments. WSSV disease in both plots was indicated by white spots on the shrimp's
carapace. Shrimp mortality in the last week was quite influential on shrimp survival so that the estimated production target was not achieved.

Shrimp production in the SC plot of 3.833 kg was relatively the same as the CD plot, which reached 3.731 kg (Table 4), but there were quite different sizes of shrimp at harvest, respectively 78 pcs/kg (CD plot) and 63 pcs/kg (SC plot). This means that the size of shrimp in the SC plot is bigger than in the CD plot. The feed conversion ratio was also relatively the same between the two plots, but the FCR value was lower in the SC plot. The high FCR is thought to be caused by the death of shrimp in the last 5 days, affecting survival, production, and FCR.

Table 4. Survival, production, FCR, maintenance water and electricity requirements in CD and SC plots

| Variables               | Central Drain | Sludge Collector |
|-------------------------|---------------|------------------|
| Survival rate (%)       | 58.20         | 50.91            |
| Production (kg)         | 3,731         | 3,833            |
| Shrimp size (pcs/kg)    | 78            | 63               |
| Food conversion ratio   | 1.95          | 1.91             |
| Feed efficiency (%)     | 51.28         | 52.36            |
| Water use (m³/kg)       | 3.67          | 3.04             |
| Electrical uses (kW/kg) | 6.00          | 5.90             |

During the cultivation process in the SC plot (3.04 m³/kg shrimp), the water requirement was relatively lower than the CD plot, which reached 3.67 m³/kg shrimp, so that the water use in the SC plot was more efficient. Meanwhile, the electricity consumption was relatively the same, respectively 5.90 kW/kg of shrimp in the SC plot and 6 kW/kg of shrimp in the CD plot. The electricity demand is dominated by the use of the aeration system, which reaches 98%, while the pump is only around 2%.

4. Discussion

The role of SC as a pond sludge removal device is determined by the accumulation of organic matter particles around the SC. The paddlewheel layout can direct the pond water flow and carry organic matter particles to the SC and CD. The results of direct monitoring at the bottom of the pond around SC did not find a pile of organic matter deposits. This means that every time the sludge is removed, most of the dirt around the SC can be thrown out. Meanwhile, in ponds with CDs, sludge piles were still found around the CDs. The presence of sludge will have an impact on the condition of pond water quality.

One of the most significant problems in the maintenance system of aquatic organisms is the deterioration of water quality due to the accumulation of nitrogen compounds, such as total ammonia (TAN = NH₃+NH₄⁺), nitrite (N–NO₂⁻), and nitrate (N–NO₃⁻) [14]. Total ammonia (TAN) is generated through the excretion and decomposition of organic matter, and when TAN exhibits higher concentrations, it can have a negative impact as it affects the organism’s performance during rearing and has the potential to cause death [15]. The content of TAN can affect the increase in ammonia levels in the blood and damage to the gills [16]; the decreased ability of blood to transport oxygen [17], shrimp are susceptible to disease and inhibit growth [18].

Removing sludge from the pond regularly before feeding can reduce ammonia levels and improve water quality. The application of probiotics RICA-Grow, RICA-Nitro, and RICA-Best, in turn, is expected to increase the nitrification rate of TAN to nitrite and the conversion of nitrite to nitrate. The application of RICA-Grow coupled with molasses as much as 3% of the total daily feed was proven to maintain TAN content below 1.5 ppm in the CD plot and 1.0 ppm in the SC plot. The addition of molasses is an effort to provide a carbon source so that C/N is at high conditions so that heterotrophic bacteria multiply and assimilate organic nitrogen (ammonia) into organic nitrogen in the form of...
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[28].

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The amount of THC obtained was still lower than that reported by Chang et al. [29] that the average amount of regular THC in Penaeid shrimp ranges from 20 to 40 x10^6 cells/mL. SC application is exceptionally influential on the THC content in shrimp. At the sampling time, there were symptoms of shrimp being attacked by EHP and WSSV, followed by shrimp death a few days before harvest. WSSV infection, which is in a critical phase, causes hemocyte cell reactions to carry out various body defense mechanisms: pathogen recognition, phagocytosis, melanization, and cytotoxicity [30] so that the THC content in shrimp in the SC plot can increase. The increase in hemocyte cells in the shrimp body plays a vital role in inhibiting or destroying pathogens that enter the shrimp body. The general condition of better water quality as a reflection of the complete disposal of organic waste through SC is thought to affect the THC content in shrimp, proven to be still harvestable as much as 3,833 kg. According to [31], water quality parameters and time of year are associated with environmental stress due to increased environmental pressure. Stocking density also affects shrimp THC, where shrimp physiologically responds to a high stocking density environment [32]. The research results by Direkbusarakom and Danayadol [33] showed that environmental stress due to low dissolved oxygen could have a significant adverse effect on the shrimp immune system and, therefore, cause disease outbreaks death. This indicates that the increase in THC is one indicator of the increased defense of the crustacean body.

The proPO content of shrimp in SC ponds was higher than in CD ponds. This indicated that the immune system of the shrimp in the SC plot was better than that of the shrimp in the CD plot. ProPO is a significant component of the innate immune system in shrimp. The cellular nonspecific immune system has two main components, the humoral and cellular systems, both of which work in tandem and are activated in the event of an immune challenge. The cellular component is mediated by hemocytes, while the humoral component involves independent components of hemolymph cells. Both are interactive and interrelated, which function synergistically to protect shrimp and remove foreign particles and pathogens. Among the various types of humoral immune responses, one of the most effective invertebrate immune techniques against foreign particles is cellular melanotic encapsulation. Melanization is a component of immune defense in crustaceans, where melanin synthesis activates the proPO system involving the PO enzyme [34]. The complex melanization sequence requires a combination of circulating hemocytes and several proteins associated with the prophenoloxidase (proPO) activating system. This system is one of the humoral elements that is often successful in overcoming diseases in invertebrates. Decreased proPO system activity can lead to failure of phagocytosis and cause tissue damage [35]. Plasma phenoloxidase (PO) activity was significantly increased in Taura Syndrome Virus (TSV) infected shrimp [36]. The research by Ekasari et al. [37] showed that PO activity was higher in shrimp reared in bioflock systems than controls. This proves that bioflocks positively affect the immune response so that vannamei shrimp have higher resistance to Infectious Myo Necrosis Virus (IMNV) challenges.

SC application is proven to reduce the organic waste load in ponds. This is reflected in water quality conditions where the average quality parameters in SC plots (TAN, nitrite, nitrate, phosphate, TOM, TSS) have lower values than CD plots. Better water quality conditions also affected the growth performance of shrimp in the SC plot, reaching a size of 63 pcs/kg higher than in the CD plot (size 78 pcs/kg). Sludge Collector is a means of complementing ponds so that its role depends on the commitment and discipline of pond operators in removing organic waste from the pond so that water quality can be controlled. Therefore, the application of SC in shrimp culture needs to be accompanied by improved aquaculture management.

5. Conclusion
The application of Sludge Collector to shrimp ponds has shown to result in a better quality condition such as total ammonia nitrogen, nitrite, nitrate, total suspended solid, and the culture performance of vannamei shrimp.
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