Design and implementation of waste cleaning automation system for the shrimp pond bottom

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Abstract. In intensive shrimp cultivation system, residual waste that settled at the bottom of the pond is impacting water quality. Therefore, there is a need to regularly clean this residual to maintain the water quality in good condition. In this paper we describe the automatic instrument system to clean up the bottom of the pond. This waste cleaning instrument uses the principle of equilibrium between the main component in the form of a pyramid and supporting components, namely the water container. The pyramid has a dimension of 2x2x1.3m and 4 poles that serve as rails and support for pulleys that hang both components. The framework of the pyramid is made of pipes and then the frame is coated with HDPE sheets and solar flat. The pyramid will go up and down in accordance with the water container, if it is filled with water and empty automatically because it is installed two submersible pumps to drain and fill the water container. From the field test results it was found that this instrument works effectively, where in one cleaning, it can be done in less than 5 minutes compared to conventional cleaning which takes hours.

1. Introduction
Shrimp is one of the excellent commodities in the world. Excellent commodity which means it has big prospects in the fisheries sector that can improve foreign exchange through exports of fisheries commodities. High demand for shrimp inside and abroad makes Indonesia as one of the largest shippers in shrimp world [1]. One of the most popular types of shrimp in the world is Vanname. Vanname shrimp is often referred to as white shrimp. Vanname shrimp is able to live in waters that have low to high salinity, then adapt to low temperature environments, and have survival which is high [2]. So that the shrimp is suitable for aquaculture activities conducted by fishpond entrepreneurs [3]. Vanname shrimp have high appetite and be able to utilize feed with low protein levels so the pattern of feed given can be adjusted to the pond culture [4].

In the times, a lot of human work has been helped with the technology, whether it's machines or robots that can work automatically without feeling tired. No exception in the field of fisheries, especially aquaculture, for example which is an automatic feeding machine. This machine is able to feed automatically by setting a schedule that has been determined by the pond entrepreneurs [5].

Workers are facilitated by these controls so as to facilitate the inside feeding shrimp. Feed given is adjusted to the conditions of shrimp feed requirements so as not to cause too much leftover feed settles at the bottom [6].

In this study will do the same thing, namely to facilitate the work humans in this case to clean the bottom of shrimp ponds from the remaining food settle which can cause a decrease in water quality. The instrument made will replace work cleaning the pond bottom previously done by workers ponds that suck up dirt directly in ponds.
2. Method
Designing and manufacturing has been carried out from March until July 2019, in the marine instrumentation laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Science, IPB University. This trial is conducted in one of pond in the coastal area of Kp Garung, Cigorondong Village, District Sumur, Pandeglang Regency, Banten Province.

2.1 Tool and materials
The table below shows tools and materials in this research.

| Table 1. The tool used in research. |
|------------------------------------|
| **Tool** | **Type** | **Category** | **Function**                                      |
| Laptop   | Asus X540 OS | Windows 10 64Bit | Designing software and schematic sequences and data processing |
| Soldering iron | 40W | Electronics | For soldering between electronic components |
| Adaptor | 5V 20A | Digital Multimeter DT-9205A | For measuring voltage and the relationship between components |
| Pliers Cut | Krisbow | Mechanical | Cutting wire, rope, iron |
| Scissors | Krisbow | Mechanical | Cut rope |
| Electric burrs | Krisbow | Mechanical | Cutting pipes |
| Electric welding | Krisbow | Mechanical | Connects iron |
| Blower | Krisbow | Mechanical | Connects HDPE sheets |
| Hacksaw | Krisbow | Mechanical | Cut HDPE |
| Electric drill | Krisbow | Mechanical | Hollow out the pipe |
| Arduino | V1.8.5 | Software | Designing software |
| SketchUp | V2018 | Software | Create instrument designs |
| Fritzing | V0.9.3 | Software | Creating an electronic sketch plot |

| Table 2. The material used in research. |
|------------------------------------|
| **Material** | **Type** | **Category** | **Amount** |
| Accumulator | 12Ah | Main materials | 1 piece |
| Arduino Uno | 3 pieces |
| Water container / drum | 200L | 1 piece |
| UBEC | 5V 3A | 1 piece |
| Pulley | 2 pieces |
| Module relay | Krakatu steel | Main materials | 4 pieces |
| Steel pipes 2", 3" dan 4" | Rucika | 4 pieces |
| Polycarbonate | Solar flat | 2 sheets |
| HDPE sheets | 30 m² |
| Water pipe | Galvanis | 3 meter |
| Stopwatch | 1 piece |
| Submersible pump | 30W | 2 pieces |
2.2 Mechanical design
The frame is formed using materials from pipes of various sizes ranging from measure 2 inches, 3 inches, and 4 inches. The pipe is filled using functioning sand to make the pyramid have enough mass so that the pyramid sinks in water. The outer layer of the pyramid is covered using sheets of HDPE (High Density Poly Ethylene). Then to make the covering stronger, then use gray flat type solar polycarbonate material with a thickness of 1.2mm.

![Figure 1. Design of the instrument and pyramid.](image)

2.3 Electronics design
This control box is made using a black electronic box made of plastic material. The components contained in this box include a microcontroller Arduino Uno, relay module, UBEC (Ultimate Battery Eliminator Circuit) and connectors connector that contains 6 pins. This box will be connected to a power supply or DC adapter 20Watt power to turn on the components that are in the control box.
2.4 Laboratory test  
Laboratory tests are carried out after the planning, design and tool creation has been completed. Laboratory tests are conducted at the Laboratory Workshop IPB Marine Instrumentation and Robotics as well as in the feed storage warehouse on site pond company. At this stage three tests will be carried out, consisting of robustness tests pyramid, water pump test and overall system test as the final stage carried out before being tested and applied in the field.

2.5 Field test  
Field testing and application of the design of the instrument system will be carried out at one of the vanname shrimp ponds belonging to CV. Usaha Tambak Sejahtera (UTS) at Kampung Garung, Cigorondong Village, Sumur District, Pandeglang, Banten.

2.5.1 Duration of cleaning. To calculate the cleaning time is done by measuring the time using a stopwatch from cleaning starts using conventional methods or chiffon until finished, then the mass is measured, then mass data is used in point 4. Then the results of the siphons are placed under the pyramid and measured using a stopwatch from the start Open the drain door until the door closes again.

2.5.2 Volume of water wasted. The procedure for calculating the volume of wasted water uses the following equation:

\[
\text{Wasted water vol} = Q \times t
\]

\[
Q = A \times V_t, \quad V_t = \sqrt{2gh}
\]

\[
A = \frac{\pi r^2}{g}
\]

where:
- \( Q \) = water discharge (m\(^3\) / s)
- \( t \) = length of time (s)
- \( A \) = pipe cross-sectional area (m\(^2\))
- \( V_t \) = the rate of water coming out of the pond (m / s)
- \( g \) = earth's gravitational force (9.8 m / s)
- \( h \) = depth or height of water surface
- \( \pi \) (phi) = 3.14
- \( r \) = radius of cleaning pipe (m)

2.5.3 Decreased pool water level. As for the calculation of the parameters of the decrease in water level can be calculated using the following equation:
\[ v = p \times l \times t, \text{ then } t = \frac{\text{Wasted water vol}}{p \times l} \]  

(2)

where:
\( t \) = decrease in water level (mm)
\( p \) = pool length (60m)
\( l \) = pool width (60m)

2.5.4 Percentage of cleanliness. Then the last for the calculation of the percentage of cleanliness parameters using the following equation:

\[ \text{Percentage} = \frac{\text{Min}}{\text{Mout}} \times 100\% \]  

(3)

where:
\( \text{Min} \) = mass of the inlet of waste put under the pyramid
\( \text{Mout} \) = mass of sewage outlets that exit at the disposal gate.

3. Results

3.1. Design and build results
The results of the design will be divided into three main components namely the pyramid, pulley system and control box. The first is the results of the design of the pyramid can be seen in Figure 4. The pyramid frame is made of pipe material which is filled with sand, then the outside is coated with sheets made from HDPE (High Density Poly Ethylene) and polycarbonate material with solar flat type. HDPE material is a material made of synthetic plastic that is hard, strong and can withstand temperatures low to high [10].

For attaching HDPE sheets, solar flat, and pipes, screws are used stainless steel type. This material is believed to be resistant to the rusting process because it has a low carbon composition and there is the addition of chromium material [11]. This is done because the pyramid will always be in condition dip or sink at the bottom of the pond. This pond contains water that has a salinity quite high because it comes from sea water and metal type material will be susceptible to rust by sea water. Because of the high salt content, sea water is very characteristic corrosive. The surrounding environment also has very aggressive metal high due to Cl ions carried into the air [12].

![Figure 3. The results of design and construction.](image)
The pipe pole in the picture is made with a height of 3.2 meters. This refers to height of the pyramid is 130 cm, then the total height of the container of water along with the strap is 125 cm. Pulley height is calculated from a hanging area of 25 cm. As well as the need to go up descend the pyramid a maximum of 30 cm. So that the total height of the pole is at least 3.1 meters.

3.2 The mechanism of the instrument

In conducting good shrimp farming, at least in the location of the pond must be there are 4 parts of the pool: the pond for the hatchery, nursery, circulation, and wastewater treatment plant. In this model the water that comes out of the pond must meet the water quality standards river in the estuary. Concentration of dissolved organic matter to a minimum so as not to ecosystem changes outside the pond plot [13].

Another important thing in conducting aquaculture in ponds is that there must be channels disposal. In an analysis of drainage calculations in the pond disposal area gravity systems and the principle of pressure in each pool are used [14].

![Figure 4. Model of a pilot farm design.](image)

Cultivation ponds at the study site were divided into two ponds, ponds for aquaculture containing vanname shrimp and harvest ponds or drainage ponds waste. The two ponds are connected by pipes that pass through the underground ones using the pressure principle of the two ponds, namely aquaculture ponds and ponds harvesting hereinafter will be referred to as “diamond”. In aquaculture ponds, mounted waterwheels on various sides that serve to direct the waste in base towards the middle area or hereinafter referred to as central drainage. In central drainage there is a pipe connected to the drainage pond. If the pipe on the diamond is opened, then waste in the central drainage will be sucked into the diamond.

The mechanism of action of the instrument is to move the pyramid up and down. The function of the instrument is so that when the cleaning process is carried out the pyramid will move down and waste will be trapped under the pyramid. This is done to prevent too many live shrimps from being sucked in when the cleaning process. The movement of the pyramid is controlled remotely using a relay module that is connected using a cable from the adapter or the power supply to the power source that gives the command to the microcontroller in the electronics box.

When the pyramid descends, the pipe in the diamond is opened so that the dirt along sucked waste. After the cleaning process is complete, the pyramid will be pulled again by pulley to move vertically upwards, and the pipe on the diamond is closed again. This is done so that no more water and even live shrimp will be sucked in through the underground channel. This research is a new research and there have been no studies on this matter before.

3.3 Laboratory test

3.3.1 Pyramid strength test. This laboratory test aims to ensure the pyramid is not broken or present leakage at any level of shrimp pond depth. This is due to height the water level in each pond is not always the same. Test carried out in 2 times replicate 5 and 10 minutes in stages with 3 different depths, respectively seen in table 1 below.
### Table 3. Test the robustness of the pyramid.

| Surface height (m) | Repeat | Duration (min) | Pyramid durability |
|--------------------|--------|----------------|-------------------|
| 0.9                | 1      | 5              | Success           |
|                    | 2      | 10             | Success           |
| 1.2                | 1      | 5              | Success           |
|                    | 2      | 10             | Success           |
| 1.5                | 1      | 5              | Success           |
|                    | 2      | 10             | Success           |

3.3.2 **Water pump test.** A water pump test is carried out to ensure the circuit of the electronic box is correct and also measure the time taken to fill and drain the water in the water container or drum.

### Table 4. Water pump test.

| Pump type  | Function      | Discharge (Fmax) | head   | t ()  | t real |
|------------|---------------|------------------|--------|-------|--------|
| GF-100N    | Fill the drum | 100L/minutes     | 2.7m   | 2 minutes | 2.61 minutes |
| GF-680     | Drains the drum | 250L/minutes | 1.0m   | 0.8 minutes | 0.68 minutes |

3.4 **Field test**

3.4.1 **Duration of cleaning.** In Figure 5, we can see a quite significant difference between the two methods. In manual or chiffon cleaning using humans, the average cleaning time ranges between 15-20 minutes and a maximum of 30 minutes. Whereas if you use this instrument, the maximum cleaning time is obtained within 2.5 minutes. This is clearly a pretty big difference. Using this instrument, cleaning can be done in a much shorter time compared to the manual chiffon method.

![Figure 5. Comparison graph of cleaning time duration.](image)

3.4.2 **Volume of water wasted.** The second parameter measured is the volume of water wasted during cleaning process. This is important to analyze because the water in ponds is necessary the quality is maintained by both physical and chemical physical parameters and nutrients, and sometimes it is given treatment with probiotic bacteria [15].
In Figure 6, it can be seen that there is a considerable difference between the two methods. In a single cleaning, on average from a manual chiffon consumes about 30,000 liters of water and even 40,000 liters when there is a lot of dirt and takes a long cleaning time. Meanwhile, if using an instrument, the volume of wasted water can be reduced to halfway, the experiment can be seen that the maximum wasted water is 26,170 liters. This difference cannot be separated from the duration of cleaning time. Comparison of water volume parameters is not too far like the time ratio due to the discharge of water that comes out during the cleaning process between the two methods. In conventional methods the water discharge is much smaller because humans use a 2.5-inch spiral hose to suck up dirt. Meanwhile, if the instrument, water along with the waste directly out through the central drainage pipe measuring 8 inches so that the flow of water is very large. Therefore, the volume of water wasted when using the instrument is not far away even though the difference in cleaning time is very large.

3.4.3 Decreased pool water level. The water level needs to be maintained to ensure that the depth of the pond is stable, this is due to the fact that water does not only decrease from the chiffon process, but also due to seepage of water at the base [16]. Although the pond system on the pond trials using tarpaulin systems or pool bases using HDPE material, fixed even there are parts that leak and allow water seepage and cause water level drops. Therefore, if the water level drops in the process cleaning the waste less and less, then the water level can be maintained its stability.

From Figure 7 it can be seen that the decrease in water level when using instruments, is maximum at 7.26 mm. Whereas if you use ordinary chiffon, the longest chiffon process causes the water to drop by 12.65 mm. This decrease in water is influenced by the reduced water volume (point 2), because the more water that is wasted, the water in the pond will be lower.

3.4.4 Percentage of cleanliness. In Figure 8, it can be seen that the ability to clean waste from equipment has reached an average rate of 90%. This can be categorized as good to replace humans in chiffon work.
Factors affecting it so that the percentage does not reach 100% can be assumed there is still some waste that is still stuck or settles in the area under the pyramid.

![Figure 8. Percentage of instrument cleanliness.](image)

4. Conclusion
Based on data from laboratory and field trial results, the instrument performed better in all test parameters, and able to work well in replacing human work in the siphoning process. For future work the system can be transformed into the IoT system (Internet of Things) so that the cleaning process can be accessed by portable and long-range using mobile phone via internet and website.

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