International Journal of Engineering & Technology, 7 (3.7) (2018) 613-616

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International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Evaluating the Efficiency of a Modified Solar Powered Pond Aerator System

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Abstract

In this contemporary world, fish may commonly die caused by warm water where the oxygen turns into a less soluble at an increased temperature or turns into a gas bubble from a carbon dioxide and ammonia which directly flow into the fish. One effective way to regulate fishkill is to guarantee the adequate amount of oxygen in the water. To lessen these pressing issues, if not to completely eradicate, a study to evaluate the efficiency of a developed Modified Solar Powered Pond Aerator System (SPPAS-500) had taken place. It is an apparatus that floats on the water which gives balanced oxygen level in the pond using the venturi air ejector technology. Furthermore, aside from direct utilization of the generated electrical power during daytime, the system also stores the surplus energy into the batteries for utilization during evening. The method used for evaluation is patterned with the data generated from application of the system in electrical and hydrological manner. Different instruments in measuring, testing and computing data are utilized to come up with significant, valid, reliable, authentic and accurate evaluation, analyses and conclusions. As a result, the SPPAS-500 is found to be capable of addressing the minimum aeration requirements needed by various size aquamarine enterprises.

Keywords: *Pond aerator, Fish kill, Venturi technology. Oxidation, Gas bubbles.*

1. Introduction

The primordial concern in fishpond farming is how to maintain the good condition and quality of pond water in order to increase the enterprise's profitability. One of the practices commonly used by the farmers in ascertaining the quality of water is through aeration system. Aeration pass through a procedure of transmitting air and water into a close contact which happen through exposure of thin drops of water into the air or through water upswing movement which produce small bubbles of air. Aeration removes specific dissolved minerals and gasses throughout the procedure called "oxidation". Thus, the common design of an aerator introduces an amount of water converted into air or vice versa. In addition, these aerators are made and designed in creating higher level of close contact through the water and air to be able to elevate the transferring of gasses
depending on the type of the used material. It is sometimes elevated through electrical or mechanical energy. These types of aerators which come in a variety are utilized in fishpond operation such as bubbler, splashed, and the pump type. Typically, fishponds are geographically located away from the electric power lines. This allows tapping the potency of each renewable types of energy, like a solar energy in which the Philippines has abundance by having a recorded annual average solar radiation of approximately 4.7 kWhr./m2/d with monthly variation of 9.2%.

1.1. The Solar Powered Pond Aerator System Project or SPPAS-500

As an intervention, the researchers initiated the development and testing of a modified technology generated study called Solar Powered Pond Aerator System project or better known as SPPAS-500 that will be of great importance in fishpond operation as an economical alternative for aeration system enhancement. The SPPAS-500 system is a material with self-contained aerator unit which floats and pumps on water surface to provide consistent level of oxygen in the pond. The five main components of the aerator are: (1) its main cradle or base, (2) the dc aerator motor and venturi type pump assembly, (3) solar panel and controller, (4) the battery bank, and (5) electronic controller circuit.

Fig.1: The completed modified solar powered pond aerator assembly

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The major feature of the pond aerator is the application of an improved venturi system in the air ejector process which provides sustained level of oxygen in the water. This is one of the latest eco-friendly innovations and contributions to the promotion of green technology approach to pond management and other related aerating applications. The pond aerator system is totally operated using solar power system that produce a minimum of 500 gallons of water per hour (500 GPH of water flow) and 1 cubic feet per minute (CFM) of air induction. It operates during day time where solar energy is harnessed through the use of solar panels and functions efficiently in the evening making use of the surplus energy stored in the batteries.

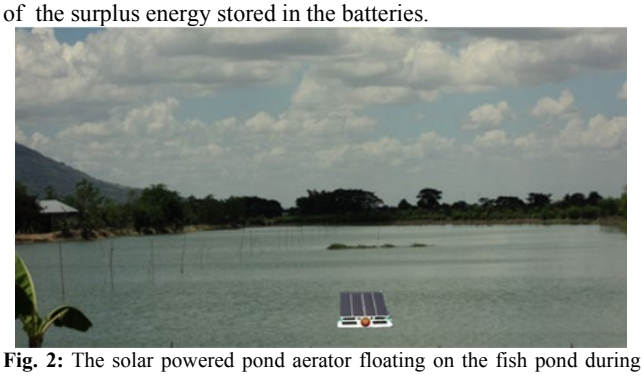

Fig. 2: The solar powered pond aerator floating on the fish pond during the testing and evaluation stages of the study.

Another interesting component of the device is the water pump instinctively designed to discharge ample amount of water through a low-pressure nozzles that produces pressures which allows air to merge in turbid water resulting to a transfer of a higher amount of dissolved oxygen.

1.2. Problem Statement

One of the problems of fishpond farming is the high level of concentration of dissolved oxygen in a pond. The insufficiency of dissolved oxygen under the surface of the water triggers fish to swim into the water surface. Cooler water makes a better capacity to hold more dissolved oxygen compared with warm water. As the temperature of water increases, the water holds less and less dissolved oxygen. That simply means that oxygen is less soluble at higher temperature of water. With this, fish may result to death sometimes because of a warm water, carbon dioxide or also known as "ammonia" or which turns into a gas bubbles in the fish's bloodstream. Rotting algae or weeds, as an outcome in using algaecides or herbicides, may also cause temporary lack of oxygen. The best way to regulate and to prevent the causes of fishkills then is the assurance of adequate dissolved oxygen which is transmitted in the pond.

As reported by the Bureau of Fisheries and Aquatic Resources (BFAR), worst fishkill incident in the Philippines happened on May 30, 2011 in Dagupan and Bolinao, Pangasinan losing more than 850 metric tons of cultured tilapia and milkfish in just three days (as shown in Figure 3).

Fig. 3: The fish kill in Bolinao, Pangasinan, Philippines

In a similar study conducted by Singian, A.B (1999), he made used of the reported cases of fishkill as a critical issue for fishpond owners which requires immediate action, especially by technology experts. This paved way for the introduction of costly pond aerators in the market which small pond owners can hardly afford.

The problem prompted the researchers to develop a modified and much cheaper 500 Gallons per Hour solar powered pond aerator system. The device was subjected to initial testing to determine its functionality. However, deeper evaluation of its efficiency was recommended to determine the usefulness and acceptability of the device to the small fishpond operators.

Specifically, the study aimed to evaluate the efficiency of the SPPAS-500 in terms of: (a) harnessing solar energy to power-up a type of pond/ water aerator, (2) invigorating the fishpond condition by producing sufficient amount of oxygen by using the venturi tube type system, (3) examining the economic and environmental impacts of the research output, and (4) assessing its contribution to the promotion of green technology in the field of aquamarine business.

2. Materials and Methods

The study comprises of the evaluation of the efficiency of the modified 500 GPH Solar Powered Pond Aerator System. The device was installed in the fishponds located at Barangay Kabuhatan, Orani, Bataan in the Philippines to test and evaluate the project regarding its actual performance.

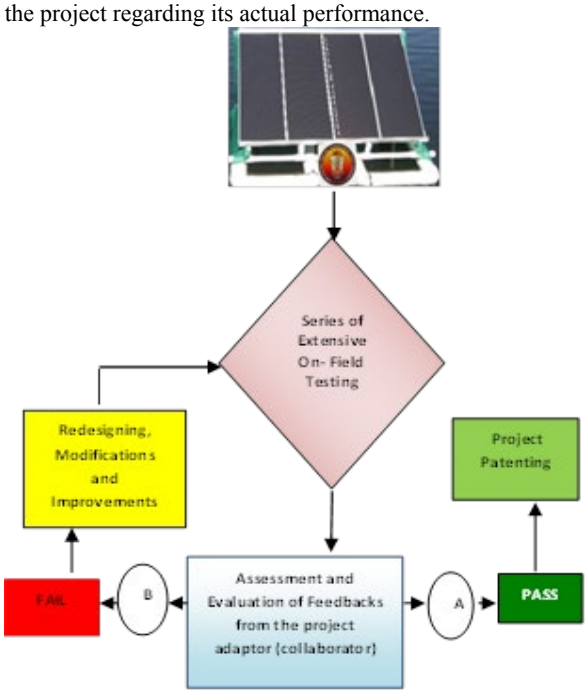

Fig.4: The evaluation and testing process flow chart

The researchers conducted unstructured interviews and fielded questionnaires to determine the need of fishpond operators for the equipment. Off-site and on-site project system testing and performance evaluation were likewise conducted.

2.1. Program Strategies, Management, and Process

The efficiency of the modified pond-aerator project is dependent on the end-users. The testing, evaluation and patenting work flow (as shown in Figure 5) was adopted by the researchers in evaluating the management practices of the end-users, collaborators, and production personnel.

3. Results and Discussion

A test pond was used for production of prawns, crabs, milkfish and tilapia in ±10,500 square meters pond area. It had four parts: one is for master pond and the three parts for enlargement ponds. All aerator loads are supplied by the generated solar power system. The pond aerator is concentrated to the 7,875 m² enlargement pond. It is essential especially during night time where the oxygen is in its lowest point in the pond is experienced. To secure the pond during evening, the exterior lighting system is installed.
The study is conducted in four months divided into 2 phases. First phase covered 2 months (60 days recorded peak of rainy season) and Phase 2 covered the 2 remaining months (60 days considered peak of summer). During the two phases, data on the quality of water are continuously recorded using instruments for testing which are suspended a meter above each pond. The maximum point is reached where nothing can be added as the air components dissolve in the water. This is called saturation.
The approximate saturation level for oxygen is at 50° F. is 11.5 mg/l, at 70° F., 9 mg/l, and at 90° F., 7.5 mg/l. Impurities mixed to the water decrease the saturation levels.

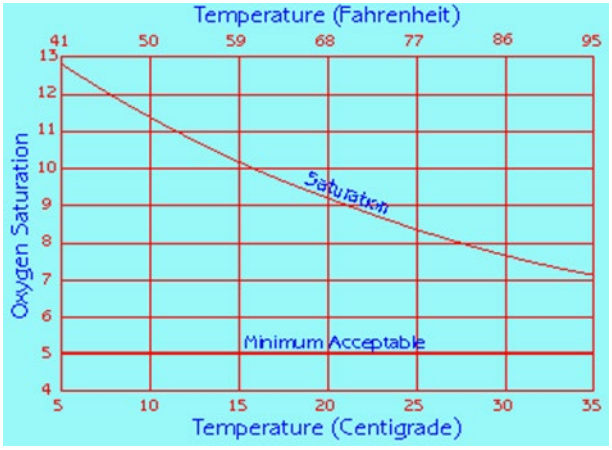

Fig. 5: Oxygen Saturation vs. Temperature

At less than 4 kilograms of salt per hundred gallons of water (5 ppt), it has a recorded decrease in oxygen saturation levels of 13 mg/l. The overall system losses is calculated with the following assumptions: battery efficiency is at 90%, inverter efficiency at 85%, and wiring efficiency at 93%, with the total load calculated as 2.378 Wh. based on the equation below:

$$\text{Total Load} = \frac{\sum \text{Edemand}}{\text{bat} \times \eta \text{ I inv} \times \eta \text{ wire } \eta}$$

The reserved power energy stored in battery's loading system and more loads can still be connected into the main system circuit.

Reserve Capacity = Battery Capacity – Maximum Demand
Daily Average Load = (Unit generated per day)/ (24 hours)

The oxygen transfer efficiency (OTE) of a diffuser system is a function of its depth in the ponds. Typically, an OTE of about 1.6% per meter of depth is found for fine bubble diffusers in a pond setting. This means that 16% of the air added to a depth of three meters will be transferred actively into the water, while 84% will just be spare that will produce bubbles going to the pond surface.
The four major indicators were carefully analyzed and presented, following the parametric results:
Performance. The aerator's nozzles infuse significantly huge volume of air bubbles that contains oxygen which is dissolved at the bottom of the pond. This is based on venture principle.
Functionality. Associated accessories can deliver at least 24% of oxygen to every volume of air pumped into the pond.
Usability. It can be simultaneously used as an alternative source of electrical energy to light up interior and exterior lightings fixtures especially during the night time of not exceeding 80% of its capacity rating.
Reliability. The operation manual is provided to guide the user on how to use the system to ensure continuous supply of needed fish pond aeration and its secondary loading systems.

3.1. Socio-Economic and Development Benefits

This modified Solar Powered Pond Aerator System directly benefited the small to medium scale fish growers especially those who are living in the lowland areas and cannot afford to buy the expensive commercial type of aerator system.

3.2. Direct Benefits

The project will provide employment for unemployed or underemployed young adults during the implementation and mass production phase of the project, especially those who will be hired for the fabrication, assembly and installation works.
There will be an increase in the supply of the project based on the need of the consumers thereby affecting prices of existing costly commercialized pond aerators which is favourable for small end-users.
There might be additional function of this technology that can be discovered by future researchers aside from providing alternative energy for effective livelihood activities.
Lastly, the project created a sense of involvement and awareness among the residents of the community and furthered the advocacy on environmental stewardship.

3.3. Indirect/Other Benefits

The government will also benefit from this project considering the employment opportunities for unemployed citizens, the cost of transactions involved, and the taxes that will be generated if the project will be mass produced.

4. Conclusion

Based on the result of the study, the following conclusions were drawn: the solar powered pond aerator system is proved to be an efficient self- contained floating pond aeration device that can efficiently provide horizontal and vertical air circulation attributed to its improved venturi nozzle design; sufficient aeration should be provided in the pond so that all areas have proper oxygenation; the project efficiently function within the ten hours per night operation using the stored power from the batteries, and finally, maintenance of the solar powered pond aerator system is easy which can be done even without using special tools.

Acknowledgment

The authors would like to express their sincerest thanks to the owner and caretakers of the fishpond located at Barangay Kabuhatan, Orani, Bataan, Philippines who willingly and actively participated in the conduct and completion of the study.

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