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Post-Harvest Loss Reduction of Fishes during Live Transportation Using Advanced Aerator

Sazzad Mahmud Rifat[1], Dr. Muhammad Ashik-E-Rabbani[2], Md. Samiul Basir[1] and Dr. A. K. M. Nowsad Alam[3]

[1]PG Student, Faculty of Agricultural Engineering and Technology, Bangladesh Agricultural University, Mymensingh-2202
[2]Professor, Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh-2202
[3]Professor, Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh-2202
E-mail: sazzadrifat43637@bau.edu.bd, ashiks424@yahoo.com,*
ronoturjosami@gmail.com, andnowsad12@yahoo.com

Abstract—*Bangladesh has become one of the biggest fish producers securing 3rd place among the inland fish producing countries. However, the report on post-harvest losses of fresh water fish is shocking. On the other hand, consumption of live fishes is increasing now-a-days. A recent study shows that about 28% of fish lost itsfreshness quality during handling and transport with about 7-19% loss inpost-harvest operation. This study was undertaken to develop an advanced, cheap and lightweight aerator-cum-oxygen-accumulator device that can run by the power of the vehicle engine for live fish transport. A 12-volt 3-ampere DC motor operated 1100 GPH bilge pump was modified with the venturi principle to construct the aerator. The experimentwas conducted to evaluate the level of dissolved oxygen in water for live fish transport and compared the results in a condition of with and without aerator. For this analysis 45(forty-five) numbers of Rohu fish (Labeo Rohita) having an average weight of 378 gm were kept in a transportation tank of 650-liter water. The amount of oxygen concentration in water was measured in both conditions after six hours of the trial period. At the very first beginning, the level of dissolved oxygen was 6.5 mg/L. With the progression of period by using aerator cum oxygen accumulator, the level was 9.3 mg/L. On the other hand, without the device, the amount of oxygen was 2.2 mg/L, which is fatal for fishes, thus lean towards to a mortality rate of 11.11%. Water temperature fluctuation was insignificant during the experiment. Results indicate that for enhancing the level of dissolved oxygen during live fish transport for reducing losses of fish, increase the income of fishermen and boost up national income the device is proficient.*

1. Introduction

The fisheries sector plays a unique status in Bangladesh economy contributing to the socio-cultural setting, rural employment and food,and nutritional security. Bangladesh holds fifth place in aquaculture production with a total production of 413.4 million MT (Fisheries Statistical Yearbook 2016-17), where aquaculture contributes 56.44 percent to total production. Government is trying to sustain this growth performance, which eventually ensures to achieve the projected production target of 4.55 million MT by 2020-21. This sector having more or less consistent growth rate, ranging from 7.32% growth in 2009-2010 to 4.04% growth in 2013-2014 (Bangladesh Economic Review, 2014).

Different programshave been taken by the government to increase the production of inland culture, inland capture (open water) and marine fisheries. In spite of all positive measures taken towards increment of production, post-harvest loss of fish in the country is also enormous. Every year about 25-30% fish and fishery products are thought to be lost due to various reasons [5]. This loss is because the government has concentrated her all-out efforts to increase fish production only, not to improve the quality situation or loss reduction of the fishes consumed in domestic markets. This huge loss in fisheries obviously exerts immense pressure on food security of the country, which requires immediate attention to resolve. Although rooms exist to triple the fish production, the present post-harvest loss is devastating,a 50% reduction of such loss can save Tk.8000 crore per annum [5].

Every year the small-scale fisheries in developing countries suffer from huge post-harvest losses. Studies revealed a very high level of post-harvest loss during pre-processing, processing, storage and transportation of fishery products [4]. The post-harvest quality loss in wet fish occurred, based on different species and seasons, from 7- 19%, with an average loss encountered, was 12.5%. When the fish was landed and sold to the nearer consumers within a few hours of harvest, the post-harvest loss was negligible. The longer the distance, the higher was the loss. From previous assessment study of losses, fish did not lose quality during handling by the fishermen, and fish farmers or at landing centers and primary fish markets, except fresh T. Elisha destined for the consumer market. Most of the quality losses were initiated at the transporters and commission agents from 4%-11% [6].

The most essential single factor in transporting fish is providing an adequate level of dissolved oxygen. Fish transport systems mostly contain water with oxygen levels that do not provide enough oxygen required to satisfy the fish bodies. The most favorable amount of dissolved oxygen in the case of transport fish is 5mg per liter [2]. If this amount of oxygen is supplied to the transporting fish, the loss due to lack of oxygen can be reduced largely. By adding oxygen and circulating water, required oxygen can be supplied. Thus, fish can be transported live with least waste.

Fishes are typically transported to processing plants or retailer shop at high densities (0.7 to 1.0 kg/L) in order to minimize transport costs. For short transport times (1-4 h), transport water aeration is usually provided by a diesel-powered regenerative blower that forces large volumes of ambient air through the transport tanks and generates considerable turbulence. Use of blower aeration is harmful and dangerous. The major water quality effects experienced by fish during transport are low dissolved oxygen levels due to oxygen consumption by respiration; an increase of carbon dioxide from respiration; depression of pH caused by carbon dioxide accumulation; and increased ammonia levels resulting from ammonia excretion [7].

Nowsad (2010) has studied that after harvesting rough handling (15%), compactness (3%), delay icing (10%), no icing (45%), marketing process (15%) and transportation (7%) lead to loss of a major proportion of total quality. So around 5-7% of total harvested fish are lost for the poor transportation system, long-distance, bamboo basket, dirty plastic box, compactness of fishes and mass handling [3]. Every year 10% total world's fish is lost due to improper handling, processing and preservation lacking. Improve fish handling can be very effective to utilize the whole world's fish catch.

Live fish transport is important in the purpose of Bangladesh as traditional transport system creates serious economic loss and degrades the quality of fish. As a result, the price of fish gets down. If fishes are transported live then there will be no headache for quality and freshness and the price of fish will be beneficial for the fisherman, thus national income will rise.

The objective of the study was to reduce post-harvest losses by transporting fishes live. For this reason,a aerator-cum-oxygen-accumulatorwas used for improved live fish transport system with least physical stress to minimize economic losses, test the performance of the device and compare different parameters by using the device and traditional method of live fish transport. These achievable objectives would lead to improve the technical capacity of the primary stakeholders, reduce huge post-harvest loss, increase protein-food supply and enhance income for the poor fishers, traders, and processors and enhance the economic growth through sustainable handling and processing systems.

2. Materials and methods

The device was fabricated and tested at the workshop of Farm Power and Machinery department, Bangladesh Agricultural University. It was a test model of Aerator-Cum-Oxygen Accumulator device that was made by the materials whichwere available in the market.

2.1 Schematic diagram of Aerator-Cum-Oxygen Accumulator

The schematic diagram of Aerator-Cum-Oxygen Accumulator was designed using Fusion 360 3D design software. Fig. 1 shows the design of Aerator-Cum-Oxygen Accumulator.

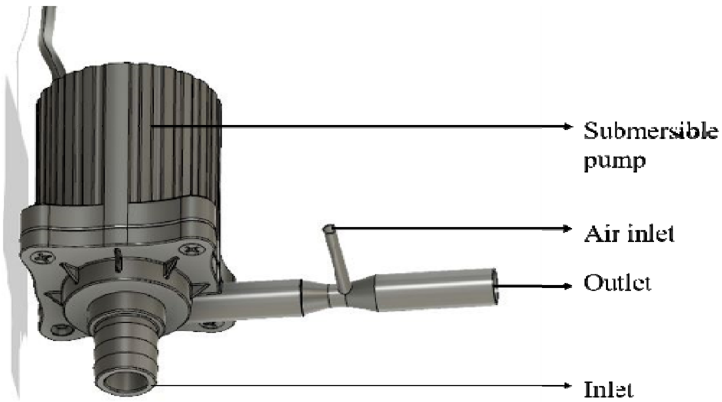

Figure 1: Schematic diagram of the aerator-cum-oxygen accumulator

2.2 Fabrication of Aerator-Cum-Oxygen Accumulator

The major materials required to fabricate the machine were a submersible pump, PVC pipe, PVC female reducer, rubber tube. The specification of aerator-cum-oxygen accumulator is given in Table 1.

Table 1: Specification of Aerator-Cum Oxygen Accumulator

Name	Specification	Material	Nos.
Submersible Pump	12V, 3-amp bilge pump, 1100GPH discharge Weight: 362.87gm High: 10.7 cm, Diameter: 6 cm with 2.9 cm, (1 1/8 ") bore hose.	Casing: Plastic body with integrated sieve Impeller: Plastic	2
Venturi	Inlet and outlet Diameter :1.91cm Length: 0.50cm Throat diameter: 1.25cm Throat length: 4cm	PVC pipe	2
Rubber tube	Diameter: 0.8 cm Length: 30 cm	Rubber	2
Outlet pipe	Length: 25cm Diameter: 1.91cm	PVC pipe	2

The submersible pump used was a bilge water pump. Two PVC reducer was attached face to face to make a venturi for pressure drop. The venturi was attached by one end to the pump outlet. The other end of the venturi unit was joined with a PVC pipe of 25cm length. At the divergentend, a hole was drilled and a rubber tube was added to accumulate ambient air. Water pressure drops and air mixes with water at the venturi unit following the venturi principle [1].

2.3 Laboratory Test Setup

The materials needed for a laboratory test are transportation tank, plastic covering, vehicle dynamo, battery, 12v relay, Aerator-Cum-Oxygen Accumulator device and most importantly live fish. Table 2 describes the materials used for the laboratory test in detail.

Table 2: Detailed information about the laboratory test setup

Name	Specification	Nos.
Transportation tank	Dimension: Length:207.26cm Width: 106.68cm Height: 30.48cm Amount of water: 650 litter	1
Triple or plastic sheet	365.76 cm×304.8 cm	1
Truck dynamo	-	-
Battery	Model: Lucas Classic NX120-7 Voltage: 12 AH (ampere hour): 80	1
12v relay	5 Pin,12v DC Relay	1
Aerator-Cum-Oxygen Accumulator device	-	-
Fish	Fish: Ruho(Labeorohita) Total Weight of Fish: 17kg Average weight of fish: 378g	45

Fig. 2 describes the power supply unit to operate the Aerator-Cum-Oxygen Accumulator device. When the vehicle was in operation, the device got electric power from vehicle dynamo. However, when the vehicle was static and the engine was stopped, the relay changed the circuit and power supply unit switched to the battery of the vehicle.

In laboratorytest, setup a tank was used to carry water and fish. Polythene cover was used to confine the water in the tank and seal the leakage of the tank. Live fishes were collected from a local pond.

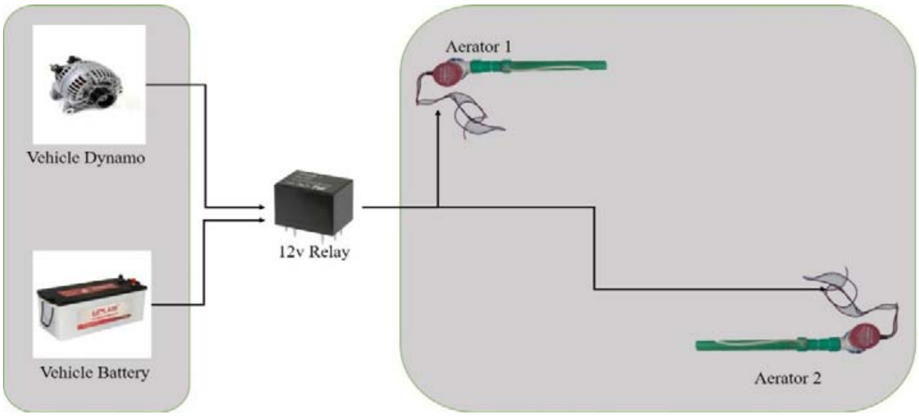

Figure 2: Schematic diagram of aerator-cum-oxygen accumulator device set up

2.4 Parameter Testing

To assess a study or work some parameters needs to be tested. The parameters that were tested in this study are the mortality rate of fish, DO (dissolve oxygen) level, temperature and pH level.

2.4.1 Mortality rate

The most imperative parameter for evaluating this study is mortality rate with respect to time. The mortality rate of fish was inspected visually and calculated against the total number of fishes that were used in the experiment. The mortality rate was calculated by-

$$\text{Mortality rate } (\%) = \frac{\text{No. of dead fish}}{\text{No. of total fish used}} \times 100 \qquad (1)$$

2.4.2 DO (dissolve oxygen) level

The fluctuation of DO was measured by a portable dissolved oxygen meter named Lutron Do-5509 Dissolved Oxygen Meter with an accuracy of ± 0.4 mg/L and resolution of 0.1 mg/L.

2.4.3 Temperature Measurement

The temperaturewas measured by a temperaturesensor, which was collaborated with a microcontroller (Arduino-UNO). A waterproof DS18B20 Digital Thermal Probe or Sensor was used as a temperature sensor and a 10K resistor was used to control electrical current.

2.4.4 pH sensor

At the time of live fish transport, respiration level and feces are increased because of stress. Hence, the pH level of water is changed. The oxygen concentration of water also depends on the pH level of water. The pH level of water was measured using a pH meter. Hanna Pocket Sized pH Meter Hi96107 was used to measure pH of water and recorded in a computer.

2.5 Experimental setup for performance test

The first experiment was done with no load condition i.e. the only aerator was used with no fish. In the secondcase, only the fishes (17kg) were loaded in the transportation tank without any aerator. At last, fishes were loaded in the transportation tank with the aerator device as the third case. Fig. 3 describes the experimentalsetup and fish welfare at the time of experiment.

Figure 3: Live fish transport with aerator cum oxygen accumulator.

3. RESULTS AND DISCUSSIONS

3.1 Fabrication of aerator-cum oxygen-accumulator

Aerator-Cum Oxygen-Accumulator was battery or dynamo operated device which consists of a submersible pump, a venturi (two reducers jointed together) and an air tube. Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section (or choke) of a pipe. Fig. 4 shows the laboratory test model of Aerator-Cum Oxygen-Accumulator device. Parameters related to live fish transport was calculated and compared with normal live fish transport.

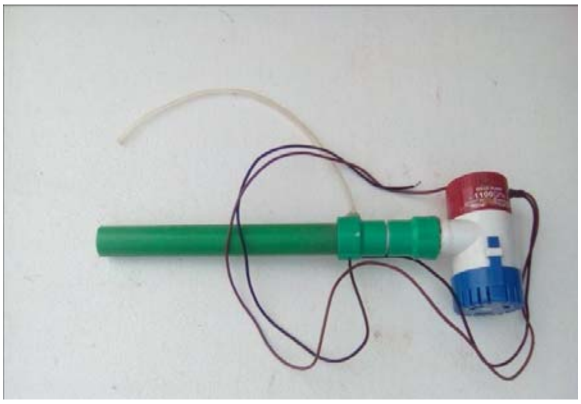

Figure 4: Aerator-Cum Oxygen-Accumulator device

3.2 Laboratory test results

There are some factors governing for the performance evaluation of Aerator-Cum Oxygen-Accumulator device for live fish transport. i.e:

- Source of water (pond water),
- Condition and density of fish (good condition and 35 kg/m^3 fish density),
- Air temperature (considered as similar, 24°C),
- Fish handling,
- Distance and route of travel and
- Fish variety and size (*Rui* fish and almost similar in size).

3.2.1 DO (dissolve oxygen) level

From table 3, the dissolved oxygen level increases with time for the first case. The oxygen level at load condition with no aerator, decreases with time as there is no supply of oxygen to be dissolved in water. But, in the third case, the oxygen level was maintained at an average rate of 8.48ml per liter of water with a standard deviation of 0.76. From the comparison, it is clear that Aerator-Cum Oxygen-Accumulator device performed satisfactorily for live fish transport as the oxygen level of water remains in the fish welfare zone (>5ml/L).

Table 3: Level of DO (dissolve oxygen) in three cases of laboratory test

Time	Dissolve oxygen level(ml/lit)		
	NO Load with aerator	Load without aerator	Load with aerator
First hour, t_0	6.2	6.5	9.5
Second hour, t_1	6.5	6.2	7.9
Third hour, t_2	7.4	5.7	8.3
Forth hour, t_3	8.5	4.5	7.5
Fifth hour, t_4	8.9	3.5	9.2
Sixth hour, t_5	9.3	2.2	8.5
AVG.	-	-	8.48
SD.	-	-	0.76

3.2.2 Temperature

Fig. 5 defines the graphical representation of water temperature level at the time of the test. Graph reveals that, at all load conditions, the temperature increased by the time as atmospheric temperature was increasing. Besides, as ambient air was mixing with water, the temperature also increased. But from the graph, it can be said that the temperature at load condition with aerator increases slower than other condition.

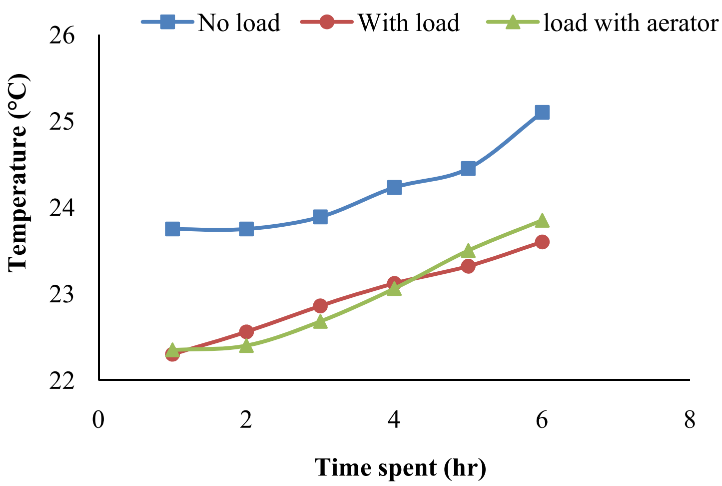

Figure 5: Graphical representation of temperature

3.2.3 pH measurement

At no load condition, as there is no living organism like fish in the water so the pH level of water was almost the same (average 7.2). At only load condition without an aerator, for the fishes and its metabolism, the pH level of water was gradually changed against time. At the last hour, the pH level was hazardous for fishes. For the third condition, load with aerator, as water was circulating, the pH level of the tank water was fairly constant with minimum fluctuation. Fig.6 describes the level of pH in three cases.

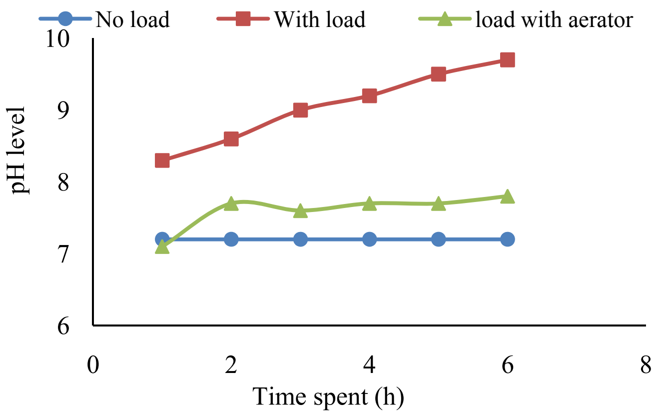

Figure 6: pH level in three conditions.

3.2.4 Mortality Rate

At load without aerator condition, the total number of fishes was 45(forty-five). After six hour of test 5 (five) fishes were dead due to low dissolved oxygen in the tank. The mortality level of this condition was 11.11%. At load with aerator condition, the total number of fishes was 40(forty). After six hours of test zero or no fish was died. Thisonly happened for having enough dissolved oxygen in the water for using the device. So, the mortality level of this condition was 0%. Even after completing the test, around 8 hours later the number of live fishes was unchanged.

4. Conclusion

For transporting live fish, it is necessary to provide oxygen and circulate the water. The concentration of dissolved oxygen is an important indicator of water quality because aquatic life lives on the dissolved oxygen in the water. Aeration can increase dissolved oxygen when levels become deficient. By using the device above two criteria are fulfilled. In load condition without an aerator, the Do level was 2.2 mg/l, which is lower than demand, and pH was at 9.70 that is fatal for fishes, as the favorable pH level of fish's lies between 6-9.5. This leads to a mortality rate of about 11.11%. On the other hand, load with aerator-cum-oxygen accumulator creates a fish welfare atmosphere. In this study, it was found that after six hours in this situation oxygen level in water was 8.5 mg/l and pH was 7.80. As the study was undertaken in laboratory, further work will be done to operate in field level. This indicates that the device is worthy for live fish transport and if fishes can be transportedlive then losses will be small, fishermen will be benefitted and national income will be increased. Besides, it is lightweight, easy construction, negligible maintenance and runs by the power of the vehicle engine.

5. Acknowledgement

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