CONSTRUCTION AND PERFORMANCE EVALUATION

OF A POND SLUDGE REMOVER

A THESIS

BY

SHAKE SHAHIDUR RAHMAN

Examination Roll No.: 1605554

Session: 2016-2017

Thesis Semester: July-December, 2018

MASTER OF SCIENCE (MS)
IN
IRRIGATION AND WATER MANAGEMENT

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

HAJEE MOHAMMED DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

DECEMBER, 2018

CONSTRUCTION AND PERFORMANCE EVALUATION

OF A POND SLUDGE REMOVER

A THESIS
BY

SHAKE SHAHIDUR RAHMAN

Examination Roll No.: 1605554
Session: 2016-2017
Thesis Semester: July-December, 2018

Submitted to the Department of Agricultural and Industrial Engineering
Hajee Mohammed Danesh Science & Technology University, Dinajpur
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)
IN
IRRIGATION AND WATRER MANAGEMENT

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

HAJEE MOHAMMED DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

DECEMBER, 2018

CONSTRUCTION AND PERFORMANCE EVALUATION

OF A POND SLUDGE REMOVER

A THESIS

BY

SHAKE SHAHIDUR RAHMAN

Examination Roll No.: 1605554

Session: 2016-2017

Thesis Semester: July-December, 2018

Approved as to the style and content by:

(Professor Dr. Mohammad Shiddiqur Rahman)
Supervisor

(Dr. Md. Ayub Hossain)
Co-supervisor

Chairman, Examination Committee and
Chairman

Department of Agricultural and Industrial Engineering
Hajee Mohammad Danesh Science and Technology University, Dinajpur

December, 2018

DEDICATED

TO

MY BELOVED PARENTS

&

HONOURABLE TEACHERS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 Background

The fisheries sector is the second largest part-time and full-time business in rural areas, directly engaging over 60% of the country side population in Bangladesh. About 57% Bengalis' protein comes from fish and annual per capita fish intake is 17.5 kg against a suggested minimum requirement of 21.0 kg/year; hence there is still essential to expand fish consumption in the country (FAO, 2014). Fish price is remaining within the financial reach of the common people and there has been a 100% increase in intake of fish over the past 10 years. Inland fisheries production has increased over the years, but the productivity per hectare water area is not yet attained at its optimum. In recent years, the bulk of the production has been obtained from marine (16.78%) and freshwater (83.22%) wild capture fisheries. In 2015–2016, Bangladesh was the 5th in world aquaculture production, which accounted for half of the country's total fish production (55.15%) (DoF, 2016). In 2014–2015, total fishery production of Bangladesh was 3,684,245 metric tons, of which 1,023,991 metric tons was obtained from inland capture fisheries, 2,060,408 metric tons from inland aquaculture and 599,846 metric tons from marine water production (FRSS, 2016). Bangladesh has ranked third in the world in terms of inland fish production in 2018(FAO, 2018), according to a report by the Food and Agriculture Organization (FAO). Initiatives by the government and NGOs to motivate farmers also facilitated farming for common carp, pangus, monosex tilapia and shing (Cat fish) in regions such as Mymensingh, Jessore, Comilla and northern districts of Bangladesh. Belton *et al*. (2011) reported that 4.27 million households (20% of rural inhabitants) operate a homestead pond, covering a combined area of 265,000 hectares. Commercial semi-intensive carp culture covers an area of 110,000 hectares, and intensive forms of entrepreneurial pond culture cover 15,000 hectares. An estimate derived from this source that around 399,000 tons of fish are produced from homestead ponds; 390,000 tons from commercial semi-intensive carp culture; 395,000 tons from pellet fed intensive systems; and 98,000 tons of shrimp and prawn (FAO, 2018). But day by day for the increasing population of Bangladesh the requirements of fish are increasing. Again there is a big foreign market available for the exporting fish in different countries. In FY18, Bangladesh earned Tk 4, 500 core by exporting around 69,000 metric tons of fish and fish products (FAO, 2018). So the production increase can be an increase of foreign revenue, which will keep a great contribution in Bangladesh economy. So the increase of aquaculture can be a great solution for gaining this great result. But the land area of Bangladesh is limited. So there is a topic of thinking how the production quantity can be increased as well the cost can be minimize without harming the quality of fish. The ponds which are used for inland fish farming is not producing the maximum yield. The amount of fish in a same pond can be increased up to three times more by practicing Intensive aquaculture.

Compared to rice, the price of fish is increasing rapidly specially for carp. Most of the rural poor just cannot afford to buy fish and as such are severely animal protein deficient and consequently malnourished. But the prices of pangus, tilapia and koi remain comparatively lower than other fishes and the price is within the purchasing capacity of the urban and rural low-income people. So, these fishes are now considered the main source of animal protein in Bangladesh. In fact, in a country like Bangladesh where fish culture has a long tradition, pond fish culture plays an important role in supplying increasing fish needs of the people (Chowdhury and Maharjan, 2000). It is very important to increase the production in pond fisheries with controlled water bodies as ponds and tanks through the introduction of modern and intensive culture method. Hence, pond fish culture has become a major income-generating element in rural development programs and supplemented with crop production and animal husbandry. This could in thus improve the quality of life of the rural poor in Bangladesh. Therefore, in the pond fish culture system, especially pond water should be clean for sustainable production of healthy fish and maintain pollution free environment.

There are two types of technical limitations to pond fish production: abiotic (e.g., problems with water, soil, temperature, etc.) and biotic (e.g., pests, predators and disease). Dey *et al*. (2005) estimated the annual financial loss caused by the various biotic and abiotic factors is about $243/ha. They also suggested that abiotic constraints are more important than biotic constraints to freshwater aquaculture development in Bangladesh. One of the main problems in abiotic problem is deposition of aquaculture sludge in fish pond. Aquaculture sludge is composed of fish waste and uneaten fish food that settles at the bottom of the fish pond (Birch *et al*., 2010). DHI group (2015) reported that sludge from fish farms originates from three origins: fish feces, drum filters and bio filters. Particularly in recirculated fish farms significant sludge production takes place. It typically has a high content of fat and volatile suspended solids. Dewatering and managing the sludge is a challenging task, as it is very unstable. They also reported that an average to large land-based fish farm (1000 tons feed/year) can produce up to 15 tons of sludge (dry matter) each month equivalent to 150 m^3 wet sludge (10% TS in wet sludge) with approximately 200 g of suspended solids (SS) per kilogram of fish feed. This sludge needs to be managed and discarded properly for desirable growth of fish.

Abdelhamid *et al. (*2014) reported that regardless of fish species, feeding fish in sewage sludge led to significantly lower values of growth performance compared to those fed in the clean water. Much contamination could be occurred in humans by consuming fish reared under polluted water conditions or fish fed contaminated diets (Abdelhamid *et al.*, 1996, 1999). Davidson and Summerfelt (2005) reported that accumulation of solids within aquaculture tanks and systems can promote an environment that harbors fish pathogens.

Ahmed *et al*. (2015) conducted a study at Trishal and Valuka of Mymensingh district and identified 55 different types of aqua-drugs and chemicals, among those, 20 types were widely used by the farmers for different fish disease treatment to reduce fish mortality. It was recorded that renamycine, cotrim vet, ossi-c, polgard plus and timsen were used for the treatment of EUS (Epizootic ulcerative syndrome) in pangus, tilapia and koi which had an average recovery of 75-85%. They also conducted histopathology test of gill and liver of fishes and were found almost normal in control ponds, whereas, in drugs treated ponds the organs had pathological changes like necrosis, pyknotic cells, hemorrhage, hypertrophy, lamellar missing, talengiactasis and vacuums.

CSISA-BD (2011) conducted a series of FGD (Focal group discussion) in Jessore region to identify the problems of commercial and intensive aquaculture. These FGDs revealed that commercial aquaculture heavily depends on pelleted feed, uneaten feedstuffs and feces of the fish have long been identified as a major contributor to sludge generation and deposition in commercial Thai pangus-tilapia-carp farms. Generally, uneaten feedstuffs and feces of the fish deposit on the pond bottom. As a result, harmful gasses are produced from the decomposition that causes oxygen depletion in water and creates bloom, affecting the production of harvestable biomass. This may be the reason of huge mortality of fish in the farms throughout the season. There is a very limited water exchange facility in this region, they are forced to apply drug and chemicals indiscriminately to minimize fish mortality which eventually lead to economic loss of the commercial farms. It is reported that farmers use chemicals amounting Taka 44000/ha/year (US$ 564/ha/year) to protect mortality of fish. Due to mortality of fish (2.0-4.5 ton/ha/year), farmers loose about Taka 0.4 million/ha/year (US$ 5128/ha/year).

The fish are fed twice or thrice daily with a commercial pelleted feed that contains 26% crude protein but no water exchange facilities is available in ponds except adding some underground water. From the beginning of a crop cycle at maximum fish density needs dissolved oxygen intake but oxygen level in water is found lower.

In Vietnam, farmers are successfully using sludge pump for removing sludge from fish pond to create healthy environment in the fish pond (Boyd *et al.*, 2011). Moreover, the sludge is dried and used as bio-fertilizer for crop production (Kim *et al.*, 2010). Aquaculture sludge from fresh water pond has also been treated by vermicomposting for subsequent use as bio-fertilizer. The nutrient content of sludge fertilizer is superior to traditional organic matter (Birch *et al.*, 2010). Sludge pumps are generally used at the bottom of fish ponds to suck away waste, sunken debris and other contaminants. The pumps are attached to a discharge tube and a power source.

In 2015 BARI (Bangladesh Agricultural Research Institute) has developed a machine to remove the sludge from the pond. That research project was funded by World Fish. The sludge remover and sludge reservoir were developed in FMPE Division BARI, Gazipur capable of removing sludge and shallow mud from the bottom of the fish pond. The main components of sludge remover are a float, axial flow pump (102 mm diameter), 12.5 hp diesel engine, sludge sucker, tower, propeller, rudder etc. The size of the sludge reservoir is 3.7 m x 1.2 m x 1.4 m with water holding capacity 6000 liter. (Hossain *et al.*, 2015) The sludge remover was complex and costly. Therefore, this research programme was undertaken to develop a simple sludge remover so that the rural labour can operate it easily.

To improve fish culture in Bangladesh there is no alternative of intensive fish culture. If the sludge from pond which are responsible for increase of ammonia and decrease of oxygen than it is required to desludging the pond. Again, the sludge is very good for plant. This sludge can be used as fertilizer.

The main objective of this research was to construct a sludge remover to solve the sludge problem in the pond.

1.2 Objectives

The specific objective of this research was

i. To design and construct a sludge remover.
ii. To study the technical performance of the sludge remover.
iii. To study the economic performance of the sludge remover.

CHAPTER II

REVIEW OF LITERATURE

Sludges and liquids from wastewater stabilization ponds are cost effective by-products useful for agriculture, aquaculture and for manufacturing building materials. They represent valuable sustainable resources as raw materials to support fisheries for human consumption, to produce animal feed derived from single cell algal proteins and aquatic weeds. (Hosetti *et al.* 1995).

Water is essential for the cultivation of fish; it will not give maximum production if the physico-chemical parameters are not appropriate for fish and another aquatic organism. (Khristine *et al*. 2017).

The pH of 6.o to 8.5 is acceptable for most pond life (Alabaster and Lloyd, 1980).

Fish farming industry is a rapidly growing industry in Bangladesh. In 2017 she achieved 3rd place on inland fish production. So, there is a scope on fish export in other countries. Now only shrimp is exporting to other countries. But there is a huge demand of processed fish on the global market. So, it is high time to increase the fish production to add extra revenue on our national economy. But the main problem is that there is no huge land area for making fish pond. So, it is necessary to think about high density fish farming. But the main problem of high-density fish framing is rapid growth of ammonia and decrease of water quality. So, in this chapter previous research about water quality in pond and pond water improvement is discussed.

Desludging was required about operation periods of 6 or 7 years. Sludge removal by pumping after or without emptying water is the most convenient and with a mean cost of 40FF per m3 the cheapest method. Mean desludging cost is eight times lower than mean investment cost. With regard to their agronomic characteristics stabilization pond sludges have a low fertilizer value because of their long maturation time. (Carré *et al*. 1990). Soil characteristics, heavier farm density, and higher land costs impeded early pond construction in Iowa (Schliekelman, I960). If all derelict and culturable ponds could be converted into cultured ponds and thus introduced just semi-intensive method of fish culture which is manageable with local resources and technology, it would be possible to increase the pond fish production 15-20 times of the total fish production of Bangladesh (Islam and Dewan: 1986). The pond bottom soil and the accumulated sediments are integral parts of ponds. Concentrations of nutrients, organic matter and microorganism density in the pond bottom are several orders of magnitude greater than in the water. (Yoram 2003). The accumulation of organic sediments may limit pond intensification. The intensive organic matter degradation at the pond bottom and high sediment oxygen demand exceeds the oxygen renewal rate. This leads to the development of anoxic conditions in the sediments and at the sediment–water interface. A series of anaerobic processes, affected by the redox potential of the system, are taking place. A large number of potentially toxic materials are generated. Among those are organic acids, reduced organic sulfur compounds, reduced manganese and sulfides. (Gat ritvo 2003)

The Optimum fish production is totally dependent on the physical, chemical and biological qualities of water to most of the extent. Hence, successful pond management requires an understanding of water quality. Water quality is determined by variables like temperature, transparency, turbidity, water colour, carbon dioxide, pH, alkalinity, hardness, unionised ammonia, nitrite, nitrate, primary productivity, BOD, plankton population etc.(Devi *et al*. 2003).

Sludge removed ponds demonstrated better FCR (1.64) and SGR (0.80%

per day) compare to FCR (1.90) and SGR (0.71% per day) of control ponds. Fish survival, net yield, net return and BCR (5.40) of sludge removed ponds were higher than those of control ponds. This sludge remover may be recommended for cleaning sludge from intensive cultured fish ponds. (M.A Hossain *et al* 2016)

Fish hydrolysate generally shows a beneficial effect on growth performances and feed utilization at low inclusion levels. The performance is postulated to be due to the balance of free amino acids, peptides and proteins in digestion, absorption and utilization. (Sahu *et al*. 2016)

These previous researches indicate that water quality is so much important for inland fish culture. To improve fish culture in Bangladesh there is no alternative of intensive fish culture. If the sludge from pond which are responsible for increase of ammonia and decrease of oxygen than it is required to desludging the pond. Again, the sludge is very good for plant. This sludge can be used as bio-fertilizer.

CHAPTER III
MATERIAL AND METHOD

3.1 Study Area

This research has accomplished on M/S Hai Hatchery and Fish farm, which is situated in Kaharole upazila in Dinajpur district. The duration of this research was January to June 2018. This fish farm is one of the biggest fish hatchery and fish production farm in Rangpur Division. After talking with the owner of the fish farm it has known that there is a direct relationship between pond environment and the fish production. When the pond environment is very good. The fishes grow very first and it is possible to produce more fish to same amount of water area. Excessive ammonia decreases the quality of the fish. The taste of the fish also reduces because of bad quality of water and pond environment. Lack of oxygen in the pond kill all the fish of the pond at a time, which cause a great loss to the fish farmer.

In a commercial farm the fish are given feed 2-4 times a day. And this fish also extracts a lot of ammonia mixed substance after digestion. All the feed given on the feed is not consumed by the fish. These leftover feeds and the fish extract simply create layer under the pond. That is called the sludge. This sludge is directly causing the increase of ammonia and decrease of oxygen in the pond water. The main purpose of this experiment to remove the sludge from the pond and create a very good environment for fish production.

Figure 3.1: Sludge remover

3.2 Design consideration of the sludge remover

The sludge remover was designed with following consideration

i. The capacity of remover should be 10-15 liter per hour
ii. It should be portable (for easy transfer from one pond to another)
iii. Fabrication cost should be as low as possible
iv. Float should be stable and easy movable by mechanical power
v. Delivery pipe should be flexible for storage of sludge in a reservoir to the required distance.

3.3 Construction of the sludge remover

The sludge remover was fabricated in a local workshop in Kaharole upazila in Dinajpur district with locally available materials such as used plastic drum, wood, rope, MS pipe, MS flat bar, Bamboo, fitting and fixing materials, etc. The main functional components of the remover are- (i) centrifugal pump (ii) engine (iii) suction pipe (iv) sludge collector with cutter (v) delivery pipe (vi) float etc.

3.4 Economic analysis of the sludge remover

The total cost of the sludge remover was calculated using the following formula,

$$TC = FC + VC\ (Q)$$

Where,

TC = Total cost

FC = Fixed cost

VC = Variable Cost

Q = Quantity

Fixed costs are those costs that do not change based on production levels. In this experiment the following parts of the device had a fixed cost.

I. Diesel engine
II. Centrifugal pump
III. Float
IV. Tube well for priming
V. Inlet pipe
VI. Outlet pipe
VII. Sludge collector

The fixed cost is calculated by the following formula

Depreciation = Actual value - Rest value (10% of new)/5 years

Variable costs increase or decrease based on production. In this experiment the cost of diesel and labor cost are the variable cost.

3.5 Design of sludge remover

The sludge remover contains the following components.

3.5.1 Centrifugal pump

A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge. Centrifugal pump of 102 mm (4 inches) diameters was used for suction of the sludge from the bottom of fish pond. It is one of the essential parts of the sludge remover that collects the sludge through suction mode**.** A tube well is attached with the pump for priming. The outlet of the pump is 3 inch in diameter. This pump was made by a local workshop for the sludge removing purpose. The pump is light weight and very easy to transport and attach with an engine. But it requires at least a 10-hp. engine to run this pump properly.

Parameter	**Characteristics**
Pump type	Centrifugal
Diameter of pump	Inlet 4inch, outlet 3inch
Length of sludge pump	1.5 m -6.0 m (Adjustable)
Source of power	12 hp diesel engines
Pump speed	2000 rpm
Delivery pipe	3.5inch diameter and 30.5 m long (flexible)

Figure 3.2: Centrifugal Pump

3.5.2 Engine

To run the sludge remover machine a diesel engine was used. It was a water cooling 12 hp diesel engine (model S195 SDMIEC, China). Which has a Rated Speed of 2000r/min.

The weight of the machine was 145 kg. It was a very heavy engine. This engine was attached with the pump to collect the sludge from the pond.

Figure 3.3: Diesel Engine

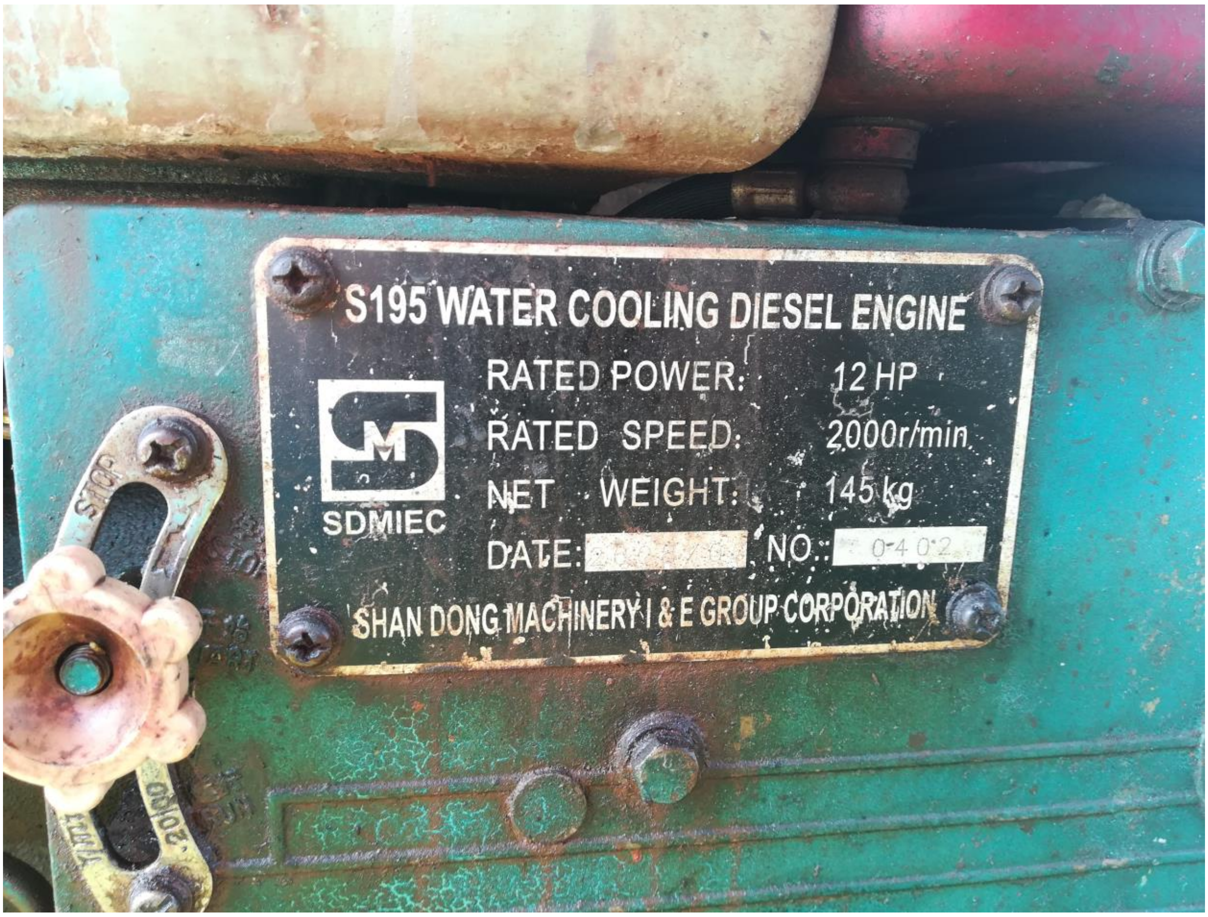

Figure 3.4: Specification of the Diesel Engine

3.5.3 Sludge collector

It is made of PVC pipe. The pipe was 165 mm diameter and 1.44 m long. The one fourth diameter of the plastic pipe is perforated holes. For experiment holes of three different diameter is used and they are 10mm, 15mm and 20 mm. A cutter of 1.35 m long and 102 mm width, made of MS sheet was fixed at the bottom of the perforated pipe. When the sludge remover moves on the bottom of the pond, sludge is cut and fed to the sucker and it sucks the sludge by the pump and sends it to the delivery pipe and exhausts out. The sludge remover can be lowered or raised using metal rope by the crane.

Figure 3.5: Close view of sludge collector

Figure 3.6: Front view of sludge collector

Figure 3.7: Top view of sludge collector

Figure 3.8: Perforated pipe (10
mm diameter)

Figure 3.9: Perforated pipe (15
mm diameter)

Figure 3.10: Perforated pipe (20 mm diameter)

3.5.4 Float

The float is very much important for the sludge remover. This float is used as a station for the diesel engine and the pump. This deck is made of bamboo and 4 plastic drums. The plastic drum make the floating in the water. And this float is well enough to bear the weight of the pump and the diesel engine. The bamboo is used in the float to hold the plastic drums. And a wooden deck was used to make a better place to place the machine.

Figure 3.11: Float Landed on the ground

Figure 3.12: Float in the pond

3.5.5 Operation principle

The components of the sludge remover are carried on the bank of the pond where sludge remover is to be operated. At first, float is placed in the pond water. Then pump, engine, delivery pipe are fitted with the float. The pump is operated with 12hp diesel engine. Twelve horse power engine is used for both the sludge and mud removing. Two persons are required to operate the sludge remover. One man operates the machine, riding on the float and another man manages the sludge pipe from the bank of the pond. Sludge pump with sucker is adjusted according to the depth of water. Engine is started and the mixture of sludge and water comes out through delivery pipe to the sludge deposition pit. This procedure will be continued until the removal of sludge from the whole pond is completed.

Figure 3.13: Operation of the Sludge remover

3.6 Technical performance of sludge remover

3.6.1 Field Trial

The field trial of the pump was done on M/S Hai Hatchery and Fish Farm, hatisha, kaharole, dinajpur. The first trial was done in front of the project supervisor and project co supervisor. The owner of M/S Hai hatchery And Fish farm, Mr. Shekh Abdul Hai also present in the first trial on October, 2018. Data collection was done on November 2018. The data was recorded 3 times. The employees of M/S Hai Hatchery and Fish Farm helped during data collection.

Figure 3.14: Field trial of the
Sludge remover

3.6.2 Sludge management

Pond sludge is a buildup of organic materials that accumulate in a pond over time, mixed with inorganic materials like sand, clay, or silt. The organic material includes animal waste, uneaten fish food, leaves and grass, dead algae, fertilizer, grease and oil from runoff, etc. As these organic materials settle in the pond, they begin the decomposition process. Decomposition requires oxygen, which is pulled from the water. While small amounts of organic material won't cause an issue, larger accumulations can greatly reduce the amount of oxygen in the bottom of the pond, resulting in an anoxic layer of water and sludge in the bottom of the pond. In the anoxic layer, decomposition cannot take place, and the sludge layer will continue to increase as more organics end up in the pond. It's a vicious cycle. This anoxic layer of sludge also plays host to unwanted anaerobic bacteria that produce hydrogen sulfide. Hydrogen sulfide is the culprit for the rotten egg smell that you notice when the pond bottom gets stirred up.

Sludge buildup is part of the natural process of any pond. If left to their own devices, ponds will go from healthy and clean to stagnant and eutrophic, slowly filling in and turning into wetlands, and then eventually reverting back to grassland. In pond management, the goal is to maintain a healthy pond and prevent this cycle.

But the compound which are present in the sludge is very good for the soil and crop production. This sludge can be used in the crop field and in the vegetable garden as a very good organic fertilizer and can become agricultural asset.

So better sludge management can make the pond healthier for the fish as well as a very good source of organic fertilizer.

Figure 3.15: Sludge Collection

CHAPTER IV
RESULT AND DISCUSSION

4.1 Data collection and analysis

The experiment was done separately for three different perforated pipe which is used in the sludge collector. The diameter of the holes of three different pipe was 10 mm, 15mm and 20 mm. For each pipe data was taken three times.
Here the data is shown in the table for different pipe.

Table 1: Sludge collection and diesel consumption for perforated pipe with 10mm hole

SL No.	Sludge extraction |(L/min)	Diesel Consumption (L/min)	Weight of Sludge(kg)
1	600.00	0.083	1.00
2	547.92	0.073	1.05
3	630.48	0.079	1.00
Average	592.80	0.078	1.01

From the table 1 for the 10mm perforated pipe, it was observed that average sludge collected by the pump was 592.8 L/min. And it consumed 1 liter of diesel for the operation of 12.73 min. That means per minute diesel consumption is 0.083 L. So, spending 1 liter of diesel the total sludge water mixture collected by the pump was 7546.344 liter. And the amount of sludge in that amount sludge water mixture is 1524.3 kg. So, 1.01 kg of sludge can be found from 5 liters of sludge water mixture.

Table 2: Sludge collection and diesel consumption for perforated pipe with 15mm hole

SL No.	Sludge extraction (L/min)	Diesel Consumption (L/min)	Weight of Sludge (Kg)
1	750.00	0.050	1.35
2	695.87	0.045	1.40
3	737.70	0.054	1.30
Average	727.85	0.049	1.35

Again, From the table 2 for the 15mm perforated pipe, it was observed that average sludge collected by the pump was 727.85 L/min. And it consumed 1 liter of diesel for the operation of 20.16 min. That means average fuel consumption is 0.049 L/min. So, spending 1 liter of diesel the total sludge water mixture collected by the pump was 14673.45 liter. And the amount of sludge in that amount sludge water mixture is 3961.8 kg. So, about 1.35 Kg of sludge was found from 5 liters of sludge water mixture.

Table 3: Sludge collection and diesel consumption for perforated pipe with 20mm hole

SL No.	Sludge extraction (L/min)	Diesel Consumption (L/min)	Weight of Sludge (Kg)
1	1080.0	0.030	0.7
2	981.8	0.031	0.7
3	1015.0	0.037	0.6
Average	1025.6	0.032	0.67

And finally, from the table 3 for the 20mm perforated pipe, it was observed that average sludge collected by the pump was 1025.6 L/min. And it consumed 1 liter of diesel for the operation of 29.67 min. That means the fuel consumption is 0.032 L/min.So, spending 1 liter of diesel the total sludge water mixture collected by the pump was 30429.5 liter. But the amount of sludge in that amount sludge water mixture is 4077.56 kg. So, about 0.7 Kg of sludge was found from 5 litres of sludge water mixture.

So, after observing the whole result it is seen that the perforated pipe with a hole of 15mm is most effective than the other two pipes. So, it is more profitable to use the perforated pipe which has a hole of 15mm.

The sludge extraction rate is high, because the engine used in the machine is a 12 hp engine. Due to this high power the suction capacity of the pump was very high. Again, there is a large amount of water mixed with the sludge. So, the sludge extraction rate was very high.

The sludge extraction rate increased with the collector size. The rate increased with the size because the openings were bigger in the increasing collector size and less contraction compare to the smaller collector. The fuel consumption also decreased with increasing collector size.

The sludge mixture was collected directly from the outlet of the pump. So, the result can be different if the data collection process is done after attaching the discharge pipe.

4.2 Economic analysis of sludge remover

4.2.1 Fixed cost

The fixed cost for the sludge remover contains the price of diesel engine, pump, sludge collector etc. The price of the materials is shown below:

Table 4: Fixed Cost

Item	Consists of	Price (Tk)
Engine	Diesel engine	35,000
Pump	Centrifugal pump	10,000
Float	4 plastic drum, wooden platform, bamboo and rope	8000
Sludge collector	4inch PVC pipe(10m), Tee pipe, workshop bill	7000
Inlet pipe	3m long bend pipe	1200
Outlet pipe	30m long	3000
Tube-well		2000
Others		5000
TOTAL		71,200
Fixed Cost Per Year		12,816
Fixed Cost Per Day		64

(See Appendix I for full data)

The fixed cost can be different in different places. The engine cost is almost 50% of the total which is made in china. The pump was local made, which was 14% of the total fixed cost. The cost price also can be different in different area.

4.2.2 Variable cost

Here the comparative variable cost is shown below for the three different hole size. The variable costs are fuel cost and labor cost. Diesel was used as fuel.

Table 5: Variable cost

Hole Size (mm)	diesel Required (L/day)	Diesel cost (Tk./day)	Total variable cost (Tk./day)
10	37.7	2450	2950
15	23.8	1547	2047
20	16.2	1051	1551

(See Appendix I for full data)

4.2.3 Total cost

The total cost will be different for the three different sludge collectors. Below the result for three different hole size is shown.

Table 6: Total cost

Hole Size (mm)	fixed cost (Tk/day)	variable cost (Tk/day)	Total cost (Tk/day)	Sludge Removed (Kg/day)	Sludge removal cost (Tk/Ton)
10	64	2950	3014	57477.8	52
15	64	2047	2111	94251.6	22
20	64	1551	1615	65966.0	24

(See Appendix I for full data)

Here a comparison among the three collectors has shown. The data shows that the fixed cost is same for all the three sample. But the variable cost is not same due to fuel consumption is different for different sludge collector. Here the data represents that sample 1 is the costliest sludge collector. But there is a very little difference between sample 2 and 3 in cost. Again, the data shows that cost per day is lowest for sample no 3. But the sludge collection per day is lower than sample no 1 and 2. That’s why sludge removal cost increased. After observing all the data, it can be said the sample no 2 is most efficient. But The result can vary with the pond size, soil type and different other considerations.

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A sludge remover constructed on M/S Hai Hatchery and Fish Farm, Hatisha, Kaharole, Dinajpur was capable of removing sludge and shallow mud from the bottom of the fish pond. This sludge remover was constructed using the local materials which has the following components.

The main components of sludge remover are a float, centrifugal pump (102 mm diameter), 12 hp diesel engine, sludge sucker, float, tube well, etc. The size of the hole of sludge sucking perforated pipe was 10mm, 15mm and 20 mm. From them it is found that the most efficient sludge sucker was 15mm holed perforated pipe. For the 15mm perforated pipe, it is observed that average sludge collected by the pump was 727.85 L/min. And the diesel consumption was 0.49 L/min. So, spending 1 liter of diesel the total sludge water mixture collected by the pump was 14673.45 liter. And the amount of sludge in that amount sludge water mixture is 3961.8 kg. And Sludge removal cost was 22TK./Ton. After cost analysis it was found that 10 mm hole size sludge collector was the costliest. The daily cost for the sample 3 is the lowest but its sludge collection rate was lower than the other two samples. The sludge remover was tested in the pond of M/S Hai Hatchery and Fish Farm situated in kaharole upazila of Dinajpur district. The farm owner showed interest in sludge removing from their fish pond. Three different sludge collectors were used which had different diameter hole to suck the sludge from the underground of the pond. Among the pipe, the pipe which had a hole of 15mm diameter were more profitable. But these results were not represented statistically, and also the experiment is based on some specific aspects, So the result can differ in different aspects. In the field trial some minor problems were observed, such as moving, turning, speed control, stacking problems, etc. These problems should be eliminated before commercial production of the sludge remover. Intensive training is needed for operation and maintenance of the sludge remover. Also, awareness building programs are needed to the farmers about the effect of sludge in fish pond, advantages of sludge removing and sludge management system to produce healthy fish for the nation as well as for the environment.

5.2 Recommendations

(i) Different pumps can be used to reduce the fuel cost.

(ii) A propeller can be used for make it auto moving.

(iii) Field experiment should be conducted to find out the efficacy of the sludge removal on growth and yield of fish as well as water and fish quality

(iv) Multi-disciplinary approach may be undertaken for future research on sludge removal, management and utilization for sustainable production of fish and crop.

REFRENCES

Ahmed, G.U., Hasan, M.T., Faruk, M.A.R., Rahman, M.K. and Haque, M.N. 2015. Aqua-drugs and chemicals: Impact on fish health and production in Mymensingh, Bangladesh. *Research in Agriculture Livestock and Fisheries.* 2 (1): 161-168.

Hosetti B.B. and Frost S., A review of the sustainable value of effluents and sludges from wastewater stabilization ponds.Ecol. Eng., 5, 421-431 (1995).

Belton, B., Karim, M., Thilsted, S., Jahan, K. M. 2011. Review of aquaculture and fish consumption in Bangladesh. Studies and Reviews 2011-53. The WorldFish Center. November 2011.

Birch, S., Bell, R., Nair, J. and Phung, C. V. 2010. Feasibility of vermicomposting aquaculture solid waste on the Mekong Delta, Vietnam: A pilot study. *Dynamic Soil, Dynamic Plant.* 4(1): 127-134.

Fish Waste Bio-Refinery Products: Its application in Organic Farming (Vol-1, Issue-4, November - December 2016)

Boyd, Claude E., Rajts, Francois and Firth, James. 2011. Sludge management at BAP *pangasius* farm cuts TAN, BOD5, TSS in discharges. Global aquaculture advocate, September 2011.

Carré J., Laigre M.P. and Legeas M., Sludge removal from some waste-water stabilization ponds. Water Sci. Technol., 22,247-252 (1990).

Chowdhury, Masudul Hoq and Maharjan, Keshav Lall. 2000. Increasing efficiency of pond fish production in rural Bangladesh. Proceedings of 10th IIFET (International Institute of Fisheries Economics and Trade) Conference, July 10-14, 2000. Corvallis, Oregon, USA.

CSISA-BD. 2011. Expansion of the Cereal Systems Initiative for South Asia (CSISA) in Bangladesh. Annual Work Plan for The First Year. October 2010 – December 2011. Prepared by International Rice Research Institute (IRRI), World Fish Centre (WF) and International

Wheat and Maize Research Institute (CIMMYT), Bangladesh, April 2011.

Dey, M. M., Alam M. F., Weimin M., Piumsumbun S., Bhatta R., Koeshendrayana S., Paraguas F. J. 2005. Constraints to higher yield in carp farming: Implications for future genetic research. In: Penman D., Gupta M.V., Dey M.M. (eds.). Carp genetic resources for aquaculture in Asia. pp 114-120. WorldFish Center Technical Report 65, 152 p.

DHI. 2015. Improved sludge management. The Danish Ministry of Science Innovation and Higher Education, Hørsholm, Denmark. www.dhigroup.com

DoF. 2010. Fisheries Statistical Year Book of Bangladesh 2008–2009. Volume 26, No. 1. Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock.

FAO. 2014. National Aquaculture Sector Overview of Bangladesh. Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Department, Rome, Italy.

Kim J. K., Dao, V. T., Kong, I. S. and Lee, H. H. 2010. Identification and characterization of microorganisms from earthworm viscera for the conversion of fish wastes into liquid fertilizer. *Bioresource Technology*. 101: 5131-5136.

Prothomalo. 2014. Bangladesh stands fourth in fish production. The Daily Prothomalo (Bangla Newspaper), 7 November 2014.

The Daily Star. 2012. Pond farming takes lead in fish supply. The Daily Star, September 3, 2012.

APPENDIX 1

4.2.1 Fixed cost

Considering the lifetime of the full machine is 5 years and rest value of the machine is 10% of the new machine price.

So,

Depreciation = Actual value - Rest value (10% of new)/5 years

So,

Fixed cost per year = (71200-7120)/5 = 12816 TK./year

Fixed cost per day = 12816/365 = 35 TK./day

But the machine will not run all over the year. If it is considered that the machine will work for 200 days in a year then the fixed cost per day will be,

Fixed cost per day = 12816/200= 64 TK./day

4.2.2 Variable cost

Here the comparative variable cost is shown below for the three different hole size. The variable costs are fuel cost and labor cost. Diesel was used as fuel.

The diesel was bought 65 TK./liter.

2 labor is required to run the machine.

Labor wages for 8 hours (1 day) is 250 TK..

For 2 labor it will be = 250 X 2 = 500 TK.

Cost for three sample was different. So, the total cost for every sample is given below:

<u>Cost calculation for perforated pipe with 10mm diameter hole</u>:

From table 1 it is seen that the pump can lift 592.8L of water per minute.

So, it can lift = 592.8 X 60 = 35568 L/hour

Again 5 liters of water contain 1.01 kg of sludge.

So, 35568 liters of water contain = (35568 X 1.01)/5 = 7184.7 kg of sludge.

So, in 8 hour (1 day) it will be = 7184.7 X 8 = 57477.888 kg of sludge/day.

1 liter of diesel can run the machine for 12.73 minutes.

Total diesel required in a day = (60/12.73) X 8 = 37.7 L/day

Total Diesel cost per day = 37.7 X 65 = 2450 TK.

So Total variable cost for a day = 2450+500 = 2950 TK.

Cost calculation for perforated pipe with 15mm diameter hole:

From table 2 it is seen that the pump can lift 727.25L of water per minute.

So, it can lift = 727.25 X 60 = 43635 L/hour

Again 5 liters of water contain 1.35 kg of sludge.

So, 35568 liters of water contain = (43635 X 1.35)/5 = 11781.45 kg of sludge.

So, in 8 hour (1 day) it will be = 11781.45 X 8 = 94251.6 kg of sludge/day.

1 liter of diesel can run the machine for 20.16 minutes.

Total diesel required in a day = (60/20.16) X 8 = 23.8 L/day

Total Diesel cost per day = 23.8 X 65 = 1547 TK.

So Total variable cost for a day = 1547+500 = 2047 TK.

Cost calculation for perforated pipe with 20mm diameter hole:

From table 2 it is seen that the pump can lift 1025.6L of water per minute.

So, it can lift = 1025.6 X 60 = 61536 L/hour

Again 5 liters of water contain 0.67 kg of sludge.

So, 35568 liters of water contain = (61536 X 0.67)/5 = 8245 kg of sludge.

So, in 8 hour (1 day) it will be = 8245 X 8 = 65966 kg of sludge/day.

1 liter of diesel can run the machine for 29.67 minutes.

Total diesel required in a day = (60/29.67) X 8 = 16.2 L/day

Total Diesel cost per day = 16.2 X 65 = 1051 TK.

So Total variable cost for a day = 1051+500 = 1551 TK.

4.2.3 Total cost

The total cost will be different for the three different sludge collectors. Below the calculations for three different hole size is shown.

<u>Total cost calculation for perforated pipe with 10mm diameter hole</u>:

Total fixed cost for a day = 64 TK. (200 working days in a year)

Total variable cost for a day = 2950 TK.

Total cost = 64+2950 = 3014 TK./day

So,

57477.888 kg of sludge can be removed by 3014 TK.

1 Kg of sludge can be removed by = 3014/57477.888 = 0.052 TK.

1Ton of sludge can be removed by = 0.052X1000 = 52 TK.

<u>Total cost calculation for perforated pipe with 15mm diameter hole</u>:

Total fixed cost for a day = 64 TK.

Total variable cost for a day = 2047 TK.

Total cost = 64+2047 = 2111 TK./day

So,

94251.6 kg of sludge can be removed by 2082 TK.

1 Kg of sludge can be removed by =2111/94251.6 = 0.022 TK.

1 Ton of Sludge can be removed by = 0.022X1000 = 22 TK.

<u>Total cost calculation for perforated pipe with 20mm diameter hole</u>:

Total fixed cost for a day = 64 TK.

Total variable cost for a day = 1551 TK.

Total cost = 64+1551 = 1615 TK./day

So,

65966 kg of sludge can be removed by 1586 TK.

1 Kg of sludge can be removed by = 1615/65966 = 0.024 TK.

1 Ton of sludge can be removed by = 0.024X1000 = 24 TK.