UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCE OF ASIAN CATFISH (Clarias batrachus linnaeus) AND WATER QUALITY IN A RECIRCULATING AQUACULTURE SYSTEM

RAHMAT FADHIL

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MASTER OF SCIENCE
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By

RAHMAT FADHIL

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

November 2012

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DEDICATED TO

My Father,
Drs. H. Syahbuddin Aziz
My Mother,
Hajjah Mardhiah Ibrahim
My Wife,
Drh. Rizki Amelia
My Daugthers,
Rumaisha Khairatun Hisan
Ruhama Althafunnisa
Rufaida Nailal Husna
My Brothers,
Nazaruddin, M.Si
Fitri Yanti (Almarhumah)
Iip Gunawan, ST
And My Nephew and Nieces
Habiburrahman
Izatul Jannah
Nurul 'Aliya
Fathiya Yasmin Putri Gunza

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia
to fulfilment the requirement for the degree of Master of Science

GROWTH PERFORMANCE OF ASIAN CATFISH (*Clarias batrachus linnaeus)* AND WATER QUALITY IN A RECIRCULATING AQUACULTURE SYSTEM

By

RAHMAT FADHIL

November 2012

Chairman : Associate Professor Ir. Johari Endan, Phd

Faculty : Engineering

Strategies to increase fish production are always being done on a continuous basis from time to time to develop a new better system. Water quality management is required in aquaculture systems, as it can affect the production and the organisms that live in the water. The use of Recirculating Aquaculture System/RAS in the fishing industry is the latest challenge to the fishing communities and researchers. The use of multi-media filtrations to maintain healthy water quality for aquaculture remains an important issue to be studied. The main problem is how to maintain the water quality parameters for fish life until the harvest. In this study, the concept of the RAS has been developed to determine the ability of controlling the quality of water for sustainable aquaculture.

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This study aimed to develop catfish breeding in an integrated utility with optimal use of water and soil. The objectives of this study were: (1) to determine the growth rate of catfish with mechanical circulatory system and water quality control through a biological filtration unit, (2) to measure the water quality parameters of fish production tanks, and (3) to study the process and the way water can be mixed up, producing more stable water quality conditions in the unit culture and reducing contaminations.

Asian catfish (*C. batrachus*) was cultured in three separate tanks, each with a size range of 5-8 cm (Tank 1), 8-12 cm (Tank 2), and 12-15 cm (Tank 3) for 30 days. Each tank contained 300 fishes. Water samples were analyzed twice (morning and afternoon) with duplicates during the experiment. Water quality parameters such as temperature, turbidity, dissolved oxygen, pH, and ammonia were measured. The entire tank was connected to water supply through a filter to each tank using PVC pipes. Resulting residues settled in a sedimentation tank. Water was pumped through the filter into a subsequent sedimentation tank and back into the tank through recirculation. Fish was fed at 3% of the total fish weight twice a day (morning and evening).

The RAS and biological filter systems with multi-media and backwash capability have resulted in improved water quality for the intensive culture of catfish. Fish survival rate was above 95% with weight gain of catfish of 11.00±1.90 gram/fish in Tank 1, 20.45±0.85 gram/fish in Tank 2, and 25.65±0.95 gram/fish in Tank 3. Rate of

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increase in length and weight of catfish in Tank 1 was from 6.5±1.5 cm (1.00±0.10 gram) to 12.0±2.0 cm (12.00±1.80 gram), Tank 2 from 10.0±2.0 cm (2.10±0.60 gram) to 16.0±2.0 cm (22.55±1.15 gram), and Tank 3 from 13.5±1.5 cm (5.65±1.25 gram) to 18.5±2.5 cm (32.33±0.30 grams).

Data analysis using Completely Randomized Design/CRD with three treatments and two replicates showed that the total percentage of survival of catfish in Tank 2 was higher than the other tanks. Percentages of survival from the highest to the lowest were 98.33%±0.33 (Tank 2), 95.33%±0.67 (Tank 1), and 95.17%±0.84 (Tank 3). ANOVA test showed no significant difference of water quality and growth performance between one tank and the rest in this trial. The results showed that RAS system can be successfully used and further developed to increase fish production, intensively. There was hardly a huge negative impact on water quality, growth, and survival rate of *catfish* in the tank for the period of observation. This indicates that differences in size of the fish in each tank did not have any great impact on the growth, survival, and quality of water in the catfish culture.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PRESTASI PERTUMBUHAN IKAN KELI *(Clarias batrachus linnaeus)* DAN KUALITI AIR DALAM SEBUAH SISTEM AKUAKULTUR EDARAN SEMULA

Oleh

RAHMAT FADHIL

November 2012

Pengurusi : Profesor Madya Ir. Johari Endan, Phd

Faculti : Kejuruteraan

Strategi untuk meningkatkan pengeluaran ikan sentiasa dilakukan secara berterusan dari semasa ke semasa untuk mendapatkan sistem baru dan yang lebih baik. Pengurusan kualiti air diperlukan dalam sistem akuakultur, kerana ia boleh menjejaskan pengeluaran dan organisma yang hidup di dalam air. Penggunaan Sistem Akuakultur Edaran Semula (*Recirculating Aquaculture System*/RAS) dalam industri perikanan adalah cabaran terbaru untuk komuniti perikanan dan penyelidik. Penggunaan penapisan dengan pelbagai media bagi mengekalkan kualiti air yang sihat untuk akuakultur masih merupakan satu isu yang penting untuk dipelajari. Masalah utama ialah bagaimana mengekalkan parameter kualiti air bagi kehidupan ikan sehingga tempoh tuaian. Dalam kajian ini, konsep RAS telah dibangunkan untuk menentukan keupayaan dalam mengawal kualiti air yang mampan bagi akuakultur.

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Kajian ini bertujuan untuk membangunkan ternakan ikan keli dalam utiliti bersepadu dengan menggunakan air secara cermat dan tanah secara optimum. Objektif kajian ini ialah; (1) untuk menentukan kadar pertumbuhan ikan keli dengan sistem peredaran mekanikal dan pengendalian kualiti air melalui unit penapisan biologi; (2) untuk mengukur parameter kualiti air tangki pengeluaran ikan; dan (3) untuk mengkaji proses dan cara yang ia boleh sebati sehingga menyebabkan lebih banyak keadaan kualiti air yang stabil dalam unit kultur dan juga dalam pengurangan pencemaran.

Ikan keli *(C. batrachus)* dikultur dalam tiga tangki berasingan masing-masing dengan saiz 5-8 cm (Tangki 1), 8-12 cm (Tangki 2) dan 12-15 cm (Tangki 3) selama 30 hari. Setiap tangki mengandungi 300 ekor. Sampel air telah diamati dalam dua waktu (pagi dan petang) dengan masing-masing dua kali ulangan sepanjang tempoh eksperimen. Parameter kualiti air seperti suhu, kekeruhan, oksigen terlarut, pH, dan amonia telah telah diukur. Semua tangki disambungkan ke pembekal air melalui penapis dengan menggunakan paip PVC. Sisa terhasil mendap ke dalam tangki pemendapan. Air yang melalui tangki pemendapan seterusnya dipam ke dalam penapis dan kembali ke tangki kultur ikan secara edaran semula. Ikan diberi makan pada kadar 3% daripada jumlah berat ikan badan dua kali sehari (pagi dan petang).

Sistem RAS dan penapis biologi dengan multimedia dan basuh balik telah berjaya menghasilkan kualiti air untuk kultur ikan keli secara intensif. Kadar kemandirian ikan adalah melebihi 95%, dengan pertambahan berat ikan keli ialah 11.00 ± 1.90 gram/ikan dalam Tangki 1, 20.45 ± 0.85 gram/ikan dalam Tangki 2, dan 25.65 ± 0.95 gram/ikan dalam Tangki 3. Kadar pertambahan panjang dan berat ikan keli dalam

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Tangki 1 dari 6.5±1.5 cm (1.00±0.10 gram) kepada 12.0±2.0 cm (12.00±1.80 gram), Tangki 2 dari 10.0±2.0 cm (2.10±0.60 gram) kepada 16.0±2.0 cm (22.15±0.30 gram), dan Tangki 3 dari 13.5±1.5 cm (5.65±1.25 gram) kepada 18.5±2.5 cm (32.33±0.30 gram).

Analisis data menggunakan reka bentuk rawak lengkap (*Completely Randomized Design*/CRD) dengan tiga rawatan dan dua replikat menunjukkan bahawa jumlah peratusan kemandirian ikan keli pada Tangki 2 bertahan lebih tinggi daripada tangki lainnya. Peratusan kemandirian daripada yang tertinggi kepada yang terendah ialah 98,33%±0,33 (Tangki 2), 95,33±0,67% (Tangki 1) dan 95,17±0,84% (Tangki 3). Ujian ANOVA menunjukkan bahawa tiada perbezaan ketara kualiti air dan prestasi pertumbuhan antara satu tangki dengan yang lain dalam percubaan ini. Keputusan menunjukkan bahawa sistem RAS ini boleh berjaya digunakan dan terus dibangunkan untuk meningkatkan pengeluaran ikan secara intensif. Hampir tidak terdapat kesan negatif yang besar kepada kualiti air, pertumbuhan dan kadar kemandirian ikan keli selama tempoh pemerhatian dalam tangki. Ini bermakna bahawa perbezaan dalam saiz ikan dalam tangki masing-masing tidak memberi kesan yang besar ke atas kadar pertumbuhan, kemandirian dan kualiti air kultur ikan keli.

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I certify that a Thesis Examination Committee has met on 09 November 2012 to conduct the final examination of Rahmat Fadhil on his thesis entitled "Growth Performance of Asian Catfish (*Clarias batrachus linnaeus)* and Water Quality In A Recirculating Aquaculture System" in accordance with the Universiti and Universiti College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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RAHMAT FADHIL

Date: 9 November 2012

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LIST OF ABBREVIATIONS

AM or am	- Ante Meridian (morning time)
ANOVA	- Analysis of Variance
ANSI	- American National Standards Institute
APHA	- American Public Health Association
ASTM	- American Society for Testing and Materials
ATC	- Automatically Compensate for Temperature
AWWA	- American Water Works Association
BOD	- Biochemical Oxygen Demand
C	- Celsius
CRD	- Completely Randomized Design
DF	- Degrees of Freedom
DGR	- Daily Growth Rate
DO	- Dissolved Oxygen
E	- Environment
ESC	- Enteric Septicemia of Catfish
F	- Fahrenheit
FE	- Feed Efficiency
FCR	- Feed Conversion Ratio
FRP	- Fiberglass Reinforced Plastic
IA	- Ionized Ammonia
JTU	- Jackson Turbidity Unit
L or l	- Liter

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LSD	- Least Significant Different
MS	- Mean Square
NSF	- National Sanitation Foundation
NTU	- Nephelometric Turbidity unit
PM or pm	- Post Meridian (afternoon time)
POE	- Point of Entry
POV	- Point of Use
PVC	- Polyvinyl chloride
RAS	- Recirculating Aquaculture System
SGR	- Specific Growth Rate
SR	- Survival Rate
SS	- Sum of Squares
T	- Tank
TAN	- Total Ammonia Nitrogen
TLR	- Total Length Ratio
TSS	- Total Suspended Solids
UIA	- Unionized Ammonia
US EPA	- United States Environmental Protection Agency
VOC	- Volatile Organic Compound
WG	- Weight Gain
WPCF	- Water Pollution Control Federation
WQS	- Water Quality Standard
Ag	- Silver Cathode
CO_2	- Carbon Dioxide
$CaCO_3$	- Calcium Carbonate

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HCl	- Hydrogen Chloride
H_2SO_4	- Sulphuric Acid
H_2O	- Water
$MnCl_2$	- Manganese Chloride
MnO_2	- Manganese Dioxide
NH_3	- Ammonia
NaOH	- Natrium Hydroxide
$Na_2S_2O_3$	- Sodium Thiosulfate
NO_2	- Nitrites
NO_3	- Nitrates
O_2	- Oxygen
I_2	- Iodine
atm	- atmosphere
cm	- centimetre
g	- gram
kg	- kilogram
m	- metre
mg	- milligram
ml	- millilitre
mm	- millimetre
nm	- nanometre
ppm	- part per million
ppt	- part per ton

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CHAPTER 1

INTRODUCTION

1. Background

Studies on aquaculture continue to grow in recent years. Its development is very crucial to the sustainability of fish supply for the community, both for direct consumption by the consumer and for further processing by the industry. Aquaculture is an attempt to cultivate aquatic animals or plants, and it became a common term used to describe this specialty. Aquaculture can be developed to produce fish and plants for food, sources of income, and others (Satar, 1984).

Fish, shrimp, seaweed, and other aquatic organisms, depend on water as internal and external media. As an internal medium, water allows reactions of a raw material to take place in the bodies, transports food throughout the body, and carries the metabolic waste to be expelled from the body. As an external medium, water functions as a habitat. The water conditions for aquaculture are very important for the animals to grow and develop optimally. If the environment is in a bad condition, the fish can experience stress, become susceptible to diseases and ultimately die (Hernawati and Suantika, 2007; Boyd, 1990). Therefore, knowing the parameters of water quality alone is not sufficient. A total understanding of the characteristics of water, which is the habitat for water organisms is essential (Kordi and Tancung,

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2007). Parameters of water quality and quantity are crucial for the maintenance of life in the water, so that the results obtained will be optimal. Several important factors that are known are sources of water quality status, the condition of the pond, feed management, water circulation, dense stocking, plankton, dirt, and the environment. These factors greatly affect the overall water quality.

In aquaculture, fish is a general term that covers fish, prawn, oyster, mollusk and others. Metabolism in a fish body secretes compounds that can be toxic to its life (Golz, 1995). In addition, the excessive remains of rotting food can accumulate and become toxic compounds, such as ammonia. In tropical climate conditions, the metabolic processes and decomposition of feed remnants happen very quickly because the environmental temperature is high. Handling these issues, thus, is very important for maintaining healthy fishes. Replacing the water is one good way to tackle this problem, but it requires adequate water supply and can cause fish stress (Sudrajat and Gunawan, 2002). Based on this fact, a recirculating system would be an alternative.

In addition, water quality plays an important role in selecting the types of animal or plant to be cultured. If the freshwater has low oxygen content (below 4-5 ppm), only certain types of fishes can survive (Tucker, 1991). One of the type of fishes that can live in such environmental conditions is the catfish *(Clarias* sp*)* (Singh and Hughes, 1971). The reason is the catfish has an additional respirator known as *arborescent* (air breathing fish), so they can absorb oxygen directly from air (Bruton, 1979; Clay, 1979; Haylor, 1993; Khairuman *et al.*, 2008; Singh and Hughes, 1971).

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The Asian catfish *(Clarias batrachus)* is one of the most potential candidate for aquaculture in Asia, especially in Malaysia, Thailand, India, Indonesia, and Laos. The potentials of these species in aquaculture have been widely reported (Areerat, 1987; Phonekhampheng *et al.* 2008; Sahoo *et al.*, 2008; Sunarma, 2004; Bhat *et al.*, 2008). The availability of stocking material is always considered important for a successful culture of any fish species through collection of natural seeds, but it is not sustainable for an intensive culture. The scarcity of marketable fishes and seeds from the natural ground has been an issue for catfish. So the fish production in hatchery will be the only alternative for obtaining an optimum quantity of fish for the purpose through intensive breeding operation (Sahoo *et al.*, 2008).

Brune (2004) reported that most aquaculture production comes from land-intensive systems, such as catfish farms. Major advantages of pond fish culture are the low capital cost of earthen ponds and the reliability of pond fish production. The disadvantages are the need to continuously manage the pond oxygen concentration and other fluctuating water quality variables, preventing off-flavor, controlling predators and diseases, and providing labor for harvesting. These management difficulties, combined with land, water, and environmental constraints, have driven the search for technological improvements in pond aquaculture. One probable solution is to shift to more energy-intensive systems, either by increasing aeration in low-cost ponds or by abandoning ponds altogether in favor of recirculating tank or raceway processes (Brune *et al.*, 2004).

The traditional aquaculture production in ponds required large quantities of water. Approximately, 1 million gallons of water per acre are required to fill a pond and an

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equivalent volume is required to compensate evaporation and seepage throughout the year. Assuming an annual pond yield of 5,000 pounds of fish per acre, approximately 100 gallons of water are required per pound of fish production (Losordo et al., 1998). This is a large investment in fish farming. Recirculating aquaculture production systems may offer an alternative to reduce the production and investment cost. In the recirculating systems, the water is treated in tanks and reused; thus, substantially less land is required (Losordo *et al.*, 1998; Yudha, 2005). It is expected that the cost needed for a recirculating system is cheaper than that of in a traditional fish production in ponds. The system is also independent of environmental changes.

Recirculating system has several advantages, such as environmentally friendly, and safe from contamination that occurs in aquatic environments. It can minimize the impact of a disease outbreak from the outside environment, and its water quality parameters are more stable. Several weaknesses of this system is the accumulation of organic material, which originated from surplus feed, fish feces, and dead planktons (Yudha, 2005). The management and maintenance of water quality require serious attention because water quality affects fish life.

Research on the concept of recirculating aquaculture production systems is important, especially related to water quality control and growth performance. The investment in the aquaculture farming model is not a problem if it is implemented in a large scale. Considering the needs and benefits of this circulation aquaculture system in the future, the experiment in a small-scale is significant.

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A key to successful recirculating production systems is the use of cost-effective components of the water treatment system. All recirculating production systems remove waste solids, oxidize ammonia and nitrite-nitrogen, remove carbon dioxide, and aerate or oxygenate the water before returning it to the fish tank (Losordo *et al.*, 1998). Applying this concept, the water quality in production ponds can be maintained for the fish survival until the harvesting stage.

1.2 Problem Statement

Strategies to increase fishery's production are constantly evolving to get better results. Water quality management is needed in the aquaculture system, because it can affect the organisms living in the water. The use of Recirculating Aquaculture System in the aquaculture industry is the latest challenge for the fishing communities and researchers. Utilization of filtration with a variety of media to maintain healthy water quality for aquaculture remains an important issue to be investigated. The main problem in fishery aquaculture is the techniques to maintain healthy water quality continuously for growth and survival of fish to the harvesting stage. Recirculating Aquaculture System (RAS) with a bio-filtration unit is developed to study the effectiveness in controlling water quality for sustainable aquaculture.

One of the advantages of this study is the use of domestic biofilter that has been used in the treatment of household water, which is now being applied in a recirculating aquaculture system to produce freshwater fish. Given the fact that domestic biofilter has been commercially available in the market and widely used in

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housing, domestic biofilter is expected to further provide convenience for fishing industry and fish farmers to increase fish production from time to time. Integrating domestic biofilter with RAS is something new, stimulating new research opportunities.

1.3 Objectives

The research aimed at developing a simple integrated system for aquaculture with thrifty water and land. Principally, the fish production under this system can add income value to fish breeders and improve the livelihood of the community. The objectives of this research were:

1. to design a small-scale Recirculation Aquaculture System (RAS).
2. to determine growth performance of various sizes of Asian catfish *(Clarias batrachus)* in RAS.
3. to assess influence of size variation of *Clarias batrachus* on water quality in RAS.

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