DESIGN AND DEVELOPMENT OF A STEADY STATE CLOSE-CYCLE AQUACULTURE SYSTEM FOR INTENSIVE CULTURE OF FRESH WATER FISH SPECIES

MD ASADUZZAMAN

DOCTOR OF PHILOSOPHY

KOLEJ UNIVERSITI SAINS DAN TEKNOLOGI MALAYSIA
(KUSTEM)

2006

DESIGN AND DEVELOPMENT OF A STEADY STATE CLOSE-CYCLE AQUACULTURE SYSTEM FOR INTENSIVE CULTURE OF FRESH WATER FISH SPECIES

MD. ASADUZZAMAN

DOCTOR OF PHILOSOPHY

KOLEJ UNIVERSITI SAINS DAN TEKNOLOGI MALAYSIA (KUSTEM)

2006

DESIGN AND DEVELOPMENT OF A STEADY STATE CLOSE-CYCLE AQUACULTURE SYSTEM FOR INTENSIVE CULTURE OF FRESH WATER FISH SPECIES

MD. ASADUZZAMAN

Thesis Submitted in Fulfillment of the Requirement for the Degree of Doctor of Philosophy in the Faculty of Agrotechnology and Food Science Kolej Universiti Sains dan Teknologi Malaysia

January 2006

"Findings of My Research Convey for the Best of Wishes
Hope that it will be Helpful for People"

Author

DEDICATION

To the loving and sacred memory of my father

ALHAJ MD. NAZMUL HAQUE

Who left me forever on 13th December 1997

AND

Ever Loving my Daughter, **LABIBAH ASAD** for her true love and affection that give me a true light which leads every success in my life.

Abstract of the thesis presented to the Senate of Kolej Universiti Sains dan Teknologi Malaysia in fulfillment of the requirements for the Degree of Doctor of Philosophy.

DESIGN AND DEVELOPMENT OF A STEADY STATE CLOSE-CYCLE AQUACULTURE SYSTEM FOR INTENSIVE CULTURE OF FRESH WATER FISH SPECIES

MD. ASADUZZAMAN

January 2006

Chairman: Prof. Hj. Mohd Azmi Ambak, PhD
Member: Assoc. Prof. Engineer Ahmad Jusoh, PhD
Assoc. Prof. Anuar Hassan, PhD

Faculty: Faculty of Agrotechnology and Food Science

This study was to design and develop a steady-state conditioned close-cycle aquaculture system to provide a conducive culture environment for intensive culture of fresh water fish species. Four major experiments were conducted to assess the efficiency of the system with varying ratios of volume of the fish rearing unit and volume of the biological filter (Aerobic) of 45:1, 23:1, 10:1 and 5:1 for the Experiment 1, Experiment 2, Experiment 3 and Experiment 4, respectively.

Fish were fed daily using commercial fish feed during experimental trials with until satiation. Each experimental trial was scheduled for 64 days excluding the 8 weeks acclimation for the system and 2 weeks species acclimation period.

In this study, the result showed that, the ratio of volume of the fish rearing unit and volume of the biological filter (Aerobic) of 5:1 was best compared to the ratio of the 45:1, 23:1 and 10:1. The best biomass yield of the *Oreochromis niloticus* (Red Tilapia) was 75.74 kg/m^3 for the ratio of 5:1. The biomass yield was 5.36, 24.36 and 42.05 kg/m^3 for the ratio of the 45:1, 23:1 and 10:1, respectively. The highest biomass yield of the *Tor tambroides* (Mahseer) was 3.22 kg/m^3 for the ratio of 45:1, where the initial density was 0.81 kg/m^3.

The concentration of NH_3-N of the fish rearing unit was 0.01, 0.004, 0.007, and 0.006 mg/L for the ratio of the 45:1, 23:1, 10:1 and 5:1, respectively, and the incoming water to the fish rearing unit was 0.001, 0.0005, 0.001 and 0.001 mg/L, respectively. Beside this, the pH of the fish rearing unit was 7.35, 6.77, 7.1 and 7.1, respectively, and the temperature was 27.7, 27.54, 28 and 27.9^{O}C, respectively. Furthermore, the system was able to add DO of 17.18, 24.66, 16.67 and 17.72 %, respectively, through the gravity aerator.

The efficiency of the sand filter was 76, 78, 73 and 73 % and the efficiency of the trickling filter was 37, 54, 70 and 70 %, for the ratio of the 45:1, 23:1,

10:1 and 5:1, respectively. Beside this, the system was producing TAN at the rate of 255.90, 454.35, 308.12 and 548.35 g/day, respectively, and the removing of TAN was at the rate of 226.87, 400.78, 284.80 and 527.62 g/day, respectively.

The carrying capacity of the system was 13.27, 19.34, 32.38 and 128.30 kg/m^3 for the ratio of the 45:1, 23:1, 10:1 and 5:1, respectively. The carrying capacity of the system was 9.02 kg/m^3 for *Tor tambroides* of the ratio of 45:1.

The economical feasibility result showed that, the system was feasible for the single expensive/valuable species of *Tor tambroides*. The Red Tilapia with the ratio of 5:1 showed that, if little increases the stocking density and increase the tanks volume of water as $9m^3$ (like Experiment 1) in each tank then it should be economically viable or self-supporting.

In this study, the result showed that the decreasing the ratio with increasing the initial stocking density, the system performed better result. The study including growth performances, individual unit's performances, kinetic and economic feasibility study, it might be concluded that the fresh water fish species as well as fingerling or growout can be cultured in this closed recirculating system producing better yield than conventional commercial fish farming. Thus, the experimental recirculating technology is technically feasible and economically viable. Moreover, the management practice is the priority factor to handle the system.

Abstrak tesis dipersembahkan kepada Senat Kolej Universiti Sains Dan Teknologi Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

Rekabentuk dan Pembangunan Sistem Akuakultur Kitaran Tertutup Yang Berkeadaan Seragam Untuk Pengkulturan Intensif Bagi Spesies Ikan Air Tawar

MD. ASADUZZAMAN

Januari 2006

Pengerusi: Prof. Dr. Hj. Mohd Azmi Ambak
Ahli: Assoc. Prof. Engineer Ahmad Jusoh, PhD
Assoc. Prof. Anuar Hassan, PhD

Fakulti: Fakulti Agroteknologi dan Sains Makanan

Kajian ini bertujuan untuk merekabentuk dan membangunkan sistem kitar-tutup akuakultur yang berkeadaan seragam yang sesuai untuk pengkulturan intensif spesis ikan air tawar. Empat eksperimen utama telah dilaksanakan untuk menilai kecekapan system dengan mengubah nisbah isipadu unit ternakan ikan terhadap isipadu penapis biologi (Aerobik) 45:1, 23:1, 10:1 dan 5:1 untuk Experimen 1, Experimen 2, Experimen 3 dan Experimen 4 secara respektif.

Ikan telah diberi makanan setiap hari sampai kenyang dengan menggunakan makanan ikan komersil semasa percubaan experimen. Setiap percubaan experimen telah dijadualkan selama 64 hari tidak termasuk 8 minggu untuk kesesuaian sistem dan 2 minggu untuk tempoh kesesuaian spesis.

Dalam kajian ini, keputusan menunjukkan bahawa isipadu unit ternakan ikan terhadap isipadu filter biologi (Aerobik) 5:1 itu adalah paling baik berbanding dengan nisbah 45:1, 23:1, 10:1 dan 5:1. Penghasilan biomas yang paling baik untuk *Oreochromis niloticus* (Tilapia Merah) ialah 75.74 kg/m^3 untuk nisbah 5:1. Penghasilan biomas untuk nisbah 45:1, 23:1, 10:1 dan 5:1 secara respektif ialah 5.36, 24.36 dan 42.05 kg/m^3. Penghasilan biomas yang paling tinggi untuk *Tor Tambroides* (Mahseer) ialah 3.22 kg/m^3 untuk nisbah 45:1, di mana ketumpatan permulaan ialah 0.81 kg/m^3.

Kepekatan NH_3-N untuk unit ternakan ikan ialah 0.01, 0.004, 0.007, dan 0.006 mg/L untuk nisbah 45:1, 23:1, 10:1 dan 5:1 secara respektif, dan air masukan ke dalam unit ternakan ikan adalah 0.001, 0.0005, 0.001 dan 0.001 mg/L secara respektif. Di samping itu, pH untuk unit ternakan ikan ialah 7.35, 6.77, 7.1 dan 7.1 secara respektif, dan suhu ialah 27.7, 27.54, 28 dan 27.9°C. Tambahan pula, sistem itu berupaya menambah DO sebanyak 17.18, 24.66, 16.67 dan 17.72% secara respektif melalui 'aerator' graviti.

Kecekapan penapis pasir ialah 76, 78, 73 dan 73% dan kecekapan penapis 'trickling filter' ialah 37, 54, 70 dan 70% untuk nisbah 45:1, 23:1, 10:1 dan 5:1 secara respektif. Di samping itu, sistem itu menghasilkan TAN pada kadar 255.90, 454.35, 308.12 dan 548.35 g/day secara respektif dan penyingkiran TAN adalah pada kadar 226.87, 400.78, 284.80 dan 527.62 g/day secara respektif.

Keupayaan 'carrying capacity' sistem ialah 13.27, 19.34, 32.38 dan 128.30 kg/m^3 untuk nisbah 45:1, 23:1, 10:1 dan 5:1 secara respektif. Keupayaan 'carrying capacity' sistem ialah 9.02 kg/m^3 untuk *Tor Tambroides* bagi nisbah 45:1.

'Feasilibiti' ekonomi menunjukkan bahawa sistem itu adalah sesuai bagi spesis bernilai tinggi seperti ikan kelah *Tor Tambroides*. Tilapia Merah yang bernisbah 5:1 menunjukkan bahawa jika ketumpatan ditambah sedikit dan isipadu air tangki ditambahkan sehingga $9m^3$ (seperti eksperimen 1) dalam setiap tangki, maka ia adalah 'viable' dari segi ekonomi.

Dalam kajian ini, keputusan menunjukkan bahawa pengurangan nisbah dan penambahan ketumpatan permulaan untuk sistem akan menghasilkan keputusan yang lebih baik Kajian ini merangkumi prestasi pertumbuhan, keupayaan unit individu, kinetik dan kajian 'feasibiliti' ekonomi, jadi,

kesimpulan ialah spesis ikan air tawar boleh diternak di dalam sistem kitar-tutup ini yang lebih baik dari segi penghasilan berbanding dengan ternakan ikan komersil secara konventional. Maka, teknologi kitar semula secara eksperimen adalah berupaya dari segi teknikal dan juga ekonomikal. Tambahan pula, teknik pengurusan merupakan faktor utama untuk mengurus sistem ini.