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NITROGEN TREATMENT IN CLOSED-SYSTEM TILAPIA CULTIVATION
USING SUBMERGED NITRIFYING BIOFILTER

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Chemical Engineering

Department of Chemical Engineering

Faculty of Engineering

Chulalongkorn University

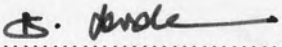
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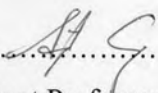
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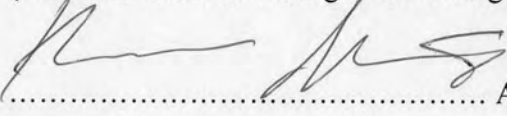
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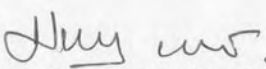
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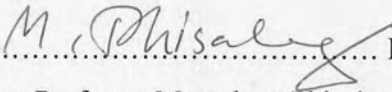

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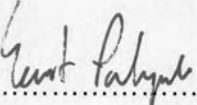
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ธนทร ศรีสุข : การบำบัดไนโตรเจนในบ่อเลี้ยงปลานิลระบบปิดโดยตัวกรองชีวภาพในตรีฟิเคชั่นแบบจม (NITROGEN TREATMENT IN CLOSED-SYSTEM TILAPIA CULTIVATION USING SUBMERGED NITRIFYING BIOFILTER) อ.ที่ปรึกษา วิทยานิพนธ์หลัก : อ.ดร.กษิตศ หนูทอง, 113 หน้า.

งานวิจัยนี้เน้นในการพัฒนาระบบเลี้ยงสัตว์น้ำที่เรียบง่ายแต่มีประสิทธิภาพสูงเพื่อการประยุกต์ใช้งานโดยเกษตรกรไทย ในส่วนแรกของงานวิจัยทำการศึกษาถึงตัวแปรและแนวทางการปรับสภาพตัวกรองชีวภาพในตรีฟิเคชั่น ในขณะที่ในส่วนที่สองทำการประเมินศักยภาพของระบบเลี้ยงสัตว์น้ำที่ออกแบบขึ้น ซึ่งมีการติดตั้งตัวกรองชีวภาพที่ผ่านการปรับสภาพแล้วในการเลี้ยงสัตว์น้ำในระบบปิดที่ระดับความหนาแน่นเริ่มต้นของสัตว์น้ำต่างกัน การเติมอาหารกึ่งสามารถกระตุ้นกระบวนการไนตรีฟิเคชั่นได้สำเร็จในระยะเวลา 3 – 4 สัปดาห์ โดยตัวกรองที่ปรับสภาพแล้วจะมีอัตราการเกิดปฏิกิริยาไนตรีฟิเคชั่นอยู่ที่ 24.1 มก. ในโตรเจน/ตร.ม./วัน ระบบเลี้ยงสัตว์น้ำที่ออกแบบขึ้นได้รวมกระบวนการเลี้ยง การบำบัดน้ำ และการแยกตะกอนเข้าด้วยกัน ซึ่งทำให้อัตราการเกิดปฏิกิริยาไนตรีฟิเคชั่นในน้ำมีความเรียบง่ายและสามารถลดต้นทุนในการดำเนินการได้ ผลการทดลองพบว่าระบบเลี้ยงสามารถควบคุมปริมาณแอมโมเนียและไนโตรที่ต่ำกว่า 1.0 มก. ในโตรเจน/ล. ถึงแม้ปริมาณของเสียอินทรีย์ในโตรเจนจะเพิ่มมากกว่า 3 เท่าจาก 5 – 18.3 มก. ในโตรเจน/ล/วัน ประสิทธิภาพของระบบเลี้ยงเกิดจากการเกิดกระบวนการไนตรีฟิเคชั่นที่สมบูรณ์และความสามารถในการตรึงเซลล์ไนโตรฟายอิงแบคทีเรียที่เจริญเติบโตได้ช้า นอกจากนี้กระบวนการไนตรีฟิเคชั่นกระบวนการนำไนโตรเจนเข้าสู่เซลล์โดยตรงและดีไนตรีฟิเคชั่นยังมีส่วนร่วมในการควบคุมปริมาณสารอินทรีย์ในโตรเจนในน้ำ ความสามารถในการจับตะกอนที่ดีของตัวกรองชีวภาพไบโอคอร์ดเป็นส่วนสำคัญในการเกิดกระบวนการดีไนตรีฟิเคชั่น การล้างตะกอนแขวนลอยที่จับบนพื้นผิวของตัวกรองสามารถลดความเสี่ยงในการเกิดกระบวนการชีวภาพที่ไม่ใช้ออกซิเจนซึ่งผลิตสารพิษ เช่น ซัลเฟอร์ไดออกไซด์ ได้ การล้างตัวกรองชีวภาพด้วยความถี่ 1 ครั้งต่อสองสัปดาห์สามารถเพิ่มผลผลิตสัตว์น้ำได้ถึง 25 – 30 กก./ลบ.ม. ซึ่งใกล้เคียงกับการเลี้ยงในกระชังซึ่งไม่เป็นมิตรต่อสิ่งแวดล้อม ในการทดลองนี้อัตราของปฏิกิริยาไนตรีฟิเคชั่นอยู่ระหว่าง 27.6 – 41.2 มก. ในโตรเจน/ตร.ม./วัน ซึ่งอยู่ในช่วงต่ำเมื่อเปรียบเทียบกับงานวิจัยในอดีต อย่างไรก็ตามระบบเลี้ยงสัตว์น้ำที่ออกแบบขึ้นก็มีจุดดึงดูดคือมีรูปแบบเรียบง่ายซึ่งเหมาะแก่เกษตรกรไทย

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สาขาวิชา.....วิศวกรรมเคมี.....

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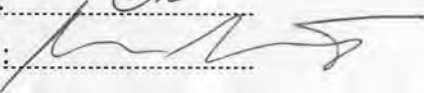
THANATHON SESUK: NITROGEN TREATMENT IN CLOSED-SYSTEM TILAPIA CULTIVATION USING SUBMERGED NITRIFYING BIOFILTER. ADVISOR: KASIDIT NOOTONG, Ph.D. 113 pp.

This work focused on a development of simple yet effective aquaculture systems for an adoption among budget-limited Thai farmers. The first part of the work investigated the parameters that influenced an acclimation of nitrifying biofilters while the second part tested for the performance of the proposed aquaculture systems integrated with acclimated nitrifying biofilters at different initial aquaculture densities. Shrimp diet addition was able to establish nitrification on Biocord™ biofilters within a period of 3 – 4 weeks. An initial nitrifying rate of Biocord™ biofilters after acclimating period was determined at $24.1 \text{ mg N m}^{-2} \text{ day}^{-1}$. The zero-water exchanged tilapia cultivation was carried out in the proposed aquaculture systems integrated with shrimp diet acclimated Biocord™ biofilters. Design of the proposed system combined aquaculture production, water treatment, and solid-liquid separation within single tank, thereby offering a possibility of process simplification and reduction in operational costs. Series of experiments indicated that the proposed aquaculture systems were capable of maintaining ammonium and nitrite concentrations below 1.0 mg N L^{-1} despite increasing inorganic nitrogen loadings more than 3-folds from $5 - 18.3 \text{ mg N L}^{-1} \text{ day}^{-1}$. Efficient performance of the systems was linked to a proper biofilter preparation to achieve fully nitrification before an initial deployment was taken placed as well as microbial immobilization that successfully retain slow-growth nitrifying bacteria in the systems. Besides nitrification, direct assimilation of inorganic nitrogen and heterotrophic denitrification were other mechanisms responsible for inorganic nitrogen control. The excellent capability of the chosen Biocord™ biofilters in retaining suspended solids was crucial for the onset of heterotrophic denitrification. Frequent suspended solid removal from Biocord™ biofilters was able to reduce the likelihood of heterotrophic denitrification and sulfate reduction, which produced toxic H_2S . Regular cleaning of Biocord™ biofilters also enhanced nitrifying rates in comparison to unclean biofilters. With biofilter cleaning (i.e., once every 2 weeks), the proposed aquaculture systems were able to increase their harvesting density to as high as $25 - 30 \text{ kg m}^{-3}$, which is comparable to unenvironmental-friendly caged production. In this work, nitrification rates obtained (i.e., $27.6 - 41.2 \text{ mg N m}^{-2} \text{ day}^{-1}$) were in the low-range compared to other works. In spite of that, the proposed aquaculture systems should remain attractive for Thai farmers due to their design simplicity.

Department : Chemical Engineering

Student's Signature : 

Field of Study : Chemical Engineering

Advisor's Signature : 

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