Chapter I
Introduction

1.1 Motivation and Background

Aquacultures in Thailand are typically performed in earthen ponds or in cages. These practices require significant amount of water from natural resources, which are often affected by diseases or waste discharges generated upstream from both domestic and industrial sources. Moreover, a release of organic and nitrogenous wastes from caged aquacultures is known to create adverse effects on aquatic environment namely ammonium toxicity and eutrophication. For these reasons, the aquaculture industry has transformed its practices from open-pond systems toward closed or semi-closed systems, which treat and recycle production water within farms. In Thailand, the closed or semi-close aquaculture systems are normally found in biosecure facilities, which strictly control the disease transmitting, or in those shrimp producing farms, which received GAP (Good Aquaculture Practice) or CoC (Code of Conduct for Aquaculture) from the Department of Fisheries.

Aquaculture ponds can be categorized into 3 types; outdoor earthen ponds, outdoor lining ponds, and indoor pond. Outdoor earthen ponds are popular among Thai farmers, while outdoor lining ponds require the synthetic materials such as HDPE sheets or cements to cover their soil sediments. Indoor ponds are similar to outdoor lining ponds but are largely limited by the availability of light. By excluding the natural factors namely light, rain, and temperature, it was apparent that water quality within aquaculture ponds is directly related to production. Excessive accumulation of ammonium and nitrite is undesirable and yet often encountered in both outdoor lining ponds and indoor ponds. These inorganic nitrogenous compounds are generated from animal excretion and biological degradation of unconsumed feeds. Buildup of ammonium and nitrite above 1.0 mg N L^{-1} is generally known to cause adverse health effects towards aquatic stocks including a higher stress, a lowering oxygen transport capability in blood, a weakening immune system or even death. Nitrification is a suitable option for controlling inorganic nitrogen compound toxicities because it biologically converts ammonium and nitrite into far less toxic nitrate under aerobic condition. In earthen ponds, complete nitrification of ammonium and nitrite occurs naturally in sediments and to much lesser extent in water columns. Nitrification process, however, is not entirely possible in the case of lining ponds, which are often reported to encounter excessive nitrite accumulation. Different design configurations of nitrification systems such as trickling filters, rotating biological contactor, and fluidized sand filters are proposed to enhance the performance of lining ponds. In spite of their successful inorganic nitrogen treatment, the existing nitrifying systems are sophisticated in their design and are costly to operate due to (1) the requirement to circulate water through aerated nitrifying biofilters located outside production ponds (2) the deposition of suspended solids between biofilter voided spaces (3) the intensive energy requirement and maintemance, and (4) the need for high skill operators. An additional difficulty of nitrifying systems is the lengthy startup period that is related to a limited growth of nitrifying bacteria and improper microbial seeding strategies.

1.2 Research Objectives

1. Investigate the factors that influence the occurrence of nitrification.
2. Inquire the startup strategies for nitrification by using easy-access biological catalyzes available in farms
3. Evalute the performance of the proposed aquaculture system, which is designed to control ammonium and nitrite toxicities based on nitrifying principle, and assess the possibility of replacing the caged production by the proposed aquaculture system.

1.3 Scopes of Research

1. The research was conducted at the Center of Excellence in Marine Biotechnology, Department of Marine Science, Faculty of Science, Chulalongkorn University for about 18 months.

2. Parameters influencing the startup of nitrifying biofilter included (1) source of ammonium (i.e., shrimp diets, NH_4Cl, and animal excretion) (2) initial ammonium concentration (i.e., 2 and 10 mg N L^{-1}), and (3) types of biofilters (i.e., Biocord^{TM} and BCN-009).
3. Evaluation of the proposed aquaculture system was carried out under the actual condition for closed-water tilapia cultivation. The zero-

water exchanged tilapia growout was carried out at different initial tilapia stocking densities of 0.7, 3.3 and 5.0 kg m^{-3} in order to obtain the harvesting density from 10 – 20 kg m^{-3}. Initial tilapia weight was set from 50 – 100 g.

4. Performance of the proposed aquaculture system was assessed by using the concentration of ammonium, nitrite, nitrate, and suspended solids as well as tilapia growth data.

1.4 Keywords

Nitrogen, Nitrification, Biofilter, Bioreactor, Tilapia

1.5 Benefit

1. Resolve the excessive ammonium and nitrite concentrations that are often encountered during the closed-water aquacultures in lining ponds and reduce the environmental concerns regarding the discharge of wastewater.
2. Obtain the strategies for nitrifying biofilter acclimation and acquire the initial design and operating guidelines of the proposed aquaculture system that is suitable for a wide adoption among budget-limited Thai farmers.
3. Transfer the technology to tilapia farmers or other aquaculturist and enhance the concept of intensive closed-water aquacultures in Thailand.