# CHAPTER 1
# INTRODUCTION

## 1.1 Backgrounds

Black tiger shrimp is one of the most significant commodities which contributes markedly to the country's economic status. History showed that the overall global production of black tiger shrimp increased from 6% to 16% in 20 years (from 1970 to 1990). (FAO, 1993) Thailand was known as the world's largest producer of farmed black tiger shrimp with approximately US$2.0 billions in export revenues during 1999. (Szuster and Flaherty, 2001) The increasing global demand for shrimp has stimulated the domestic compulsion for shrimp farms which, in 1990, led to the consideration of turning the rice field into the shrimp farm. (Fast and Menasveta, 1998)

Although the importance of shrimp industry can readily be realized from the economical point of view, the shrimp farming is renowned for its negative impacts on the environment. The apparent environmental problems created from the shrimp farming are derived from the need for large quantity of high quality circulating water in shrimp ponds which leads to the deterioration of seawater at the wastewater discharged area.

During the shrimp culture, the seawater in shrimp pond accumulates several components such as uneaten feed, feces and metabolic wastes. These mineralized nutrients stimulate algae growth and leads to dense bloom in the pond. Some of the degradation products are toxic to the shrimp and may also cause stress and mortality through disease and oxygen depletion. (Fast and Menasveta, 1998) Hence, periodical or partially exchanges of seawater in the pond are necessary for further growth of the shrimp. At this point, the cultural seawater will be discarded and replaced with new fresh, high quality, seawater. The wastes in the utilized seawater are thereafter degraded through microbial and other decomposition processes to produce, among others, ammonia, nitrite and nitrate.

Conventional water exchange systems in shrimp farms are operated in several modes, *i.e.* open, semi-closed and closed systems. In opened water exchange systems, seawater flows continuously through the pond. The advantages of opened systems are the ease of operation and low cost. However, this system inherits two problems: high energy requirement from heating and pumping, and large quantity of polluted water released into the environment causing the disruption of estuarine ecosystems. (Sauthier et al., 1998) This open system is highly prone to contamination with disease which is delivered by the in-flow seawater.

Semi-closed systems require up to 10% of makeup water per flow-through. (Kaiser and Schmitz, 1988) The probability of exposure to disease of shrimp in this kind of system is still high due to the carried over of the disease with the in-coming seawater. Also some metabolic wastes contained in the culture seawater still remain in the system.

Closed systems are usually operated with a makeup water volume of up to 2 % of the systems volume per day. (Kaiser and Schmitz, 1988) These systems are one such innovation, which holds much promise for profitable and sustainable shrimp culture. Results from earlier work showed a better control, less water demand, and improved effluent quality of closed system. (Fast and Menasveta, 1998)

One of the drawbacks of the closed culture system is the necessity to have treatment to prevent the accumulation of metabolic wastes, particularly nitrogen compounds, *e.g.* ammonia, nitrite, and nitrate in seawater. This can be accomplished through processes of nitrification and denitrification. The nitrification is fundamentally the oxidation of ammonia to nitrate by nitrifying bacteria whilst the denitrification is to reduce corresponding nitrate to nitrogen gas by denitrifying bacteria.

Traditionally, nitrification has been conducted using many different technologies *e.g.* trickling filters, fixed-film columns and rotating biological contactors. On the other hand, denitrification which requires anaerobic condition cannot take place in the same place as the oxygen-required nitrification process. Hence units such as packed bed columns, fluidized beds and floating carriers have to be employed separately for denitrification. The separation of nitrification and denitrification units requires that large area must be available for the installation of the treatment system and this leads to extra needs of other facilities such as energy and maintenance.

This work proposes a novel nitrification and denitrification apparatus based on the airlift reactor configuration. The airlift system provides both aerated and unaerated compartments which serve as the nitrification and denitrification in the same unit, respectively. In addition, liquid velocity in the airlift system can be adjusted simply by altering the gas throughput in the system. Hence, in terms of facilities requirement, the airlift reactor is highly attractive, not to mention the low energy and operating costs associated with the operation of the system.

## 1.2 Objective

To develop a treatment system for inorganic nitrogen removal in marine shrimp pond using a closed-circulating seawater external loop airlift bioreactor.

## 1.3 Expected Benefit

The outcome from this work will potentially be beneficial for the future growth of the shrimp industry in Thailand. The success of the work will provide a novel and environmentally benign system for shrimp culture. In addition, the results from this work will serve as an example of the local development of airlift bioreactor for agricultural applications.

## 1.4 Working Scopes

1. All experiments were performed in an external loop airlift bioreactor packed with immobilized bioballs.
2. Ammonia, nitrite, and nitrate concentrations, pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) were monitored to indicate the performance of airlift bioreactor.
3. $NH_4Cl$ was used as a source of inorganic nitrogen in seawater.
4. Methanol was used as a carbon source for the denitrifying bacteria.
5. Size of downcomer was varied to yield the ratio between area of downcomer and riser ($A_d/A_r$) around 10.
6. Aeration rate in riser was adjusted to keep the level of dissolved oxygen higher than 3 ppm.