

專案名稱 Project name:

FEF22004 新型漁網技術減低海洋網箱養殖中魚類疾病的影響

FEF22004 Novel net technology to mitigate fish diseases in ocean net pens

項目推行期 Project Duration:

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申請人名稱/項目負責人:

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專案摘要 Project summary:

本專案探討使用石墨烯技術減少病原體對香港鹽水網箱養殖場的影響。傳染病導致的死亡率是網箱養殖業可持續增長的最大限制因素之一。香港周邊海洋環境富含營養，有助於病原體增殖，包括細菌和有害藻類。新技術可提供緩解策略，減少被動進入網箱的病原體數量。我們建議開發石墨烯電極網，對流經網箱的水進行消毒。本專案目標是將石墨烯水消毒技術應用於開放式網箱養殖場，減少緩解傳染病所需的藥物使用。

我們發現石墨烯在實驗室條件下，以小電荷激活時，對鹽水中的細菌和病毒有極高殺滅效果。然而，材料在使用過程中緩慢降解，且放大規模時產生過多氯，對網箱內魚類有害。因此，我們對原始概念設計進行多次調整。最初，我們採用混合金屬氧化物（MMO）和石墨化碳纖維氈（gCFF）電極，這兩者均具有高表面積，可使用低電壓促進病原體直接氧化。雖然這些系統降低了消毒所需電壓及氯產生量，但水平仍過高，無法讓魚類存活。

儘管如此，混合金屬氧化物電極在我們的實驗中展現出極佳耐用性和產生消毒劑的效率。因此，我們重新設計概念，使用具鈦塗層鈦電極的電化學反應器，在接觸室中消毒海水，隨後以亞硫酸鈉中和，然後把已消毒海水的用於流通式半封閉養殖系統（圖 8）。海水經消毒後細菌病原體顯著減少，顯示這可能是減少病原體進出網箱系統的檢疫或處理槽解決方案。雖然我們未在系統中加入廢水處理，但電極可安裝於出水管口，以處理廢水並減少病原體對鄰近魚類的影響（圖 2）。此消毒系統對魚類健康的研究結果顯示，經處理的電解海水對水生生物安全。此消毒方法也可輕易應用於陸基養殖設施常用的流通式和批次水處理，以及循環養殖系統，為改善香港及中國海水養殖生產提供潛在解決方案。

This project investigated the use of graphene technology to reduce the impact of pathogens on salt water net-pen farms in Hong Kong. Mortality from infectious disease is one of the biggest limiting factors to the sustainable growth of the net-pen aquaculture industry. The marine environment around Hong Kong is rich in nutrients which promotes pathogen proliferation including bacteria and harmful algae. New technology may provide a mitigation strategy to reduce the quantity of pathogens that passively enter net pens. Here we proposed to develop a graphene electrode net to inactivate pathogens passively with the movement of water through the system. The goal of this project is to adapt graphene water disinfection technology to open net pen farms to reduce the use of medication required to mitigate infectious diseases.

We have found that graphene was very effective at killing bacteria and viruses in salt water when activated with a small electrical charge under laboratory conditions. However, the material slowly degraded during operation and produced too much chlorine for fish in the net pens when scaled up. We therefore had to make several adaptations to our original concept design. We initially adapted mixed metal oxide (MMO) and graphitized carbon fibre felt (gCFF) electrodes, both of which have a high surface area that promote direct oxidation of pathogens using low voltages. Although these systems reduced the voltage required for disinfection and consequently the amount of chlorine generation, the levels remained too high for fish survival.

Nevertheless, the mixed metal oxide electrodes demonstrated exceptional durability and efficiency in generating disinfectants in our experiments. Therefore, we redesigned the concept and used our electrochemical reactor with Ruthenium Iridium coated titanium electrodes to disinfect seawater in a chamber followed by neutralisation with sodium thiosulfate. This water was then used in a flow-through closed containment system (Figure 8). The incoming disinfected water was significantly lower in bacterial pathogens suggesting a possible solution for quarantine or treatment tanks to reduce pathogens entering and leaving net pen systems. Although we did not add the effluent treatment to our system, the electrodes could be installed on the outflow pipe of the containment unit to treat the outgoing water and reduce exposure to neighbouring fish (Figure 2). Results of our system on fish health demonstrated that the treated electrolysed seawater was safe to aquatic organisms. This disinfection method can also be readily applied to flow-through and batch water treatments commonly used in land-based aquaculture facilities and recirculating aquaculture systems, offering potential solutions to improve saltwater aquaculture production in Hong Kong and China.