# 中文摘要

本論文之研究目的主要為評估脈衝水域銅對吳郭魚生態生理反應及族群動態之影響。本研究將前人急性與慢性毒資料及生物累積資料重新分析並考慮生物可獲取率之概念以推估各生命階段吳郭魚族群之生態生理參數並藉由機制模式推估各階段吳郭魚之生命參數。進一步，利用矩陣族群模式推估吳郭魚族群暴露於定值或脈衝暴露情境時之族群成長率($\lambda_{max}$)並預測其族群豐量。結果顯示稚魚對銅之生物濃縮因子(bioconcentration factor, BCF)為6157 mL $g^{-1}$高於幼魚之3805 mL $g^{-1}$及成魚之1208 mL $g^{-1}$。且成魚之4d-LC50(外部半致死濃度)為6228 μg $L^{-1}$高於幼魚之2553 μg $L^{-1}$及稚魚之204 μg $L^{-1}$。而稚魚及幼魚之3d-IEC50(半數成長抑制之體內銅濃度)與成魚之7d-IEC50分別為4.54、4.89及10.15 μg $g^{-1}$。此外，結果顯示稚魚、幼魚及成魚於未受銅暴露時之每日存活機率及成長機率，分別為0.9983與0.166、0.9990與0.048及0.9989與0.025 $d^{-1}$，且成魚繁殖力為0.38 $d^{-1}$。然於定值暴露(銅活性為1.8 μg $L^{-1}$)及脈衝情境(銅活性為1.5 – 9 μg $L^{-1}$)時，稚魚之每日存活機率會分別下降34及91 – 98%且每日成長率則分別下降90及88 – 89%。本研究結果亦指出吳郭魚族群於未受銅暴露時之$\lambda_{max}$為1.0865 $d^{-1}$，然暴露於脈衝情境時，$\lambda_{max}$皆小於1 $d^{-1}$，表示吳郭魚族群有減量風險。此外，本研究靈敏度分析指出稚魚成長至幼魚階段之機率及成魚存活機率為主要影響$\lambda_{max}$之生命階段動態參數。因此，本研究可提供一方法評估現地吳郭魚暴露於脈衝水域銅之族群動態，並可推估主要影響族群動態之參數，以供未來研究評估養殖魚類之脈衝金屬暴露風險之參考。

**關鍵字：**矩陣族群模式；吳郭魚；銅；脈衝暴露；生物可獲取率；生物濃縮

# Abstract

The purpose of this thesis was to investigate the effects of pulsed waterborne Cu on the ecophysiological responses and the population dynamics of tilapia. This study reanalyzed the published acute and chronic toxicity and bioaccumulation data of tilapia and took into account the bioavailability for estimating the ecophysiological parameters of each life stage. This study used mechanistic models to estimate the vital rates for tilapia. Further, this study used matrix population model with the estimated vital rates to estimate population growth rates ($\lambda_{max}$) and the tilapia population abundances in constant and different pulsed exposure scenarios can also be predicted. Results showed that larvae had the highest bioconcentration factor, BCF of 6157 mL $g^{-1}$ greater than those of juveniles (3805 mL $g^{-1}$) and adults (1208 mL $g^{-1}$). Results showed that adults had the highest 4d-LC50 of 6228 μg $L^{-1}$ greater than 2553 μg $L^{-1}$ of juveniles and 204 μg $L^{-1}$ of larvae. 3d-IEC50 of larvae and juveniles and 7d-IEC50 of adults were 4.54, 4.89, and 10.15 μg $g^{-1}$, respectively. Furthermore, the results indicated that the daily survival and growth probabilities of larvae, juveniles, and adults under non-exposure scenario were 0.9983 and 0.166, 0.9990 and 0.048, and 0.9989 and 0.025 $d^{-1}$, respectively. The fertility of adults was 0.38 $d^{-1}$. Under constant Cu activity (1.8 μg $L^{-1}$) and pulsed scenarios with the highest Cu activity (1.5 – 9 μg $L^{-1}$) exposures, the daily survival rates of larvae were decreased nearly 34 and 91 – 98%, respectively, and the daily growth rates of larvae were decreased nearly 90 and 88 – 89%, respectively. Results indicated that the $\lambda_{max}$ for non-exposure scenario was 1.0865 $d^{-1}$, whereas for pulsed scenarios, $\lambda_{max}$ were below 1 $d^{-1}$, indicating that there was potential risk for decrease in the tilapia abundance. The sensitivity analysis revealed that $\lambda_{max}$ was most affected by the larval growth and adult survival probabilities. In conclusion, this study provides an approach for assessing the population dynamics for tilapia in real field situation in response to pulsed Cu exposure and is able to estimate the most influential parameters in tilapia population dynamics and assess the pulsed metal exposure risks of framed fishes in the future study.

***Keywords*:** Matrix population model; Tilapia; Copper; Pulsed exposure; Bioavailability; Bioconcentration