中文摘要

本論文主要研究目的在於評估淡水蜆(*Corbicula fluminea*)暴露於砷之蜆殼律動毒性反應及生物動力。本研究完成實驗室 14 天之暴露試驗，並以一階單區塊模式擬合暴露試驗資料推估生物濃縮因子(bioconcentration factor, BCF)及排除速率常數(depuration rate constant, k_2)等生物動力參數。本研究以關鍵體內濃度(critical body residue, CBR)模式、關鍵濃度曲線面積(critical area under the curve, CAUC)模式及損害評估模式(damage assessment model, DAM)等三種急性毒模式模擬 7 天急性砷毒生物試驗所求得之外部半致死濃度(external median lethal concentration, LC50)與時間關係的資料。本研究亦發展一套以感應線圈為基礎之蜆殼開闔監測技術特性化淡水蜆暴露於砷之每日蜆殼律動，並以三參數 Hill 模式推估半數蜆殼反應之效應濃度(median effect concentration, EC50)與時間之關係。結果顯示淡水蜆暴露於砷之 BCF, k_2 及 96 小時 LC50 值分別為 4.38 mL g^{-1}、0.39 d^{-1} 及 20.74 mg L^{-1}。本研究採四參數正弦函數擬合無砷汙染下蜆殼每日開殼律動情形，同時結合 Hill 反應函數建構出淡水蜆暴露於砷之蜆殼每日律動方程式。結果指出一天中蜆殼開殼機率之最佳描述式可表示為 $\psi = 58.75 + 12.89 \times \sin[2\pi(t + 0.034)/21.32]$。經由推估所得砷暴露下時變之 EC50 值於整合時間 10、15、30、60、120 及 300 分鐘下分別為 4.65、3.48、1.38、0.60、0.38 及 0.35 mg L^{-1}。模擬結果顯示在蜆殼開殼時間為 3:00 – 8:00 時，在不同砷暴露濃度 0.3 ~ 1.0 mg L^{-1} 下預測之淡水蜆每日蜆殼開殼變化與實驗結果非常穩合，其均方根誤差為 4 – 10 %。此外，本研究結合 DAM 模式及 Hill 模式建構以內部效應濃度為基礎之時變致死率模式，進而推估出淡水蜆體內砷含量與致死率之關係。本研究指出淡水蜆暴露於砷將導致行為改變及死亡情形，於日後可提供

淡水蜆養殖場一水域含砷之品質標準。

關鍵詞：淡水蜆；砷；生物累積；急性毒；劑量反應；貝殼行為活動；生物監測

Abstract

The purpose of this thesis is to assess the biokinetics and toxicological response of valve daily rhythms in the freshwater clam *Corbicula fluminea* following exposure to waterborne arsenic. We carried out a laboratory 14-day exposure experiment to obtain biokinetic parameters of bioconcentration factor (BCF) and depuration rate constant (k_2). A one-compartment first-order model was used to fit the exposure data to estimate BCF and v values. The three acute toxicity models, critical body residue (CBR) model, critical area under the curve (CAUC) model and damage assessment model (DAM) were verified with time-dependent external median lethal concentration (LC50) data obtained from a 7-day acute arsenic toxicity bioassay. We develop an inductance-based valvometry technique to characterize the valve daily rhythms in *C. fluminea* in response to arsenic, and use a three-parameter Hill model to estimate intergration time-specific median effect concentration (EC50) values. The resulting values of BCF, k_2 and 96-h LC50 of *C. fluminea* exposure to arsenic were 4.38 mL g^{-1}, 0.39 d^{-1} and 20.74 mg L^{-1}, respectively. We fitted valve opening daily rhythm in the absence of arsenic as the form of $\psi = 58.75 + 12.89 \times \sin[2\pi(t + 0.034)/21.32]$ by 4-parameter sine function, linking Hill response function to predict valve daily rhythm dynamics in response to arsenic. The time-varying EC50s are estimated to be 4.65, 3.48, 1.38, 0.60, 0.38 and 0.35 mg L^{-1}, respectively, at integration times of 10, 15, 30, 60, 120 and 300 min. The simulation results show that in the valve opening hours from 03:00 – 08:00 h the predicted daily rhythm changes in valve opening in response to different arsenic exposure concentrations ranging from 0.3 to 10 mg L^{-1} are notably agreed well with the observations justified by the root mean squared errors (RMSE) ranging from 4 – 10%. Moreover, we also kinetically linked a DAM model and a Hill sigmoid model to reconstruct an internal effect concentration based time-mortality model assessing the effect of soft tissue arsenic burden on the *C. fluminea* mortality. Our study indicates that *C. fluminea* exposed to arsenic will cause behavioral changes and mortality, suggesting that our results can provide the knowledge to establish the arsenic water quality criteria to clam farm.

Keywords： Freshwater clam; *Corbicula fluminea*; Arsenic; Bioaccumulation; Acute toxicity; Dose-response; Valve movement; Biomonitor