中文摘要

本研究推導三個急性毒模式並模擬魚類/螺貝類暴露於不同重金屬環境中之急性毒效應。模式主要考慮的因子為暴露時間、水中重金屬濃度、生物濃縮因子(BCF) 及排除速率常數 (k_2)。第一個模式為「吸收-排除急性毒模式」(uptake-depuration toxicity model) 簡稱為 UD 急性毒模式，UD 急性毒模式乃根據重金屬進入魚體內形成殘毒效應對魚體的影響及魚體排除現象的關係，及考慮吸收-排除作用對魚類/螺貝類的影響。第二個模式為「時間積分濃度急性毒模式」(time-integrated concentration toxicity model) 簡稱為 TIC 急性毒模式，TIC 急性毒模式乃根據毒理學中之不可逆受體理論，模擬重金屬進入魚體後體內濃度變化。第三個模式為 「濃度-時間急性毒模式」 (concentration-time toxicity model) 簡稱為 CT 急性毒模式，CT 急性毒模式亦基於不可逆受體理論，考慮整個魚體內濃度變化和暴露時間變化的現象做為討論重金屬濃度對魚類/螺貝類之影響。模擬資料是以砷 (As) 、鈷 (Co) 、銅 (Cu) 及鈷/銅混合物分別對虹鱒 (*Oncorhyuchus mykiss*) 及黃錫鯛 (*Sparus sarba*) 及鋅 (Zn) 對九孔 (*Haliotis divesicolor supertexta*) 之急性毒實驗為主，並以發展出之急性毒模式最佳套配實驗結果之半致死濃度 (LC50(t)) 與時間之關係。由模式驗證結果顯示 TIC 及 CT 兩急性毒模式可成功地描述 4-18 天急性毒實驗結果之 LC50(t) 值 (具高顯著相關, r^2>0.9)。最後並以三種急性毒模式預測生物半數致死時體內之重金屬濃度(CL,50(t))。本研究建議可以 TIC 及 CT 兩急性毒模式應用於魚類/螺貝類急性毒之研究，以推估起始 LC50 及 CL,50 值。

關鍵詞：魚群動態；水文學急性毒 ； 魚類/螺貝類；模擬；水中重金屬

Abstract

Three proposed acute toxicity models, uptake-depuration (UD) toxicity model, time-integrated concentration (TIC) toxicity model, and concentration-time (CT) toxicity model, are derived and verified with acute toxicity data to estimate the internal residues of waterborne heavy metals in fish and shellfish as a function of a few constants and variables. The main factor are the exposure time, the external exposure concentration, the bioconcentration factor (BCF), and the depuration rate constant (k_2). The UD toxicity model is based on the concept of residue levels at the cell membrane well correlating with the whole-body concentration, whereas the TIC and the CT toxicity models are based on the idea of irreversible receptor theory governing the heavy metal acute toxicity in that heavy metals in the entire fish and shellfish or in the aqueous phase can be described by the critical area under the time-concentration curve that is associated with a critical TIC of toxicant in the target tissue. A highly significant correlation (r^2>0.9) was found between predictions and LC50(t) data for both the TIC and the CT toxicity models, indicating successfully describe 4-18-d LC50(t) data of arsenic (As), cobalt (Co), copper (Cu), and Co/Cu mixture in rainbow trout (*Oncorhyuchus mykiss*) and of Cu in fingerlings and subadults of silver sea bream (*Sparus sarba*) as well as of znic (Zn) in abalone (*Haliotis diversicolor superterta*). The time-dependent lethal internal concentration at the site of action that causes 50% mortality is also predicted for a given compound and species. It concludes that the TIC and the CT toxicity models can be applied to regulate the acute toxicity and to estimate incipient LC50 values and internal residues of waterborne heavy metals in fish and shellfish.

***Keywords*:** Acute toxicity; Fish/shellfish; Toxicity modeling; Waterborne heavy metals