中文摘要

本研究利用"一階單區塊生物累積模式"分析食物與水體中鋅在養殖九孔及龍鬚菜體內的吸收、排除現象，並發展以生理學為基礎之"六區塊藥理動力學模式"推估鋅在九孔體內主要器官之分布情形，並預測其在各組織內之含量。研究結果顯示，根據"一階單區塊模式"求出之吸收及排除速率常數(k_1 及 k_2)，與 14 天實驗所得之結果相當吻合。在暴露於不含龍鬚菜且鋅濃度為 1 μg ml^{-1} 的海水中時，模式所求得九孔之 k_1 及 k_2 值分別為 101.4 ml g^{-1} d^{-1} 及 0.611 d^{-1}；而餵食龍鬚菜之九孔其 k_1 及 k_1 值則分別為 114.5ml g^{-1} d^{-1} 及 0.636 d^{-1}。龍鬚菜及九孔之生物濃縮因子根據計算分別為 170 及 180，故九孔之生物放大因子為 1.06。不論野外調查或室內實驗資料皆顯示鋅之生物放大因子約等於 1，此外在室內實驗中餵食及不餵食龍鬚菜的九孔皆吸收等量的鋅。因此，對於排除及短期吸收的實驗而言，上述模式可用來評估吸收及排除速率常數，進而預測穩定狀態下之生物濃縮與生物放大因子，並具有相當的可信度。且我們亦可得知九孔主要是由周遭水體吸收鋅，而非由龍鬚菜。而利用"六區塊藥理動力學模式"模擬的結果顯示，九孔經由水及食物攝入鋅的濃度會在 10 天內達到平衡，但對於殼及軟體組織而言，則不會達到穩定狀態。整體而言，若以目標區塊之鋅動力學評估九孔主要組織內鋅的風險性時，可利用藥理動力學模式加以推算。

關鍵詞：九孔；龍鬚菜；生物累積；藥理動力學模式；鋅

Abstract

Uptake and depuration of dietary and waterborne 65Zn(II) were analyzed in aquacultural abalone Haliotis diversicolor supertexta and the red alga Gracilaria tenuistipitata var. liui using a simple first-order one-compartment bioaccumulation model. A six-compartment physiologically based pharmacokinetic model of the disposition of Zn(II) in abalone key organs was developed to predict tissue distributions. The one-compartment kinetic model was successfully fitted to determine uptake and depuration rate constants (i.e., k_1 and k_2, respectively) based on a 14-d exposure experiment. The resulting values of k_1 and k_2 of H. diversicolor supertexta were 101.4 ml g^{-1} d^{-1} and 0.611 d^{-1}, respectively, when the abalone were exposed to 1 μg ml-1 Zn(II) seawater without the presence of G. tenuistipitata var. liui. When the abalone were fed with the algae, k_1 and k_2 values were estimated to be 114.5 g g^{-1} d^{-1} and 0.636 d^{-1}, respectively. Bioconcentration factors (BCF) for the alga and abalone were determined to be 170 and 180, respectively; and the biomagnification factor (BMF) was 1.06 for the abalone. Both field and laboratory data show that BMF for Zn(II) were about 1. Further more, the abalone in the tank without algae absorbed the same quantity of Zn(II) as the abalone in the tank with alga. Results indicated that estimating uptake and depuration rates from depuration and short-term uptake experiments was a relizable means of predicting BCFss and BMFss, and we can conclude that Zn(II) in the abalone comes primarily from the ambient water and not from the algae. Model simulations using the six-compartment pharmacokinetic model for both water and food exposure routes indicated that the whole body Zn(II) concentration was calculated to reach equilibrium in 10 days. Zn(II) however did not attain a steady-state in the soft tissue and the shell. It is concluded that a pharmacokinetic model is necessary for assessment of Zn(II) risk to abalone key

tissues based on the Zn(II)-dynamics in target compartments.

Keywords：Abalone; Algae; Bioaccumulation; Pharmacokinetic model; Zn(II)