水体镉铅铜复合污染对玉蕊生长及元素吸收的影响

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摘要：【目的】探究水体 Cd-Pb-Cu 重金属复合污染对玉蕊生长和元素吸收的影响，为玉蕊在重金属复合污染湿地修复方面的应用提供理论依据。【方法】以玉蕊为材料，采取室内盆栽试验模拟湿地环境，研究 Cd-Pb-Cu 复合污染对玉蕊（Barringtonia racemosa）生长、养分和重金属吸收分配的影响。【结果】（1）玉蕊株高在 20 mg·L-1Cd+200 mg·L-1Pb+400 mg·L-1Cu 污染水平下显著受到抑制，与 CK（无污染）相比减少 12.44%，而各处理地径生长均未受显著影响；（2）在 5 mg·L-1Cd + 100 mg·L-1Cu+50 mg·L-1Pb 污染水平下玉蕊的总生物量较 CK 显著增加；（3）玉蕊在各处理下氮磷钾养分含量均与 CK 无显著差异，但全株各养分元素累积量均显著高于 CK；（4）Cd-Pb-Cu 复合污染增加了玉蕊全株 Cd、Pb、Cu 含量和累积量，各部位 Cd、Pb、Cu 含量和累积量均随污染浓度升高呈先升后降趋势；（5）相关性分析表明，复合污染下 K 和 Cu 对玉蕊的株高生长、环境适应能力的影响比其他元素更明显；（6）综合转移系数和聚类分析表明，玉蕊在 10 mg·L-1Cd+100 mg·L-1Pb+200 mg·L-1Cu 污染水平下具有更强的重金属富集能力和转移能力。【结论】在模拟湿地污染环境下栽种半年的玉蕊，玉蕊在适应重金属污染水体环境时对 N、P、K 元素表现出了较大的需求，并且对 Cd-Pb-Cu 复合污染水体具有较强的适应性和修复能力，在 Cd、Pb、Cu 污染湿地的生态修复中有较好应用前景。

关键词：重金属；复合污染；玉蕊；元素吸收；湿地修复

Effects of Combined Pollution of Cd, Pb and Cu on Growth and Elements Absorption of *Barringtonia racemosa*

Abstract: 【Objective】To explore the effects of Cd-Pb-Cu combined heavy metal pollution on the growth and element absorption of *Barringtonia racemosa*, and to provide theoretical basis for the application of *B. racemosa* in the remediation of heavy metal combined pollution wetland. 【**Method**】The effects of Cd-Pb-Cu compound pollution on the growth, nutrient uptake, and heavy metal uptake and distribution of *B. racemosa* were investigated by an indoor pot experiment simulating wetland environment. 【**Results**】(1)The plant height was significantly inhibited at 20 mg·L^{-1}Cd+200 mg·L^{-1}Pb+400 mg·L^{-1}Cu, decreasing by 12.44% compared with CK (no pollution), while the growth of ground diameter was not affected under all pollution treatments. (2)Comparing with CK. the total biomass of *B. racemosa* increased remarkably at 5 mg·L^{-1} Cd + 100 mg·L^{-1} Cu + 50 mg·L^{-1} Pb. (3)The content of N, P and K was not significantly different from CK under all pollution treatment, however, the accumulation of all three nutrient elements in whole plant was higher than that of CK significantly. (4)Besides, the content and accumulation of Cd, Pb, Cu in whole plant was improved under Cd-Pb-Cu compound pollution conditions. With the increase of pollution concentration, the content and accumulation of Cd, Pb, Cu all showed a trend of increasing first and then decreasing. (5)The correlation analysis showed that K and Cu had more pronounced effects on plant growth and environmental adaptability of *B. racemosa* than other elements. (6)The integrated transfer coefficient and cluster analysis showed that *B. racemosa* demonstrated stronger enrichment and transfer ability for heavy metals at 10 mg·L^{-1}Cd+100 mg·L^{-1}Pb+200 mg·L^{-1}Cu. 【**Conclusion**】*B. racemosa* has strong adaptability and restoration ability to Cd-Pb-Cu compound polluted water, which can be used for ecological restoration of Cd, Pb, Cu polluted wetlands.

Key words: Heavy metal; Combined pollution; *Barringtonia racemosa*; Element absorption; Wetland restoration