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Heavy Metal Removal from Acid Mine Drainage Using Continuous-Flow Constructed Wetlands with Clamshell Substrate

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INTRODUCTION

Constructed wetlands (CWs) offer a promising alternative to conventional methods for treating acid mine drainage (AMD). Incorporating calcium-rich by-products, such as aquaculture **clamshells** into CWs as a substrate can enhance treatment efficiency and contribute to solid waste reduction. This study investigated lab-scale two-stage CWs filled with clamshells for treating AMD containing high concentrations of manganese (Mn) and zinc (Zn).

Objective:

(1) To evaluate the performance of CWs in removing Mn and Zn.

(2) To assess the effects of hydraulic retention times (HRTs)

(3) To examine the role of plants in heavy metal removal.

METHOD

Two parallel two-stage CWs filled with clamshells (3-7 mm, 45% porosity, 90% $CaCO_3$) were prepared (Fig. 1), one planted with common reeds (P1, P2) and the other unplanted (UP1, UP2).

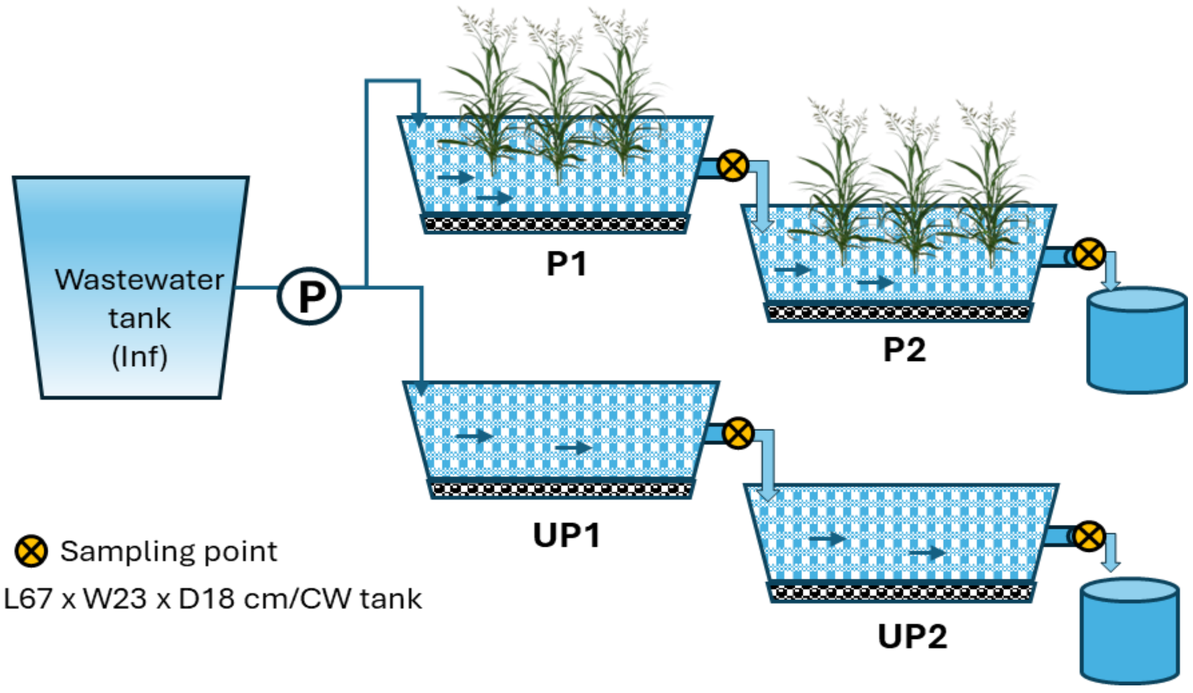

Fig.1 Diagram of the treatment system.

Synthetic AMD (**67.3 mg/L Mn, 10.6 mg/L Zn, pH 5.3**) was continuously fed to CWs in four phases (I-IV) with HRTs of 48, 24, 12, and 48 h, respectively. Water samples were collected to analyze heavy metals and other parameters. Mn-oxidizing (MnOB) and sulfate-reducing bacteria (SRB) were detected using modified AY medium and Postgate's medium F (Miyata et al., 2004), respectively.

RESULTS & DISCUSSION

During the experiment, clamshells with high $CaCO_3$ content effectively neutralized AMD, raising the effluent pH to 7.4–8.4. All CWs efficiently removed Mn (94.0–95.0%) and Zn (99.4–100%), maintaining stable removal across all HRTs, although Mn slightly re-eluted in Phase IV. Effluent concentrations of Mn (0–9.4 mg/L) and Zn (0–0.7 mg/L) met Japan's discharge standards (Fig. 2).

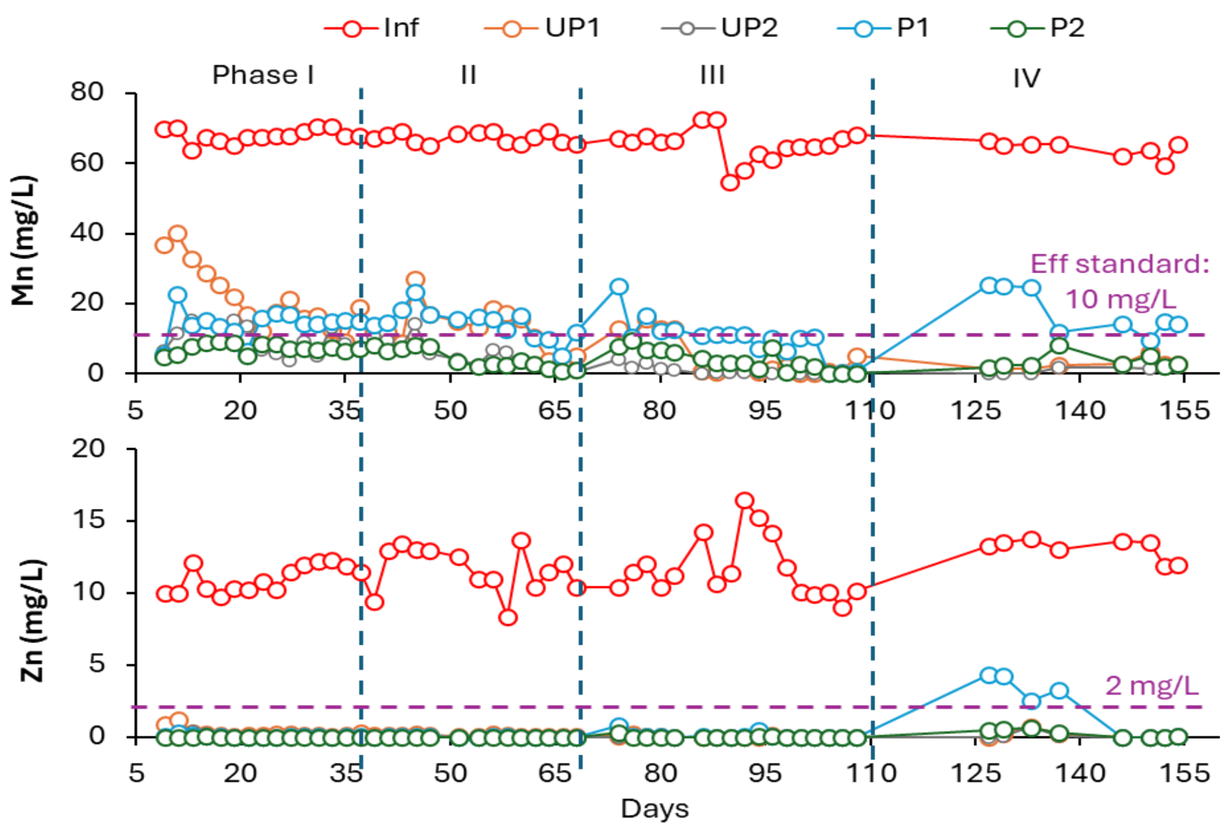

Fig 2: Mn and Zn concentrations during the experiment.

Vegetation contributed significantly to Mn removal in Phase I, but its effectiveness decreased in Phases II-IV. Notably, MnOB and SRB were detected in both systems, potentially promoting the precipitation of Mn oxides and metal sulfides. The Mn and Zn concentrations correlated negatively with pH values, implying that Zn was removed as the hydroxide and adsorbed onto the Mn oxide.

CONCLUSION

Two-stage CWs filled with clamshells demonstrated high treatment performance for Mn- and Zn-rich AMD, even at a short HRT of 12 h. Reeds played a significant role in heavy metal removal during the first phase but were less effective in the later phases. This study provides an ecological approach to reducing the environmental burden of seashell waste while lowering the cost of wastewater treatment.

REFERENCES

N. Miyata, Y. Tani, K. Iwahori, M. Soma: FEMS Microbiol. Ecol., 47(1), pp. 101–109 (2004).

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