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Adsorptivity of heavy metals Cu^{II}, Cd^{II}, and Pb^{II} on woodchip-mixed porous mortar

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HIGHLIGHTS

- Woodchip-mixed porous mortar (WPM) was developed.
- Cation exchange capacity of WPM is twice as large as that of wood chips.
- WPM can adsorb 23 times the amount of Cd^{II} as can wood chips.
- Speciation of Cu, Cd, and Pb adsorbed to WPM allows control of elution behavior.
- WPM maintains high adsorptivity for Cu, Cd, and Pb even after immersion for 1 year.

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ABSTRACT

Here, we developed a woodchip-mixed porous mortar (WPM) by mixing wood chips obtained from thinned Japanese cedar wood with porous mortar aggregates and evaluated the adsorption properties of the heavy metal ions Cu^{II}, Cd^{II}, and Pb^{II} on the WPM. The cation-exchange capacity (CEC) of cup-shaped WPM was approximately twice as large as that for wood chips. The saturation adsorption capacity of WPM for the heavy metal ions Cu^{II}, Cd^{II}, and Pb^{II}, determined by passing an aqueous solution of heavy metal ions, was 6, 23, and 7 times as much, respectively, as wood chips alone. Furthermore, the elution behavior of heavy metal ions adsorbed by WPM was studied by fractionation, wherein the metal speciation was divided into five classes by a sequential extraction method. The leached percentage of Fractions 1 and 2 combined, corresponding to the more easily eluted species of Cd^{II}, was higher than those of Cu^{II} and Pb^{II}. Finally, we found that the immersion of flat WPM in pure water and 3% sodium chloride for 1 year did not degrade the sample, which maintained its high adsorption capacity for heavy metal ions.

1. Introduction

With the revitalization of industrial activities over recent years, scrap wood has emerged as a major form of waste that is discharged into Japan's environment, with approximately 1500 t generated annually. Scrap wood can be classified as: (1) wood chips and bark generated from sawmills, (2) residual wood materials such as packaging materials generated from plants, (3) discarded wood materials generated in the construction of new buildings and the demolition of existing structures, and (4) unused wood chips generated from the thinning and felling that is related to forest maintenance [1].

To make use of this scrap wood, a multistage (cascade) procedure has been recommended in which wood waste is first put to one use and then the remainder is used for another purpose. For example, disassembled scraps from lumber products and wood scraps are converted into chips, which are then used to manufacture particle board [1] and bark compost [2,3]. In addition, such scraps could be carbonized for use in controlling moisture under the floors of houses, eliminating odors in a room, or adsorbing hazardous chemical substances [4]. The remaining degraded materials can then be converted into pellets [5] and fuels such as bioethanol [6], completing the multistage recycling process.

In this context, one approach to effectively utilizing unused wood waste is to convert it into an adsorbent for heavy metal environmental pollutants. For example, the application of aspen and maple sawdust as heavy metal adsorbents has been investigated, utilizing the metal adsorption properties of lignin and cellulose contained in the wood [7–12].

We have investigated the heavy metal ion adsorption properties of wood chips generated from the wood waste of Japanese cedar

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