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Raw and Treated Rice Husks as Sorbents for Mercury Removal from Aqueous Solutions

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Environmental pollution with heavy metals is a growing problem and the need for adequate and inexpensive techniques for removal is urgent. Sorption is an effective method for removing heavy metals from aqueous solutions. During rice milling, large quantities of rice husk waste are generated. This product is used in part as fuel in drying grain plants, which generates a second byproduct: rice husk ash. By this way, two types of relatively low-cost materials are obtained, which seem to be promising sorbents for the removal of heavy metals from aqueous systems. The aim of this study was to evaluate the ability of two groups of materials obtained from rice residues to remove mercury from aqueous solutions. The first group consisted of different size fractions of rice husk (RH): RH1 (>1.18 mm), RH2 (0.15 to 1.18 mm) and RH3 (<0.15 mm). The second group consisted of rice husk pyrolyzed at different temperatures and sizes to obtain the following biochars: RHA3 (>1.18 mm; 850ºC), RHA4 (0.15 to 1.18 mm; 850ºC), RHA300 (raw; 300ºC). The ash from rice husk pyrolyzed at 800ºC in oven of the grain drying plant (RHA800) was also evaluated. The surface area and pore volume were determined using nitrogen adsorption/desorption at liquid nitrogen temperature. The surface morphology of the materials was characterized by Scanning Electron Microscopy. The BET surface area varied between a minimum of 0.76 m2/g (RH2) and a maximum of 330 m2/g (RHA4). The range of the average pore diameter was between 46 Å (RHA4) to 266 Å (RH2). The pore size distribution analysis showed that the materials were mainly low porous or mesoporous except RHA4 that was microporous (53% of the pore volume for RHA4 is due to micropores). The effect of the initial solution pH on the mercury uptake was studied in the range of 2 to 6, using a contact time of 24 h and an initial concentration (Co) of 50 mg Hg(II)/L. The greatest mercury uptake occurred for pH values between 4 and 5. Four materials were selected for further study: RH2, RHA3, RHA4, and RHA800. The batch adsorption kinetic experiments were performed at Co = 50 mg Hg(II)/L, pH 5, and values were taken periodically since the first 5 min until 480 h. The equilibrium was attained at 240 h for RHA3 and RHA4 and at 48 h for RH2 and RHA800. According to the kinetic data, the equilibrium adsorption capacities achieved were: 12 mg/g (RH2), 15 mg/g (RHA800), 27 mg/g (RHA3) and 61 mg/g (RHA4). Sorption kinetics was well described by the pseudo-second-order model. The mercury removal capacity was found to be in the following order: RHA4> RHA3> RHA300> RH3> RHA800> RH2> RH1. The pyrolysis of rice husk resulted in an increase of the specific surface area, which is very important for the removal of mercury. The sorption values achieved in the present study is lower compared with other mesoporous materials reported in literature. Nevertheless, the mercury sorption capacity values obtained are comparable with values found by other authors in similar conditions using rice husk and its ash.