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Interaction of Steel Slag and Zeolite on Ammonium Nitrogen Removal and Its Illumination on a New Carrier Filling Configuration for Constructed Wetlands

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Abstract : Nitrogen and phosphorus are essential nutrients for biomass growth. But excessive nitrogen and phosphorus can contribute to accelerated eutrophication of lakes and rivers. Constructed wetland is an efficient and eco-friendly wastewater treatment technology with low operating cost and low-energy consumption. Because of high affinity with ammonium ion, zeolite, as a common substrate, is applied in constructed wetlands worldwide. Another substrate seen commonly for constructed wetlands is steel slag, which has high contents of Ca, Al, or Fe, and possesses a strong affinity with phosphate. Due to the excellent ammonium removal ability of zeolite and phosphate removal ability of steel slag, they were considered to be combined in the substrate bed of a constructed wetland in order to enhance the simultaneous removal efficiencies of nitrogen and phosphorus. In our early tests, zeolite and steel slag were combined with each other in order to simultaneously achieve a high removal efficiency of ammonium-nitrogen and phosphate-phosphorus. However, compared with the results when only zeolite was used, the removal efficiency of ammonia was sharply decreased when zeolite and steel slag were used together. The main objective of this study was to establish an overview of the interaction of steel slag and zeolite on ammonium nitrogen removal. The CaO dissolution from slag, as well as the effects of influencing parameters (i.e. pH and Ca2+ concentration) on the ammonium adsorption onto zeolite, was systematically studied. Modeling results of Ca2+ and OH- release from slag indicated that pseudo-second order reaction had a better fitness than pseudo-first order reaction. Changing pH value from 7 to 12 would result in a drastic reduction of the ammonium adsorption capacity on zeolite, from the peak at pH7. High Ca2+ concentration in solution could also inhibit the adsorption of ammonium onto zeolite. The mechanism for steel slag inhibiting the ammonium adsorption capacity of zeolite includes: on one hand, OH- released from steel slag can react with ammonium ions to produce molecular form ammonia (NH3•H2O), which would cause the dissociation of NH4+ from zeolite. On the other hand, Ca2+ could replace the NH4+ ions to adhere onto the surface of zeolite. An innovative substrate filling configuration that zeolite and steel slag are placed sequentially was proposed to eliminate the disadvantageous effects of steel slag. Experimental results showed that the novel filling configuration was superior to the other two contrast filling configurations in terms of ammonium removal.

Keywords : ammonium nitrogen, constructed wetlands, steel slag, zeolite
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