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Opinion

The Important Role of Biochar-Mineral Components in Adsorption Applications

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Opinion

Biochar consisting of both carbon and mineral fractions is a porous carbonaceous material with a large specific surface area produced by the pyrolysis of biomass in closed containers, in an oxygen-free or limited oxygen environment [1]. Biochar, sometimes called agrichar, is obtained from the thermal decomposition of a wide variety of carbon-rich biomass materials such as grasses, hard and soft woods, and agricultural and forest residues [2]. Although biochar is generally used for improving soil fertility, increasing soil nutrient levels and water holding capacity, and reducing greenhouse gas emissions through carbon sequestration, it is suitable for adsorption of both organic (antibiotics, pesticides, dyes) and inorganic pollutants (nutrients, heavy metals). It has been used as a costly adsorbent [3-6]. Lately it has been demonsrated that biochar with minerals such as alkaline or earth alkaline metals have enormous effect on the final properties of the materials. Clay minerals are widely applied in agriculture and industrial engineering. A few of the important physical and chemical properties that make clay minerals valuable are particle size, surface chemistry, and surface area [7]. The negatively charged layers in the clay mineral are balanced by the hydrated exchangeable cations (Na^+, Ca^{2+}, Mg^{2+}) in the interlayer space [8]. Clay minerals have a great potential to absorb various pollutants such as heavy metals, dyes and organic compounds through the cation exchange mechanism due to their high surface area and high ion exchange capacity [9,10]. It has been observed that biochar is less effective in removing pollutants from the aqueous medium by adsorption, compared to activated carbon, due to the characteristics of the extraction processes, its relatively low surface area and adsorption capacity [11]. Therefore, it has been observed that biochar composites prepared by impregnating biochar with specific materials such as clay minerals have been successfully used for the adsorption of organic and inorganic pollutants from water [6,12-14].

Biochar-clay composites are prepared according to the following procedure. 2 g of clay (montmorillonite or kaolin) is placed in 500 ml of deionized water and kept in an ultrasonic bath for 30 minutes. 10 g of biomass ground to a size of less than 2 mm, five times the amount of clay, is added to the stable clay suspension prepared by sonication and mixed for 1 hour. The homogeneous mixture is filtered and dried in an oven at 80 °C. Clay-treated biomass feedstocks are placed in a quartz tube and pyrolyzed slowly for 1 hour at 600 °C in N2 environment in the tube furnace. All biochar samples are washed several times with deionized water to remove impurities, oven dried and stored in a sealed container for testing. These conditions enable the successful production of biochar-based composite materials [6,15-18]. Heavy metals are pollutants with acute toxicity, persistence, non-biodegradability and bioaccumulation [19]. Heavy metals entering the water cycle accumulate in the sediment and their concentration in the water is many times higher. The sediment is an important reservoir and aggregation site for heavy metals in the water, and is also the main habitat and food source of benthic organisms [20]. Heavy metals in the sediment can accumulate in benthic organisms, inhibiting their growth and reproduction, and can also be enriched in shellfish, fish, and mammals through food chain biomagnification and eventually enter the human body [21]. At the same time, heavy metals in the sediment can be re-released into the water body through dissolution, desorption and biodegradation, causing secondary pollution. In order to break this vicious cycle, water contaminated with heavy metals should not be released into nature without being treated. Clay-biochar composites have an important function in heavy metal adsorption from waters due to their cheap, natural, easy to prepare and high absorption capacity. Wang et al. [22] reported that by functionalizing biochar/clay composites, they further increased their efficiency and reduced the bioavailable fraction of arsenic (As) and cadmium (Cd) in the river sediment. In this study, biochar-based attapulgite composites were prepared by slow pyrolysis of rice straw biomass pretreated with attapulgite and $ZnCl_2$. They showed that the As and Cd adsorbing capacity of the functional biochar/atapulgite composite is higher than that of the original biochar, and that its diffusivity can be prevented by fixing the heavy metals in the sediments in situ. Ying et al. [23] successfully removed Cd(II) ions in water by using bentonite-biochar composite that they prepared using bentonite and Alternanthera philoxeroides biomass. They stated that adsorption also increased, but there was no significant increase after pH 8. Hai Wang et al. [24] reported that montmorillonite-biochar composites, which they synthesized using peanut shell biomass, were successfully used in the adsorption of Cr(VI), one of the most dangerous pollutants in Acid Mine Drainage (AMD) produced in gold, copper and nickel mining. they have done. Arabyarmohammadi et al. [25] synthesized an organic-inorganic bionanocomposite consisting of chitosan, nanoclay and biochar (MTCB) to simultaneously immobilize Cu, Pb and Zn metal ions in polluted soil and water environments and reported that they removed these three heavy metals simultaneously.

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