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Silver Nanoparticles in the Water Environment in Malaysia: Inspection, characterization, removal, modeling, and future perspective

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The current status of silver nanoparticles (AgNPs) in the water environment in Malaysia was examined and reported. For inspection, two rivers and two sewage treatment plants (STPs) were selected. Two activated carbons derived from oil palm (ACfOPS) and coconut (ACfCS) shells were proposed as the adsorbent to remove AgNPs. It was found that the concentrations of AgNPs in the rivers and STPs are in the ranges of 0.13 to 10.16 mg L^{-1} and 0.13 to 20.02 mg L^{-1}, respectively, with the highest concentration measured in July. ACfOPS and ACfCS removed up to 99.6 and 99.9% of AgNPs, respectively, from the water. The interaction mechanism between AgNPs and the activated carbon surface employed in this work was mainly the electrostatic force interaction via binding Ag^{+} with O^{-} presented in the activated carbon to form AgO. Fifteen kinetic models were compared statistically to describe the removal of AgNPs. It was found that the experimental adsorption data can be best described using the mixed 1,2-order model. Therefore, this model has the potential to be a candidate for a general model to describe AgNPs adsorption using numerous materials, its validation of which has been confirmed with other material data from previous works.

In the past several years, the development of nanotechnology has marched progressively in numerous fields of application such as electronics, biological sensors, and water treatments. One of the recent advances is the development of silver nanoparticles (AgNPs) for various consumer products such as detergents, textiles, cosmetics, sprays, paints, and metal products due to their remarkable physical, chemical, and biological features[1–7]. It was estimated that the worldwide production of AgNPs was about 500 tons per year[8]. This implies that AgNPs are widely utilized on a global scale. Of central concern to the industry stakeholders, policymakers, communities, as well as researchers, however, is their disposal into the water environment such as rivers. This is because there is an accumulated evidence demonstrating that AgNPs are toxic to the aquatic animals such as bacteria[7,9], algae[10], and plankton[11]. They also possess the capability to alter their surrounding beneficial microbial communities[12]. Since the vast majority of the sources for drinking and household uses particularly in Malaysia are greatly dependent on the water from rivers, the current status of AgNPs in the water system should be well-understood so that a probable water treatment can be carried out.

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