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Chemical reduction of nitrate by zerovalent iron nanoparticles adsorbed radiation-grafted copolymer matrix

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Abstract. This research specifically focused on the development of a novel methodology to reduce excess nitrate in drinking water utilizing zerovalent iron nanoparticles (nZVI)-stabilized radiation-grafted copolymer matrix. nZVI was synthesized by borohydrate reduction of $FeCl_3$ and stabilized on acrylic acid (AAc)-grafted non-woven polyethylene/polypropylene (NWPE/PP-g-AAc) copolymer matrix, which was grafted using gamma radiation. The use of nZVI for environmental applications is challenging because of the formation of an oxide layer rapidly in the presence of oxygen. Therefore, radiation-grafted NWPE/PP synthetic fabric was used as the functional carrier to anchor nZVI and enhance its spreading and stability. The chemical reduction of nitrate by nZVI-adsorbed NWPE/PP-g-AAc (nZVI-Ads-NWP) fabric was examined in batch experiments at different pH values. At low pH values, the protective layers on nZVI particles can be readily dissolved, exposing the pure iron particles for efficient chemical reduction of nitrate. After about 24 h, at pH 3, almost 96% of nitrate was degraded, suggesting that this reduction process is an acid-driven, surface-mediated process. The nZVI-water interface has been characterized by the 1-pK basic Stern model (BSM). An Eley-Rideal like mechanism well described the nitrate reduction kinetics. In accordance with green technology, the newly synthesized nZVI-Ads-NWP has great potential for improving nitrate reduction processes required for the drinking water industry.

Keywords: 1-pK basic Stern layer model • acid-driven surface-mediated process • Eley-Rideal like mechanism • priority contaminant • zerovalent iron nanoparticles

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Introduction

Nitrate contamination of global water resources because of globalization of modern agricultural practices is an emerging threat worldwide. In spite of the usefulness of nitrate and nitrogenous compounds as essential elements in the life process, nitrate is potentially hazardous when present in drinking water at sufficiently high concentrations. It acts as a precursor for several health hazards ranging from blue baby syndrome to gastric cancer. As it neither forms insoluble minerals that would be removable as precipitates nor significantly adsorbs under aquifer conditions, reduction is the only possible way to decrease the nitrate contamination from ground water. Concern for potential health consequences has led to the adoption of stringent nitrate standards [1, 2] (US EPA: 44 mg/L nitrate, WHO: 50 mg/L nitrate) in water for human consumption. Nitrate because of its high solubility is possibly the most widespread water contaminant [3, 4]. As it is thermally stable, boiling has no effect on it. Although nitrate in itself is relatively non-toxic, it can be reduced bacterially to nitrite in the intestines of newborn infants and may result in the disease methemoglobinemia (i.e.