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Redox transformation of Arsenic by redox-activated natural nontronite under oxic and anoxic conditions

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Clay minerals are essential components in soils and sediments due to their ability to adsorb toxic trace metals. Nontronite, a type of 2:1 phyllosilicate clay minerals, is particularly expected to play a key role in redox reactions because it contains approximately up to 30 % of high iron (Fe) which substitutes for aluminum (Al) or silicon (Si) in the mineral structure. The Fe redox couple (Fe(II)/Fe(III)) in nontronite is known to be important in controlling the biogeochemical behavior or toxicity of redox-sensitive elements in soil environments. Researchers have extensively studied the sorption properties of smectite type clay minerals to reduce contaminants, including arsenic (As), which is commonly found in soil and groundwater environments. In this study, we investigated the redox transformation of As on redox-activated natural nontronites under oxic and anoxic conditions to understand the reaction mechanisms. From the results of X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) analysis, it was found that redox-activated nontronites can be activated by either partial reduction (structural Fe-reduced nontronite) or addition of aqueous Fe(II) (Fe-added nontronite) while still maintained their characteristics as a nontronite. Especially, the XRD patterns indicate that there are increased trioctahedral domains in octahedral sheet of modified nontronites comparing that the natural nontronite is mainly composed of dioctahedral domain. Also, the Fe2p XPS spectra showed significant contribution of Fe(II) in Fe-reduced nontronite. Also, the enhanced As removal was observed from Fe-added nontronite probably because there are more adsorption sites on Fe-added-nontronite surfaces than natural and structural Fe-reduced nontronite. This study contributes to the fundamental understanding of the mobility and fate of other redox-sensitive elements with Fe-containing clay minerals.