Article Summary

“Advanced Reduction Processes: A New Class of Treatment Processes” by Bhanu Prakash Vellanki, Bill Batchelor, and Ahmed Abdel-Wahab, Environ Eng Sci. 2013 May; 30(5): 264–271, discusses a new class of treatment processes called advanced reduction processes (ARPs), which form highly reactive reducing radicals to degrade oxidized contaminants, such as nitrates, and perchlorates.

ARP solutions have reducing free radicals that rapidly degrade oxidized contaminants. Reducing free radical are defined as any species having an odd number of electrons and thus having an unpaired electron. A reducing free radical normally has a strong tendency to either give up the unpaired electron or accept another electron to form a pair. Therefore, they act as effective reductants (donating electrons) or oxidants (accepting electrons). The ARP mode of operation is similar to that employed by advanced oxidation processes (AOPs), but differs in that reducing radicals are produced rather than oxidizing radicals such as the hydroxyl radical.

ARP solutions are formed by applying ultraviolet light, ultrasound, electron beam, and microwaves to dithionite, sulfite, ferrous iron, and sulfide reducing agents to form highly reactive reducing radical solutions. The ARP sulfite reducing radicals degraded four target contaminants (perchlorate, nitrate, perfluorooctanoic acid, and 2,4 dichlorophenol). The most effective ARP solutions were elevated pH adjusted sulfite solutions energized by a low-pressure mercury vapor lamp (UV-L) to degrade nitrates and perchlorates without bioremediation. The effectiveness of this UV-L/sulfite ARP treatment process improved with increasing pH above 7 for both perchlorate and nitrate degradation.

For wastewater treatment, the kinetics of the ARP redox reactions involved in degradation are the crucial factor in deciding the feasibility of a treatment process. The formation of highly reactive reducing radicals increases the kinetics of degradation reactions of nitrates and perchlorates, where they ordinarily are too slow. Enhanced sulfite radical ARPs are thus well-suited as effective water treatment reductants where they transform target contaminants into more innocuous or simpler products via decomposition of nonbiodegradable organic pollutants into biodegradable intermediates. Conversely, conventional water treatment techniques for contaminated waters, such as ion exchange, reverse osmosis, and nanofiltration/ultrafiltration, only concentrate the contaminant without degradation.