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Use of Advanced Oxidation Process in Wastewater Treatment: A Review

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Abstract

This technology can degrade less reactive toxic pollutants like phenols, synthetic dyes, petroleum, organic compounds, pesticides and aromatics into biodegradable components which can be further treated by conventional biological treatment. The OH• are very powerful oxidizing agent and can be generated by using various processes viz. radiation, photolysis and photocatalysis, sonoelectrolysis, electrochemical oxidation, fenton based reaction and ozone based processes from H2O and H2O2. AOP technology is applicable in drinking water supply, industrial and municipal wastewater treatment, electronic & pharmaceutical industries, steel plant industries, fish hatcheries etc. The objective of this study is to review and investigate the feasibility of AOP technology as a suitable pre-treatment or post-treatment option to conventional biological treatment for complete removal of recalcitrant and less reactive organic pollutants.

Keywords

Advance oxidation process; Hydroxyl radical; Organic matter; Wastewater treatment

Introduction

Advancements in water treatment technology have affected all areas of industrial water treatment. Although mechanical filtration, such as reverse osmosis, is widely employed to filter contaminants,

other technologies including the use of ozone generators, wastewater evaporation, electrodeionization and bioremediation are also able to address the challenges of industrial water treatment.

Well-established technique for wastewater treatment is Advance Oxidation Process (AOP), The only feasible option for biologically persistent wastewater is the use of advanced technologies based on chemical oxidation, such as the Advanced Oxidation Processes (AOPs), widely recognized as highly efficient treatments for recalcitrant wastewater. Application of separation treatment prior to AOP treatment to transfer pollutants to another phase so that they can be treated more easily. Such separation treatment includes stripping coagulation-flocculation, sedimentation, filtration, adsorption etc. This AOP technology was first introduced in 1980s for water treatment and later was widely used for treatment of different wastewater. This technology can degrade less reactive toxic pollutants like phenols, synthetic dyes, petroleum, organic compounds, pesticides and aromatics into biodegradable components which can be further treated by conventional biological treatment.

Examples of AOPs

Many methods are classified under the broad definition of AOPs. The table shows some of the most studied processes. Advanced oxidation generally uses strong oxidising agents like hydrogen peroxide (H_2O_2) or ozone (O_3), catalysts (iron ions, electrodes, metal oxides) and irradiation (UV- light, solar light, ultrasounds) separately or in combination under mild conditions (low temperature and pressure). Among different available AOPs, those driven by light seem to be the most popular technologies for wastewater treatment as shown by the large amount of data available in the literature (STASINAKIS 2008). Solar AOPs are particularly attractive due to the abundance of solar light in regions where water scarcity is high and due to their relatively l ow costs and high efficiencies.

AOP Mechanism

(Mazille, Félicien. "Advanced Oxidation Processes | SSWM. Sustainable Sanitation and Water Management". Archived from the original on May 28, 2012. Retrieved 13 June2012.)

Advanced oxidation involves several steps schematised in the figure below and explained as follows:

1. Formation of strong oxidants (e.g. hydroxyl radicals). 2. Reaction of these oxidants with organic compounds in the water (KOMMINENI et al. 2008) producing biodegradable intermediates. 3. Reaction of biodegradable intermediates with oxidants referred to as mineralisation (i.e. production of water, carbon dioxide and inorganic salts).

AOPs can be applied in pre-treatment stage to enhance biodegradability and to reduce toxicity followed by biological post-treatment. This approach is based on the fact that biological treatment is perhaps less costly and more environmentally friendly than other destructive treatments and that complete mineralisation by AOPs incurs excessive treatment costs.

Apo Technologies

AOPs can be divided into established and emerging technologies based on the existing literature and the water treatment industry’s experience with the technology. Emerging technologies are defined here as technologies that have very limited, if any, full-scale applications in drinking water treatment. The following AOPs technologies are discussed in this report: Each of the above AOPs technologies is evaluated in Section on the basis of its performance reported in the engineering literature, results of manufacturer or vendor studies, and the industry’s experience with the technology. The following sections include detailed discussions of each technology's chemistry, advantages and disadvantages, key variables and design parameters, and available performance data from bench, pilot, and field-scale tests.

Hydroxyl Radical-Based AOPs

Hydroxyl radical (·OH) is the most reactive oxidizing agent in water treatment. Hydroxyl radicals attack organic pollutants through four basic pathways: radical addition, hydrogen abstraction, electron transfer, and radical combination. Their reactions with organic compounds produce carbon-centered radicals (R· or R·–OH). With O2, these carbon-center radicals may be transformed to organic peroxyl radicals (ROO·). All of the radicals further react accompanied with the formation of more reactive species such as H2O2 and super oxide (O2•−), leading to chemical degradation and even mineralization of these organic compounds. Because hydroxyl radicals have a very short lifetime, they are only in situ produced during application through different methods, including a combination of oxidizing agents (such as H2O2 and O3), irradiation (such as ultraviolet light or ultrasound), and catalysts (such as Fe2+).

Sulfate Radical-Based AOPs

Huling SG, Pivetz BE. In-situ chemical oxidation; DTIC Document. 2006.). Once activated by heat, ultraviolet (UV) irradiation, transitional metals, or elevated pH, S2O82− can form more powerful sulfate radicals (SO4·−, E=2.6 V) to initiate sulfate radical based advanced oxidation processes. In contrast, sulfate radicals tend to remove electrons from organic molecules that are subsequently transformed to organic radicalcations. It would be noted that hydroxyl radicals can also be produced from sulfate radicals. The metal activation method only generates 50 % of a sulfate radical yield produced from the heat or UV-activated per-sulfate method. Therefore, the metal activation method is not theoretically efficient. The most frequently used metals include ferrous (Fe(II)) and ferric (Fe(III)) ions, though other metals have been demonstrated to have an activation capability, such as Cu(I) and Ag(I). (Anipsitakis GP,

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