# Chapter 3
# Advanced Oxidation Processes for Water and Wastewater Treatment:
## An Introduction

**Ahmed Hisham Hilles**
*Environment Quality Authority, Palestine*

**Salem S. Abu Amr**
*Universiti Kuala Lumpur, Malaysia*

**Hamidi Abdul Aziz**
*Universiti Sains Malaysia, Malaysia*

**Mohammed J. K. Bashir**
*Universiti Tunku Abdul Rahman, Malaysia*

## ABSTRACT

*Advanced oxidation processes (AOPs) have recently received attraction for treatment of different wastewaters. AOPs have an ability to oxidize a high quantity of refractory organic matters, traceable organic, or to increase wastewater biodegradability as a pre-treatment prior to an ensuing biological treatment. In this chapter, the fundamental mechanisms of different AOPs such as ozonation, hydrogen peroxide, UV, persulfate, and Fenton oxidation are summarized. The combination of different oxidation processes such as O3/H2O2, O3/UV, O3/Fenton+, O3/persulfate are evaluated. Several persulfate activation techniques are also summarized.*

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## INTRODUCTION

The advanced oxidation processes (AOPs) have been widely studied for the treatment of drinking water and industrial effluents. Generally, most AOPs are based on the generation of the highly reactive oxidizing species, such as hydroxyl radicals (Buxton et al., 1999), which could degrade a variety of organic pollutants. Table 1 shows the oxidation potential of some of common and strong oxidizing radicals.

Advanced oxidation processes (AOPs) are currently popular in effluent treatment to degrade recalcitrant compounds, which are difficult to remove by biological processes. Despite being highly efficient, when applied in an isolated way in leachate treatment, AOP do not reach effluent discharge standards established by the existing legislation, requiring post-treatment techniques to also be applied (Moravia et al., 2013).

They are also characterised by a little selectivity of attack which is a useful attribute for an oxidant used in wastewater treatment and for solving pollution problems. The versatility of AOP is also enhanced by the fact that they offer different possible ways for radicals production. Thus allowing a better compliance with the specific treatment requirements (Andreozzi et al., 1999).

A suitable application of AOP to solid waste leachate treatments must consider that they make use of expensive reactants as $H_2O_2$, and/or $O_3$. Therefore it is obvious that their application should not replace, whenever possible, the more economic treatments as the biological degradation (Andreozzi et al., 1999). A list of some of different possibilities offered by AOPs is given in Table 2.

*Table 1. Oxidation Potential for some common oxidants (Huling & Pivetz, 2006)*

| No. | Oxidant Radical | Oxidation Potential ($E_h$) |
|---|---|---|
| 1 | Hydroxyl radical $OH^{\bullet}$ | 2.8V |
| 2 | Sulfate radical $SO4^{\bullet-}$ | 2.6V |
| 3 | Ozone $O_3$ | 2.1V |
| 4 | Persulfate anion $S_2O_8^{-2}$ | 2.1V |
| 5 | Hydrogen peroxide $H_2O_2$ | 1.8V |
| 6 | Permanganate ion $MnO_4^-$ | 1.7V |
| 7 | Peroxymonosulfate anion $HSO_5^-$ | 1.4V |

*Table 2. Advanced oxidation processes (Andreozzi et al., 1999)*

| | |
|---|---|
| $H_2O_2/Fe^{2+}$ | (Fenton) |
| $H_2O_2/Fe^{3+}$ | (Fenton-like) |
| $H_2O_2/Fe^{2+}$ $(Fe^{3+})$/UV | (Photo assisted Fenton) |
| $H_2O_2/Fe^{3+}$ - Oxalate | |
| $Mn^{2+}$/Oxalic acid/Ozone | |
| $TiO_2$/hv/$O_2$ | (Photocatalysis) |
| $O_3$/ $H_2O_2$ | |
| $O_3$/ UV | |
| $H_2O_2$/ UV | |