

# Enhanced Removal of Emerging Recalcitrant Pharmaceutical Contaminants through Integrated Anaerobic and Photocatalytic Treatment.

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## Abstract

This study integrated anaerobic digestion (AD) and heterogenous photocatalysis, an advanced oxidation process (AOP), to treat tetracycline (TC), an emerging recalcitrant contaminant. The integrated system comprising an annular photocatalytic reactor and bioreactor was fed with simulated wastewater containing TC. The photocatalytic treatment was aided by a nano-engineered composite catalyst containing titanium dioxide (TiO<sub>2</sub>) and multi-wall carbon nanotubes (MWCNT). Heterogeneous photocatalysis as a single approach resulted in 90% TC degradation, 39% chemical oxygen demand (COD) reduction, 28% total organic carbon (TOC) removal, and minimal biochemical oxygen demand (BOD) reduction. AD on its own removed 56% and 52%, respectively of the COD and BOD. When applied as a pre-treatment, heterogenous photocatalysis improved the biodegradability (BOD<sub>5</sub>/COD ratio) from 0.12 to 0.42 resulting in improved COD, BOD, and TOC removals of 71%, 70%, and 76%, respectively in the ensuing AD process. Kinetic studies revealed that the ratio of the photocatalytic reactor unit to the anaerobic reactor unit for an integrated system with constant feed flow should be 12:1. Photodegradation as the only form of treatment used more energy than the integrated approach. The bioenergy generated by AD could supply the energy needs of the sequential system resulting in 20% energy savings and a carbon dioxide emission reduction (CER) of 22.74 kg for every cubic meter of treated wastewater. An integrated AOP-AD approach is thus promising for treating recalcitrant organic contaminants of emerging concern.

**Keywords:** Anaerobic digestion; Antibiotic; Biodegradability, Energy analysis, Heterogenous photocatalysis; Tetracycline

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