

Research Highlights

A. Research Interests

As an interdisciplinary researcher, Dr. Choi focuses on four thematic areas: i) Physicochemical Processes for Water and Wastewater Treatment including Advanced Oxidation Technologies and Membrane Separation Processes, ii) Remediation of Contaminated Groundwater, Soil and Sediment, iii) Destruction of Emerging Chemicals of Concern, and iv) Green Synthesis and Environmental Applications and Implications of Nanostructured Functional Materials.

A.1. Physicochemical Processes for Water and Wastewater Treatment

Recent improvement of life standard has invoked serious concerns for the quality of treated water, particularly, drinking water. In order to respond to the concern, Dr. Choi develops more innovative and cost-effective technologies for the treatment of water and wastewater. His research interest includes mainly advanced oxidation technologies and membrane separation processes.

Advanced Oxidation Technologies: The so-called advanced oxidation technologies, where reactive radical species (e.g., hydroxyl and sulfate radicals) readily attack organic chemicals in water, are among the most emerging chemical oxidation processes. Dr. Choi is particularly interested in TiO₂ photocatalysis. Reactive species generated from TiO₂/UV system participate in redox reactions to decompose almost all organic contaminants eventually to H₂O, CO₂, and other non-harmful mineral species in short treatment times. For the widespread full-scale application of this technology, he addresses several well-known concerns and challenges, including enhancement of photocatalytic reactivity of TiO₂, immobilization of the dispersed particles in suspension as form of TiO₂ film and membrane, and reduction of high band gap of TiO₂ for its activation under visible light irradiation to utilize sustainable solar light.

Membrane Separation Processes: Membrane technology is becoming more and more promising. One of the most serious obstacles to the successful application of the technology is the high operation costs associated with routine membrane cleaning due to fouling (flux decline over time). Dr. Choi investigates the fouling of membrane systems in many applications including drinking water treatment and wastewater treatment. Particularly, He is interested in investigating the problem of biofouling on membrane surface and examining the conditions that might prevent the initiation of biofouling.

A.2. Remediation of Contaminated Groundwater, Soil and Sediment

Soils and sediments are the ultimate sink for many persistent organic and inorganic contaminants, act as a long term source for contamination of the environment (e.g., groundwater), and thus have

the potential to impact human and environmental health. Chemicals of interest include polychlorinated biphenyls (PCBs), chlorinated ethenes (TCE and PCE), and polycyclic aromatic hydrocarbons (PAHs).

In Situ Capping and Remediation: Dr. Choi's research interest includes the development of more practical, plausible, and applicable approaches for in situ remediation of contaminated sites with organic compounds. He addresses the integration of the physical adsorption of PCBs with their chemical dechlorination on reactive activated carbon (RAC) impregnated with Fe/Pd bimetallic nanoparticles. He is interested in i) developing and evaluating RAC caps capable of cost-effectively containing or treating sediment contaminants, ii) determining the physicochemical process affecting the performance and longevity of the sediment caps, and iii) documenting their ability to perform in the field.

Sorption of Organic Contaminants to Sediments: Sorption plays a strong role in the availability of contaminants to organisms as well as remediation processes. Understanding of the physics and chemistry of sorption is essential to many decisions regarding regulatory approaches to dealing with environmental contamination and to choosing specific remediation options at contaminated sites. Dr. Choi studies the sorption of PCBs and PAHs to the components of soil and sediment and uses that knowledge to develop an effective method to treat them.

A.3. Destruction of Emerging Chemicals of Concern

Many human-made organic and inorganic compounds and even naturally-occurring chemicals pose serious environmental health impact to human and living creatures. Particularly, the increasing occurrence of cyanobacteria harmful algal blooms in water resources is alarming the environment because of their ability to release toxic metabolites, cyanotoxins. Dr. Choi develops cost-efficient advanced oxidation technologies to treat water contaminated with such biological toxins and he also investigates the decomposition pathways and kinetics of the toxins. The emerging chemicals of concern might also include carcinogenic PCBs, PAHs, and chloroethenes in groundwater, soil and sediment.

A.4. Green Synthesis and Environmental Applications and Implications of Nanostructured Functional Materials

Precise manipulation of matter at nanoscale regions enhances our potential to synthesize materials with tailor-designed properties, versatile functionalities, and eventually environmental applications. Dr. Choi has extensive experience and knowledge on the synthesis and environmental applications of nanomaterials including TiO₂ photocatalyst, Co catalyst, and Fe/Pd bimetallic nanoparticles. In particular, he has researched nanostructured TiO₂ photocatalysts for the development of highly efficient water treatment processes. His research explores the

development of innovative nanotechnological procedures for the preparation of highly efficient nanostructured TiO₂ photocatalytic particles, films, membranes, and devices for environmental applications. For example, the multifunctional properties of TiO₂ films and membranes (decomposition, disinfection, anti-biofouling action, and separation) are of great interest in the field of water treatment and purification. Visible light-activated TiO₂ has the potential for *in-situ* remediation and disinfection of water contaminated with naturally occurring toxins, other harmful organic substances, and pathogenic microorganisms using solar light. Meanwhile, he also addresses that the unique properties of nanomaterials that may escape to the environment could cause secondary environmental and health problems. Dr. Choi is interested in the environmental risks of engineered nanomaterials, focusing on their sources, transport, fate, and implications from cradle to grave.

B. Research Funding and Opportunities

TBA

C. Research Collaborations (Recent 5 Years)

State and National

Dionysios D. Dionysiou	Environmental Engineering, University of Cincinnati PCBs Decomposition Using Oxidation and Reduction
Daniel B. Oerther	Environmental Engineering, University of Cincinnati Preventing Membrane Biofouling
Suzanne Lunsford	Chemistry, Wright State University Development of Environmental Sensors and Electrodes
Armah A. de la Cruz	US Environmental Protection Agency TiO ₂ Photocatalytic Destruction of Biological Toxins
Souhail R. Al-Abed	US Environment Protection Agency PCBs Cleanup in Contaminated Sediments
Hugo Destailats	Lawrence Berkeley National Laboratory Photocatalytic Degradation of TCE in Air

International

Li Puma Gianluca	University of Nottingham, UK Photocatalytic Treatment of Indoor Air Pollutants
Mme Cécile Raillard,	Ecole des Mines de Nantes, France VOCs Treatment Using Photocatalytic TiO ₂ Thin Films
Valerie Hequet	Ecole des Mines de Nantes, France VOCs Treatment Using Photocatalytic TiO ₂ Thin Films

Elias Stathatos

University of Patras, Greece
Visible Light-Activated TiO₂