

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

AMEREN ENERGY RESOURCES)	
)	
)	
)	PCB 12-126
Petitioner,)	(Variance - Air)
)	
v.)	
)	
)	
ILLINOIS ENVIRONMENTAL)	
PROTECTION AGENCY,)	
)	
Respondent)	

PC#1921

NOTICE OF FILING

To: Attached Service List

PLEASE TAKE NOTICE that on August 1, 2012, I filed with the Clerk of the Pollution Control Board of the State of Illinois **COMMENTS OF KIMBERLY GRAY**, a copy of which is attached hereto and herewith served upon you.

Respectfully submitted,

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Feasibility of Dry Sorbent Injection for SO₂ Control from Ameren's Coal-fired Power Plants

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Dry Sorbent Injection (DSI) is emerging as a pollution control technology to address sulfur dioxide (SO₂) emissions. Specifically, for Ameren's fleet of coal fired electric power plants (particularly, the E. D. Edwards and Joppa plants) DSI represents a technically and economically feasible strategy to reduce SO_x and other acid gases (e.g., HCl and HF).

DSI systems do not require major capital investment and are very robust and flexible in design. SO₂ reductions in the range of 50-80% can be achieved and reductions of as high as 95% have been documented. Further, simply by adjusting the dry sorbent feed rate, removal rates can be tuned to changes in operating conditions (i.e., changes in fuels, loads, regulations, etc.).

Our analysis of the estimated performance of DSI at the E.D. Edwards and Joppa plants reveals that, by employing DSI to achieve just 50% SO₂ removal efficiency at the Edwards and Joppa plants, Ameren should be able to achieve a fleetwide average of 0.25lbs/MMBtu SO₂. Furthermore, the capital costs of DSI for both plants are estimated to be less than \$200M (approximately \$50M at Edwards and \$145M at Joppa).

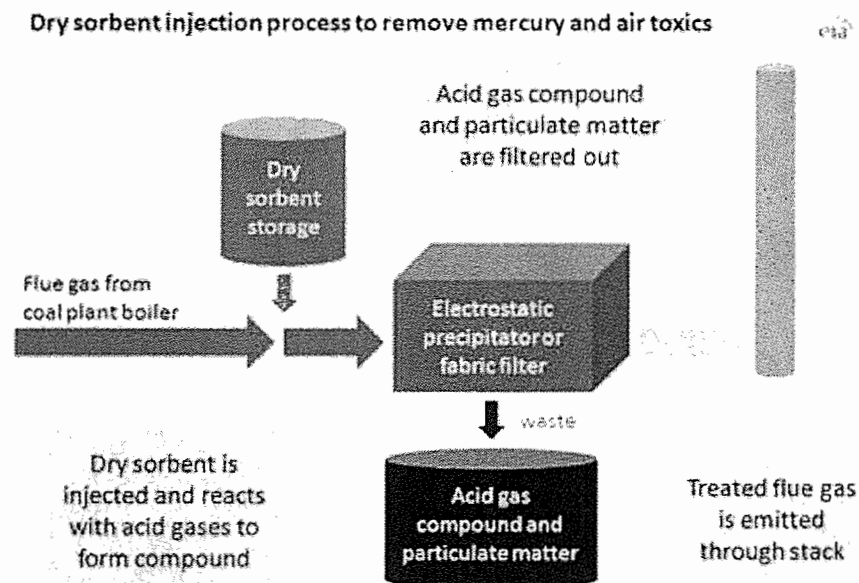


Figure 1. Schematic of DSI injection and removal system. Source – US Energy Information Agency. (<http://www.eia.gov/todayinenergy/detail.cfm?id=5430>)

1. Flue Gas Desulfurization

Flue-gas desulfurization (FGD) is a set of technologies used to remove sulfur dioxide (SO₂) and other acid gases from the exhaust flue gases of fossil-fuel power plants, and other SO_x-emitting

processes. A variety of sorbents are used in either wet or dry FGD processes. Depending on the way in which spent sorbents are treated, FGD processes can be further divided into once-through process or re-generable process. The costs of the re-generable technologies, however, are more expensive compared to that of the once-through technologies; thus, the re-generable processes are not widely used to remove SO₂.

An example of a typical wet, lime/limestone FGD system is illustrated in Figure 2 and consists of three major sub-systems: 1) reagent (lime or limestone slurry) preparation; 2) scrubber/SO₂ absorber and mist eliminator; 3) slurry/solid waste disposal systems.

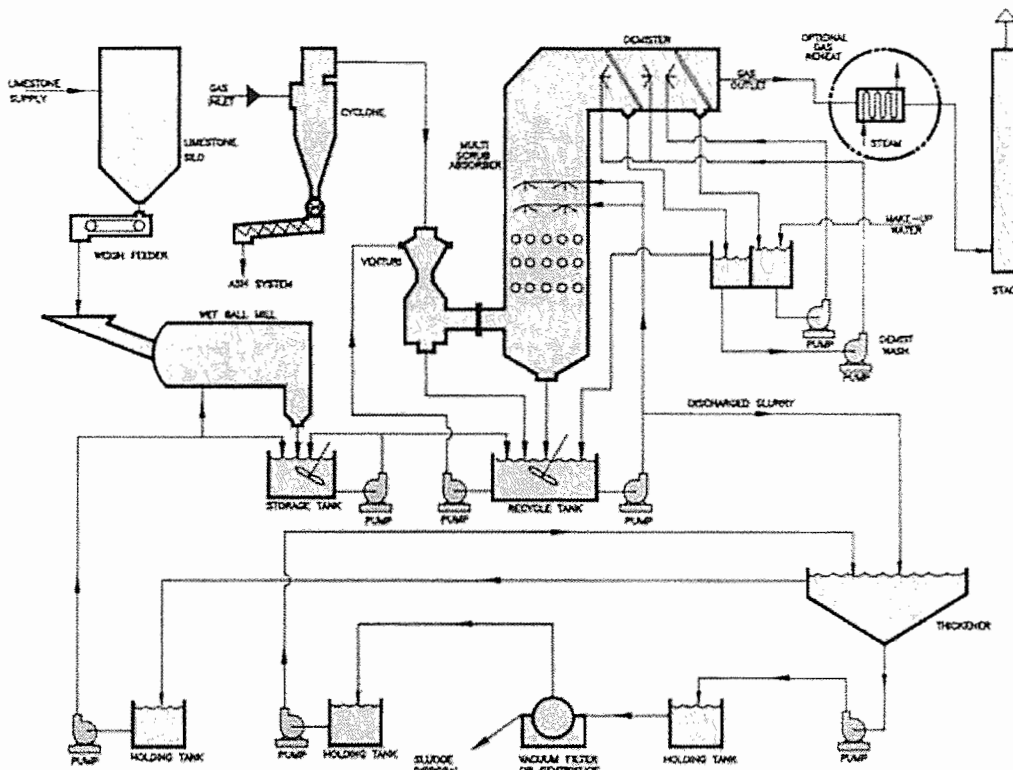


Figure 2. Clean Gas Systems, Inc. Wet Flue Gas Desulfurization process train.
http://www.cgscgs.com/ga_fgd.htm

Nearly 90% of the electricity capacity in the U.S. is generated by plants using wet FGD. Although wet FGD systems clearly predominate over dry sorbent injection (DSI) systems, which are discussed further below, the capital costs can be as much as 10 times greater. Table 1 compares the key features of wet FGD and DSI. The major advantages of wet systems is that very high SO₂ reduction efficiencies are achieved, in the range of 95-98%, whereas removal efficiencies between 50-80% are typically attained by DSI systems. Furthermore, the alkaline sorbent demand of wet FGD is approximately 2-3 times less than that of DSI. DSI has a number of advantages over wet FGD, however. DSI produces dry wastes that are generally easier to dispose of than the wet wastes generated by wet FGD, which in some cases require wastewater treatment prior to discharge. Power consumption, pumping requirements, and pressure drop across absorbers for DSI systems are lower than those for wet FGD system. Other advantages of DSI include: shorter residence times are necessary than with wet FGD, solids are less likely to agglomerate or deposit on internal supports, and the high resistivity problems associated with many alkali materials are

avoided. Perhaps the biggest advantage of DSI is lower cost compared to wet FGD, with DSI averaging 10-25% of the cost of wet FGD.

	Wet FGD	Dry Sorbent Injection
Capital Cost	\$200-400/kW	\$40-50/kW
Coal Sulfur Content for Best Application	>2%	<1.5%
SO ₂ Reduction Efficiency	95-98%	50-80%
Power Consumption, % of electric generation	1.0 - 2.5%	0.1 - 0.5%
Byproducts	Gypsum solid or MgSO ₄ solution for use or disposal	Collected with fly ash
Alkaline Reagent or Sorbent Consumption, kg/kg SO ₂ in flue gas	~2	~3-7
Water consumption, m ³ /hr/MW	0.2-0.3	None
Wastewater treatment required?	Yes	No
Flue gas reheating required?	Yes	No
Ease of retrofit to existing power station	Very difficult	Easy

Table 1: Comparison of different parameters for wet and dry FGD systems. (<http://www.mobotecusa.com/mb/technology/dry-sorbent-injection.htm>)

Our analysis of the estimated performance of DSI at the E.D. Edwards and Joppa plants is consistent with the data shown in Table 1. Conservatively, employing DSI to achieve 50% SO₂ removal efficiency at the Edwards and Joppa plants, Ameren should be able to achieve 0.25lbs/MMBtu. Furthermore, the capital costs of DSI for both plants are estimated to be less than \$200M (approximately \$50M at Edwards and \$145M at Joppa).

2. Dry Sorbent Injection

In DSI systems, calcium-based dry sorbents such as limestone (CaCO₃) or hydrated lime (Ca(OH)₂) are injected into the upper portion of a coal-fired boiler where combustion gas temperature is optimal for SO₂ capture. SO₂ reacts rapidly with the calcium-based sorbent to form stable calcium sulfate solid. Sodium-based dry sorbents such as trona or soda ash can be injected directly into the hot flue gas at multiple points as illustrated below in Figures 4 and 6.

Most dry desulfurization systems use calcium-based alkali, such as lime and limestone, as sorbent for reduction of SO₂ from flue gas since these alkaline materials have a relatively lower unit price. However, since calcium-based alkali injection process has very low sorbent utilization capacities, high sorbent injection rates are required to achieve significant SO₂ reduction from flue gas from coal-fired power plants, resulting in high operating and maintenance costs².

According to previous studies, sodium-based compounds have higher reactivity against SO₂ compared to calcium-based sorbent³. Of sodium-based sorbents, sodium bicarbonate (NaHCO₃) is more efficient in removing SO₂ compared to sodium carbonate (Na₂CO₃)⁴. This is due to the additional reactive surface area that is created as sodium bicarbonate converts to sodium carbonate in a hot gas stream prior to reaction with SO₂⁵. This thermal decomposition reaction can improve

the utilization of sodium bicarbonate for SO₂ removal compared to sodium carbonate by as much as 40%. However, since NaHCO₃ is much more expensive than lime as shown in Table 2, use of NaHCO₃ as sorbent creates higher operating and maintenance costs than does lime.

Sorbent	Cost (per ton)
Dry hydrated lime	\$ 40 - \$ 70
Sodium Bicarbonate (NaHCO ₃)	\$ 260
Nahcolite (NaHCO ₃)	\$ 200
Trona (Na ₂ CO ₃ ·NaHCO ₃ ·2H ₂ O)	\$ 70

Table 2: Comparison of various sorbents and their costs.

3. Trona

Trona (trisodium hydrogencarbonate dihydrate), (Na₂CO₃·NaHCO₃·2H₂O) is a naturally occurring, evaporite mineral. Figure 3 shows microscopic images of trona powders. Although the principal use of trona is to produce soda ash for glass and powdered detergent⁶, research has demonstrated that it is effective in reducing the SO_x and other acid gas emissions from power plants⁷.

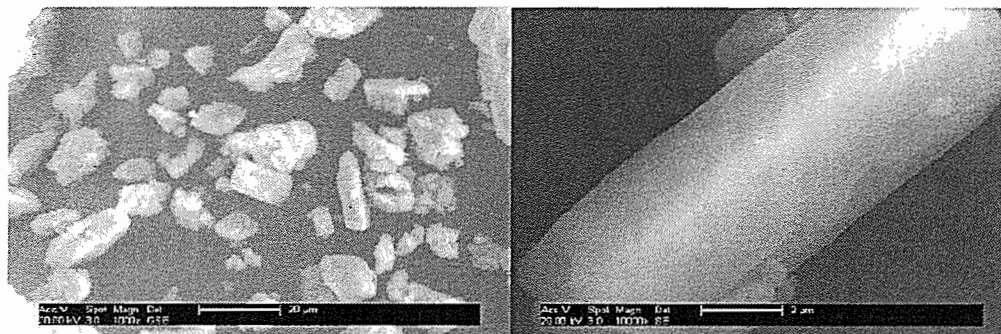


Figure 3: Microscopic views of trona after processing.

Trona consists of both sodium carbonate and bicarbonate (Table 3) and due to its lower cost, it has the potential to replace lime and limestone as the most widely used sorbent in the desulfurization processes. It is already the most common sodium-based dry sorbent in use.

Constituent	Percent (%)
Na ₂ CO ₃	46
NaHCO ₃	36
H ₂ O	16
SiO ₂	< 0.4
H ₂ O insoluble	< 2

Table 3: Composition of trona

3.1 Mining

Trona is mined underground and processed into soda ash or bicarbonate of soda for a variety of uses. Wyoming has the world's largest deposit of trona, found at depths from 600 to 3500 ft over an area of approximately 2500 square miles. Wyoming supplies about 90% of the nation's soda ash⁸. Today four companies, FMC, OCI, Solvay and Green Chemical, currently mine trona in the Green River Basin, but only two, Solvay Chemicals and FMC, market trona for SO₂ control⁹.

3.2 Processing

Trona can be processed into soda ash or sodium bicarbonate. Trona decomposes by calcination at any temperature over 70°C, but most manufacturers prefer to use 130°C. The calcined material is dissolved, clarified, filtered and re-crystallized. It is then centrifuged to remove excess water and dried. The dried product is shipped as either a bagged or bulk product.

4. Trona Injection & SO₂ emission control

4.1 Trona Injection

In a DSI system, trona is injected directly into hot flue gas (> 275°F) as shown in the Figure 4.

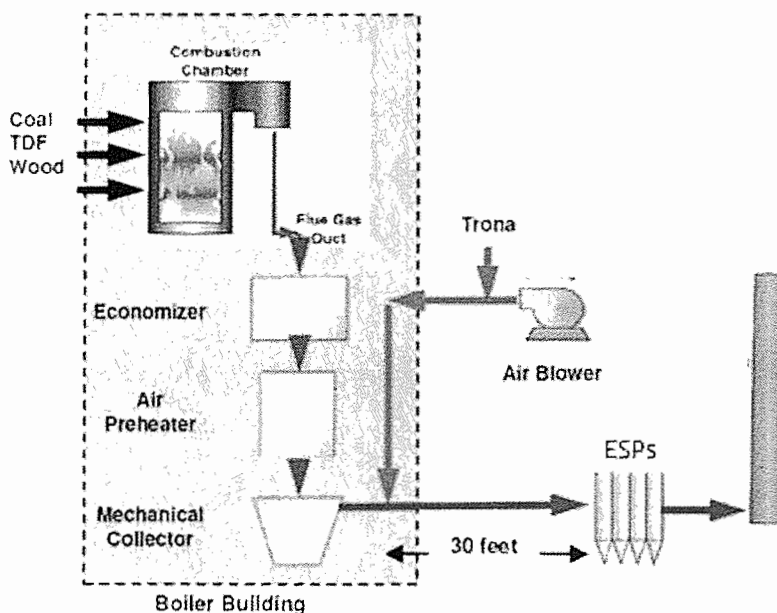
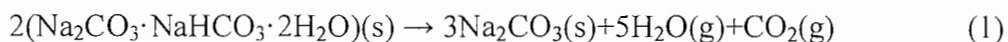


Figure 4: A coal power plant system with trona injection.

After injection, the sorbent is calcined into porous sodium carbonate as shown in Figure 5. Upon decomposition to sodium carbonate, a significant increase in the surface area of the particle is produced in what is commonly referred to as the “popcorn effect”. The high surface area enables fast gas-solid reactions between trona and SO₂. The product Na₂SO₃ is then collected either by electrostatic precipitators or fabric filters. The chemical reactions are shown below.

Trona calcination:



SO₂ adsorption:

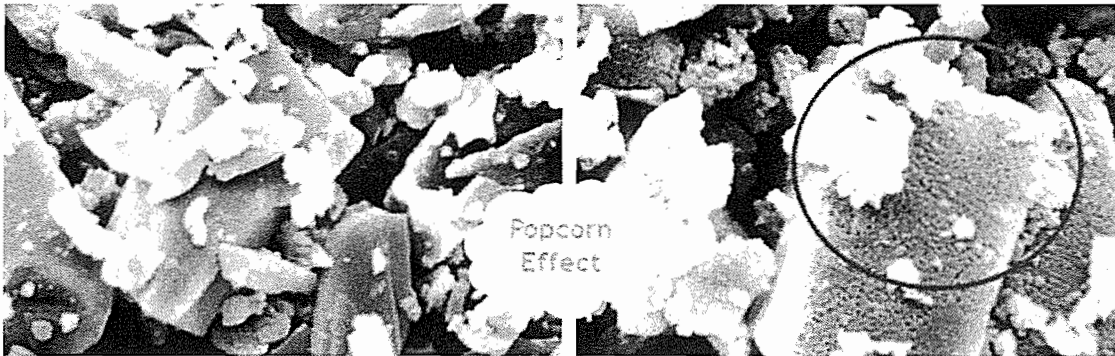
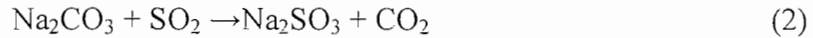


Figure 5: Sorbent is calcined into porous sodium carbonate- Popcorn effect

Trona can be injected at almost any location in the gas stream (Figure 6) but each location has its own advantages and disadvantages.

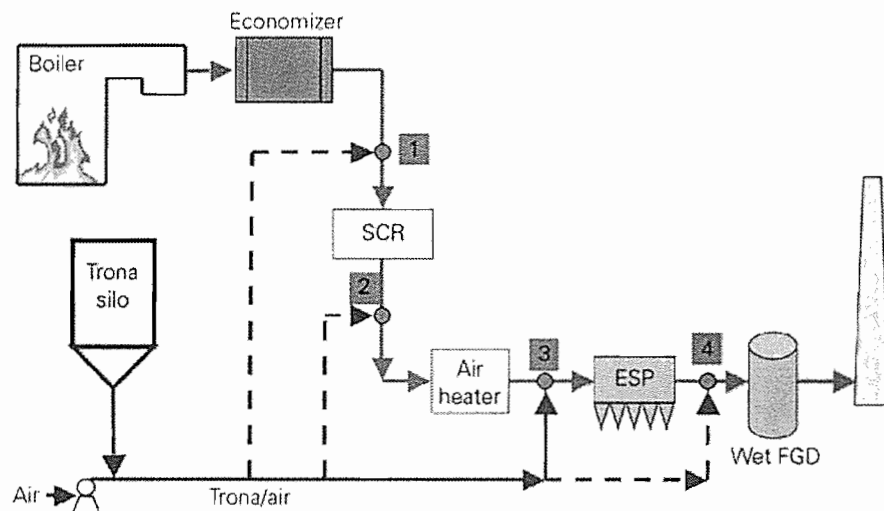


Figure 6: Different locations for Trona injection.

Upstream of the SCR (Location 1)

- Injecting trona at this location can remove most SO₃ ahead of the SCR to eliminate the formation of NH₄HSO₄, or ammonium bisulfate, inside the catalyst and consequently lower the minimum operation temperature.
- This is the preferred location if there is a hot-side electrostatic precipitator (ESP) upstream of the SCR catalyst.

Between the SCR and Air Heater (Location 2)

- Injecting trona at this location removes SO₃ ahead of the air heater so that it can run at lower temperatures, resulting in higher plant thermal efficiency.

Between the Air Heater and ESP (Location 3)

- This is the most common location to inject trona to eliminate the blue plume caused by SO_3 .

Between the ESP and Wet Flue Gas Desulfurization (Location 4)

- Injecting trona at this location is effective in mitigating SO_3 .
- A wet scrubber is needed downstream to capture the reaction product (Na_2SO_4) and unreacted sorbent (Na_2CO_3).
- Na_2CO_3 will enhance the performance of SO_2 removal in the wet scrubber.

4.2 SO_2 emission control

A number of researchers have investigated the efficiency of trona to control SO_2 . In one study, Cho conducted modeling and experimental studies in order to optimize trona's reactivity with SO_2 in DSI¹.

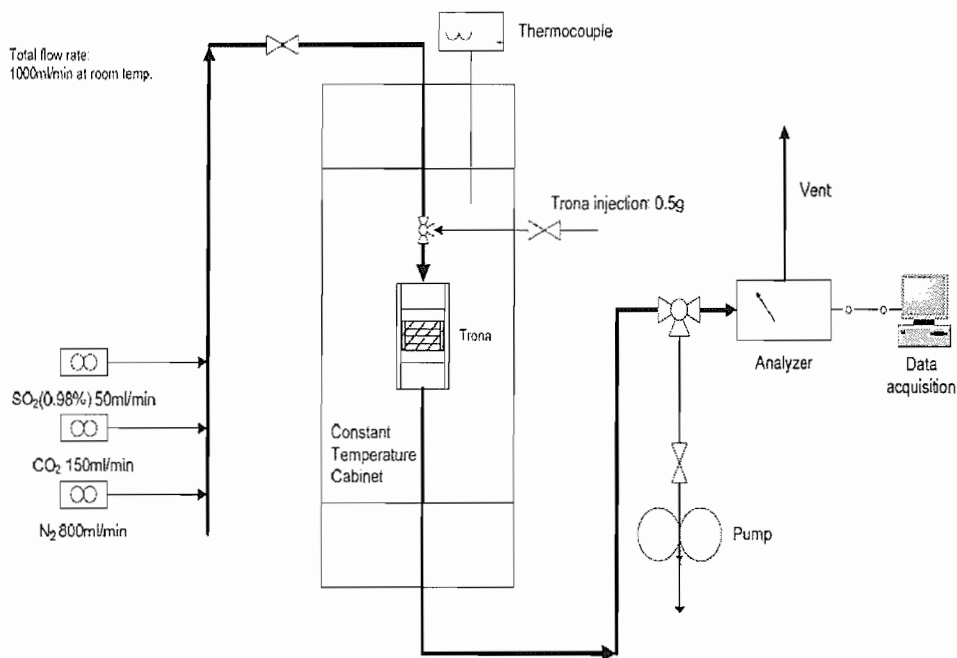


Figure 7: A schematic diagram of fixed bed reactor

A schematic diagram of fixed bed reactor is shown in Figure 7. For Cho's study, the reactor was brought in steady condition prior to trona injection. The exhaust gas was monitored continuously for SO_2 in real time by an infrared gas analyzer. Experimental conditions in the fixed bed reactor were as follows: the flue gas temperature was 150°C ; flue gas SO_2 concentration was 510-530ppm; and flow rate was 1000ml/min. Trona could reduce 60-80% of the SO_2 gas (Figure 8). Water is essential for the reaction of trona. Water vapor had a high influence and caused 38-53% change in the reaction.

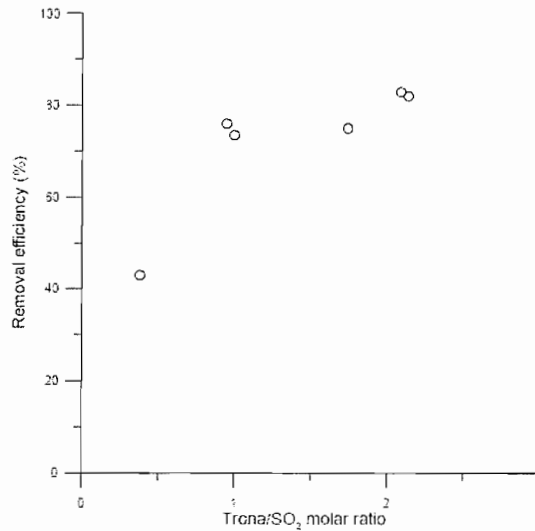


Figure 8: Plot describing the removal efficiency in variation with trona and SO₂ molar ratio

As shown in Figure 8, removal efficiency increased with increasing trona concentration and decreased with an increase in SO₂ gas.

The conversion/reactivity of trona (X_t) can be theoretically calculated by:

$$X_T = 1 - \frac{\frac{4}{3} \times \pi \times r_c^3}{\frac{4}{3} \times \pi \times R^3} = 1 - \left(\frac{r_c}{R}\right)^3 = 1 - \left(1 - \frac{u}{v_B}\right)^3 \quad (3)$$

Where,

R= Radius of the particle

R_c= Radius of trona particle

T_b= Time required to complete the conversion of trona

X_t= conversion of trona

u = velocity (cm.sec)

Figure 9 shows the positive effect of temperature on removal efficiency.

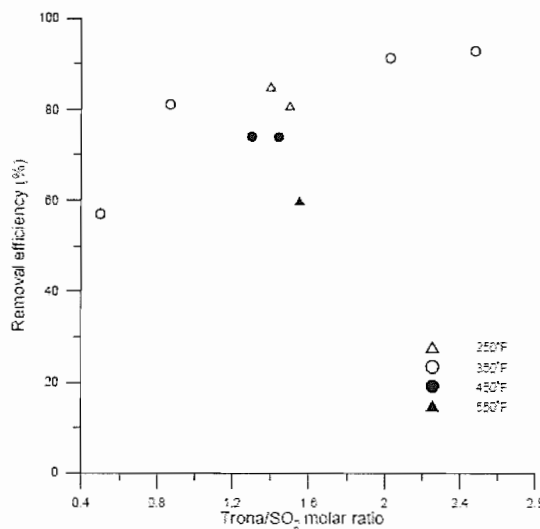


Figure 9: Plot describing the removal efficiency in variation with trona and SO₂ molar ratio with different temperatures.

Figure 10 illustrates the effect of size of trona on removal efficiency, where smaller particles of trona treat more SO₂ compared to larger-sized particles.

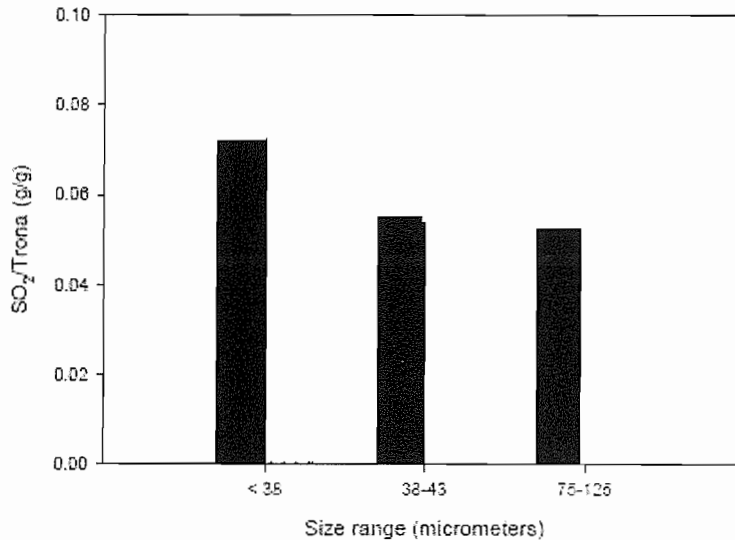


Figure 10: Effect of size of trona on removal efficiency

5. ESP Upgrades

5.1 Electrostatic Precipitators

Particulate matter (PM) is a by-product of fossil fuel combustion used to generate steam for industrial processes. Electrostatic precipitators (ESP) are one of the major particulate collection devices used today. They can handle large gas volumes with a wide range of inlet temperatures, pressures, dust volumes, and acid gas conditions. They can collect a wide range of particles in dry and wet compositions. For many industries, the collection efficiency can be as high as 99%.

As flue gas passes across a series of electrically charged plates and wires, PM (ash and injected sorbents) becomes statically charged. These charged particles collect on the electrically grounded plates. The plates are periodically “rapped” to dislodge PM, which is then collected and disposed as shown in Figure 11¹⁰.

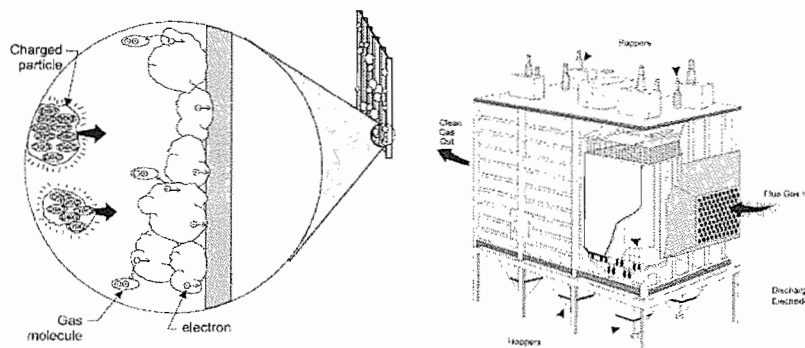


Figure 11: Design of ESP, showing the particle capture

In order to accommodate the additional PM loaded to the ESPs from trona and to improve the control efficiency of the ESPs, some modification of existing ESPs may be required, such as changing the location of the combustion air preheater (“hot-side” to “cold-side” ESP design) and/or installing high frequency transformer rectifier sets on ESPs.

5.2 Hot-side Versus Cold-side ESPs

In describing ESPs installed on industrial and utility boilers, *cold-side* and *hot-side* refers to the placement of the ESP in relation to the combustion air preheater. The air preheater in a cold-side ESP is located *before the ESP*, whereas in a hot-side ESP it is located *after the ESP*¹¹ as shown in Figure 12.

The air preheater is a tube section that preheats the combustion air used for burning fuel in a boiler. When hot flue gas from an industrial process passes through an air preheater, heat exchange occurs whereby heat from the flue gas is transferred to the combustion air stream. The flue gas is therefore “cooled” as it passes through the combustion air preheater. The warmed combustion air is sent to burners, where it is used to burn gas, oil, coal, or other fuel including garbage¹².

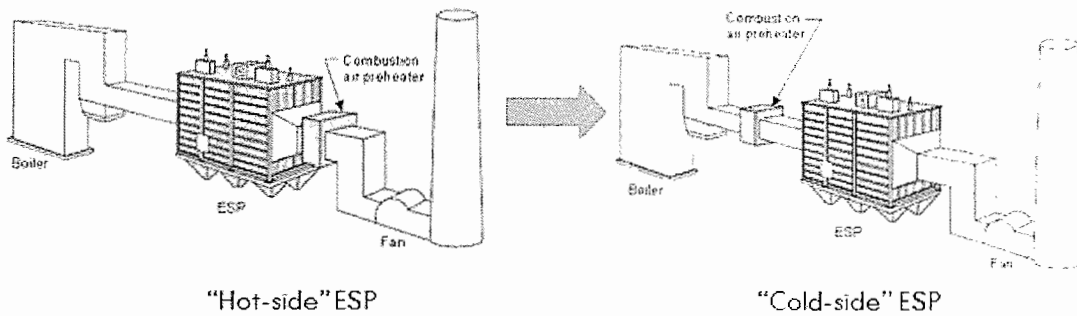


Figure 12: Schematic diagram of hot-side and cold-side ESP

Although the use of hot-side precipitators can help reduce corrosion and hopper plugging, there are also some disadvantages. In a hot-side ESP the temperature of the flue gas is higher, and hence, the gas volume treated in the ESP is larger. Consequently, the overall size of the precipitator is larger, making it more costly. Other major disadvantages include structural and mechanical problems that occur in the precipitator shell and support structure as a result of differences in thermal expansion.

With cold-side ESPs, in contrast, the volume of flue gas that is handled is reduced in comparison to hot-side ESPs because cold-side ESPs are operated at lower temperatures. Thus, the overall size of the unit can be relatively smaller, making it less costly. The decreased gas volume also increases the gas residence time in the ESP, thus increasing the control efficiency of the ESP. In addition, injection of sodium-based dry sorbents may reduce the resistivity of the fly ash resulting in improved ESP effectiveness. Experimental results shown in Table 4 demonstrates the better control achieved by cold-side ESPs¹³.

Emissions before and after cold-side conversion		
Emission	Hot-side	Cold-side (Estimated)
Opacity (%)	7-20	10
Particulate (lb/mm btu)	0.063	0.03
SO ₂ (lb/mm btu)	0.63	0.63
NO _x (lb/mm btu)	0.34	0.34

Table 4: Emissions before and after cold-side conversion from Midwest Power’s Council Bluffs Energy Center experiment.

One of the disadvantages of converting ESPs from hot-side to cold-side operations, however, may be an increase in the ash loading on the air heater. The increased loading occurs because 100% of the fly ash will pass through the air heater. Since replacement and cleaning work could be difficult, it is recommended that dense pack baskets be replaced with loose pack baskets.

Finally, the burning of low-sulfur coal makes fly ash collection by cold side ESPs alone ineffective. Fly ash produced from low sulfur coal-fired boilers has high resistivity, making it difficult to collect. Therefore, in general, cold-side ESPs are used along with conditioning agents when burning low sulfur coal.

5.3 Transformer Rectifiers Sets

Transformer rectifiers supply DC voltage and current to ESPs. High-frequency transformer rectifiers supply high power, voltage and current to ESPs and, thus, may improve the dust collection efficiency of ESPs. Such enhancements to ESPs at existing plants appear sufficient to address the increased PM load that trona systems generate, rendering additional PM control devices, such as fabric filters, unnecessary.

5.4 Effect of trona on PM

With the use of trona, the control efficiency of ESPs improves. Data from trona injection tests (Mirant’s Potomac River Station on Unit 1 between November 12 and December 23, 2005¹⁴), indicated that ESP performance improved with trona injection, even though trona reaction with SO₂ leads to PM formation. The reason for this has not been studied yet, but it likely results from a lower resistivity of PM after the injection of trona.

6. Feasibility Study of trona injection to other plants

6.1 Existing coal power plants

There are a number of the existing power plants that use DSI in the form of trona injection:

- (i) **GenOn Energies** - GenOn Energies employs trona to achieve 40-60% of SO₂ emissions reduction. A dry powder form of trona is injected into the exhaust gas stream where it neutralizes and bonds with the SO₂. The dry byproduct is then removed in the particulate emissions control equipment and collected with ash¹⁵.

- (ii) **American Electric Power (AEP)** - American Electric Power (AEP) tested several sorbents and sorbent systems and selected trona as the best solution for their fleet of plants. They developed a reliable and cost-effective trona handling, conveying and injection system. Positive results include a substantial reduction in SO₃ and enhanced performance of the existing dry ESPs. Additionally, operational and maintenance costs were minimized¹⁶.
- (iii) **Dominion Resources** - Kincaid Generation LLC, a subsidiary of Dominion Resources Inc., awarded the KBR Power & Industrial Group a contract to provide engineering, procurement, and construction services for a DSI system to reduce sulfur dioxide emissions at its 1,158 MW Kincaid coal-fired power plant in Illinois. The project is scheduled for completion in late 2013¹⁷.

6.2 Case Studies

- (i) **Mirac Potomac River generating station** – A series of 32 experiments were conducted at the Mirac Potomac River generating station to test the performance of trona obtained from the Green River, WY mine. A Continuous Emission Monitoring System (CEMS) was installed to monitor SO₂ emissions and 80% sulfur removal was consistently achieved. Figure 13 illustrates the percent of SO₂ removal as a function of trona feed stoichiometry¹⁸.

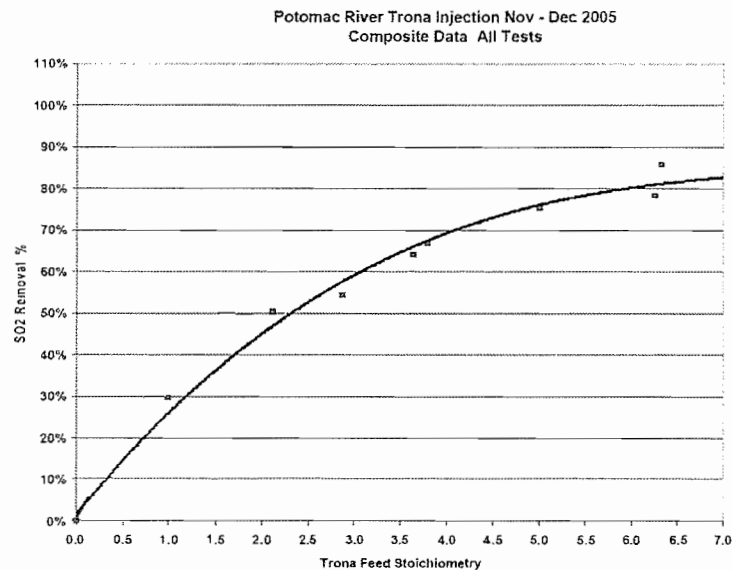


Figure 13: Plot showing direct relationship between SO₂ removal and trona dose.

- (ii) **Nalco Mobotec** - Most Nalco Mobotec solutions require only minimal modification of existing furnaces and associated systems and can be implemented at a fraction of the cost of installing alternative air pollution control equipment. They offer furnace and post-furnace sorbent injection systems that are very easy to retrofit to existing power plants. Power consumption is low—less than 0.5% of generating capacity. They have their own design for sorbent injection system as shown in Figure 14, which consists of independent feed hoppers, various types of feed equipment, and a bin vent filtration system. This system includes several equipment advancements to ensure consistent sorbent flow-ability and accurate sorbent injection rates¹⁹.

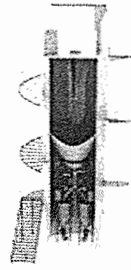


Figure 14: Design of sorbent injection system by Nalco Mobotec

6.3 Commercialization of trona

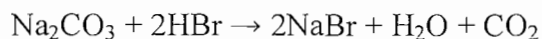
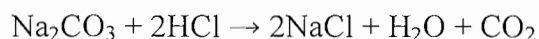
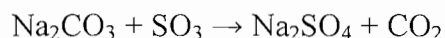
Trona is commercialized by a variety of industries such as:

- (i) Babcock and Wilcox provides an SO₃ mitigation technology through a license with AEP ProServ, Inc., a subsidiary of American Electric Power (AEP)²⁰.
- (ii) Tata Chemicals (Soda Ash) with Church & Dwight Company and FMC Corporation have signed a definitive agreement to form a partnership to manufacture and market sodium-based dry sorbents for air pollution control in electric utility and industrial boiler operations. Natronx will produce, sell and distribute sorbents to users of DSI technology. USEPA estimates that DSI technology will likely be employed by nearly 20% of US coal-fired electric generation capacity as part of compliance with air pollution regulations recently issued in March 2011. Natronx intends to invest approximately \$60 million to construct a 450,000 tons-per-year facility to produce trona sorbents by the fourth quarter of 2012²¹.
- (iii) Solvair Solutions markets trona not only in coal-fired power plants but also in energy-from-waste plants, industrial boilers, municipal waste incinerators and other industries.

6.4 Effect of trona injection on other contaminants

Trona injection is also an effective technology for the removal of other coal combustion contaminants, such as SO₃, HCl and mercury (Hg).

- (i) **Field Tests** - Trona removes SO₂, SO₃, mercury (Hg), HCl and HF at higher rates than lime and costs less than sodium bicarbonate. Field testing by SOLVAir Solution Company showed the removal rates of SO₂ as 90%. It has routinely achieved HCl removal of 95-99%. In addition, it is able to remove 20-70% of Hg used alone, and over 90% in combination of activated carbon²².



HCl and HBr can oxidize mercury, thus enhancing mercury removal.

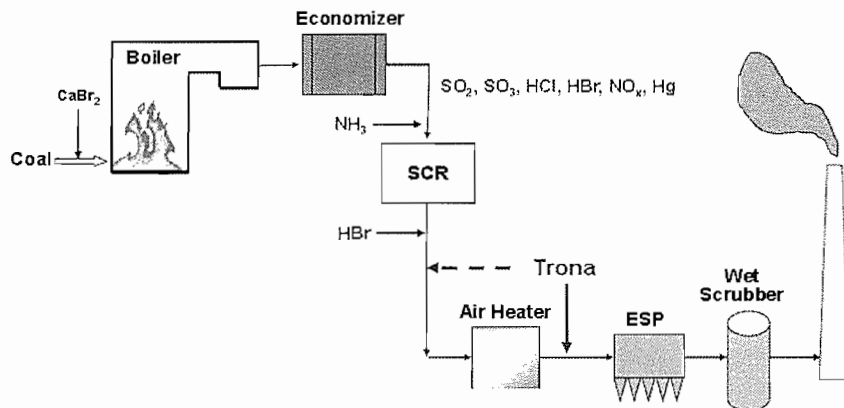


Figure 14: Schematic diagram of other contaminant removal by trona.

- (ii) **Trona's effect on NO_x** - Coal-fired power plant use selective catalytic reduction (SCR) systems to reduce the emissions of nitrogen oxides (NO_x). But for many plants, adding an SCR system has unintended consequences: greater oxidation of SO₂ to sulfur trioxide (SO₃), and a rise in stack opacity. This problem can be solved by combining trona injection with SCR systems, which results in considerable reduction of NO_x. This combination is already being used in Dunkirk generating station, CR Huntley generating station and Indian River generating station²³.

6.5 Potential health effects related to trona exposure

The Virginia Department of Health investigated the possible health effects of trona²⁴. Since trona is a caustic substance, it can have an irritant effect on the respiratory system, mucous membranes, eyes, and skin. Excessive levels of airborne dust may irritate the mucous membranes and upper respiratory tract. Aside from these irritant effects, no chronic loss of lung function is attributed to trona in the studies examined, and interventions to reduce dust levels improved respiratory and/or skin-related symptoms. Beyond the occupational setting, available data suggest that trona is only a transient irritant. Yet, to date, there are no published epidemiologic studies of populations living near power plants where trona is used for air pollution control, nor studies examining the health effects as a result of exposure to trona dust among the general population or among special populations that may be at increased susceptibility to airborne irritants. As a food substance, refined trona is commonly added to animal feed to increase the milk yield and double-refined trona is designated by the Food and Drug Administration as safe when used appropriately.

6.6 Conclusion

This review of the literature and practice, in addition to our own analyses, supports the position that DSI is an efficient, robust, flexible, and cost-effective strategy to retro-fit selected Ameren plants, specifically E. D. Edwards and Joppa, in order to bring their fleet into compliance with the Illinois Multi-Pollutant Standard. Laboratory and full-scale tests have demonstrated that trona typically achieves 60-95% reduction in SO₂ emissions. Trona is particularly well suited for this application and is easily integrated into the flue-gas and the cold-side ESP system of Ameren's plants. If Ameren were to employ DSI to achieve just 50% SO₂ removal efficiency at

the Edwards and Joppa plants, it should be able to meet its fleetwide SO₂ limits of 0.25lbs/MMBtu with a total estimated capital cost of less than \$200M.

Qualifications of Professor Kimberly A. Gray

Kimberly A. Gray is an environmental engineer with over 30 years of experience. Since 1995 she has been a professor of Environmental Engineering in the Department of Civil and Environmental Engineering at Northwestern University. Previously, she held a similar academic post at the University of Notre Dame. She worked in industry in Paris, France and Miami, FL., and continues to work with a wide range of industrial partners on research and consulting projects. She is a qualified expert in the areas of emissions treatment technologies, environmental testing and analytical chemistry, contaminant fate, environmental quality and public health. She studied the formation and control of detached plumes in Portland Cement manufacturing plants and has provided technical assistance to the Chicago Legal Clinic on over 60 environmental projects in the Chicago area. Of these, about 20% focused on air quality issues associated with fossil fuel combustion and in many cases, specifically the SO_x, NO_x and CO₂ emissions from coal-fired electric power generation. Gray is an internationally recognized scholar in the areas of physicochemical processes in environmental systems and the development of photocatalytic treatment technologies for air and water remediation. She is the author of over 100 scholarly papers and reports, holds patents for photocatalyst synthesis and application, and lectures widely on energy, environmental and urban sustainability issues.

References

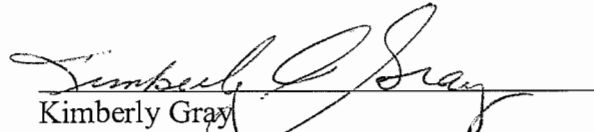
1. Cho, K. J. (2007). "A modeling and experimental study of the conversion of Trona to increase its reactivity with SO₂ in dry injection systems," PhD Dissertation (Environmental Engineering), University of Cincinnati, <http://etd.ohiolink.edu/view.cgi/CHO%20KYUNGMIN%20JACOB.pdf?ucin1185822434>
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3. E.A. Samuel, D. A. F., R.L. Ostop, SO₂ removal using dry sodium compounds. *Am. Inst. Eng. Semp.* **1981**, 77, (211).
4. Keener, T. C.; Davis, W. T., Study of the reaction of SO₂ with NaHCO₃ and Na₂CO₃. *Journal of the Air Pollution Control Association* **1984**, 34, (6), 651-654.)
5. Bares, J.; J., M.; Mocek, M.; Erdös, E., Kinetics of the Reaction between the Solid Sodium Carbonate and the Gaseous Sulfur Dioxide. III. *Coll. Check. Chem. Commun.* **1970**, 35.
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7. <http://www.netl.doe.gov/technologies/coalpower/cctc/resources/pdfs/pscol/netl1160.pdf>
8. <http://www.wma-minelife.com/Trona/tronmine/tronmine.htm>
9. http://www.wma-minelife.com/Brochures/Trona_08.pdf
10. http://www.precip.com/index.php?option=com_content&view=article&id=49&Itemid=60
11. <http://yosemite.epa.gov/oaqps/eogtrain.nsf/b81bacb527b016d785256e4a004c0393/>
12. APTI Course SI: 428A *Introduction to Boiler Operation* describes boilers and heat recovery equipment in greater detail.
13. <http://www.isesp.org/ICESP%20V%20PAPERS/ICESP%20V%20Papers%2003%20ESP%20USER%20EXPERIENCE%20AND%20FIELD%20STUDIES.htm>
14. <http://energy.gov/oe/downloads/Trona-injection-tests-mirant-potomac-river-station-unit-1-november-12-december-23-2005>
15. <http://www.genon.com/company/env-Trona.aspx>
16. http://www.coalpowermag.com/plant_design/SO3-Control-AEP-Pioneers-and-Refines-Trona-Injection-Process-for-SO3-Mitigation_29.html
17. <http://www.kbr.com/Newsroom/Press-Releases/2012/05/07/KBR-Power-and-Industrial-Group-Awarded-Dominion-Resources-Inc-EPC-Contract/>
18. <http://oldtownalexandria.patch.com/topics/Potomac+River+Generating+Station>
19. <http://www.nalcomobotec.com/mb/technology/dry-sorbent-injection.htm>
20. <http://www.babcock.com/library/brochures-environmental.html>
21. <http://www.4-traders.com/TATA-CHEMICALS-LIMITED-9058951/news/Tata-Chemicals-Limited-Tata-Chemicals-Church-Dwight-and-FMC-announce-joint-venture-for-air-pol-13808631/>
22. <http://www.solvair.us/EN/products/select200/solvairirselect200and150Trona.aspx>
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Trona-Injection-Process-for-SO3-Mitigation_29.html

24. Virginia Department of Health, Office of Epidemiology & Office of Environmental Health (June 2007). "Health Effects Associated with Exposure to Trona: A Review of the Biomedical Literature," <http://www.atsdr.cdc.gov/hac/pha/MirantHC/AppendixF-TronaSummary.pdf>

Under penalties as provided by Illinois law, the undersigned certifies that the statements set forth in this instrument are true and correct.

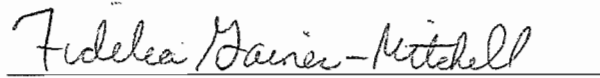
Executed this 31 day of July, 2012 in
Chicago, Illinois.



Kimberly Gray
Professor of Civil and Environmental Engineering
Northwestern University

CERTIFICATION

Kimberly Gray appeared before me and subscribed, and swore or affirmed that the foregoing Affidavit is true, correct and executed as a knowing, free and voluntary act for the purposes stated this 31 day of July 2012.



Fidelia Gaines-Mitchell

NOTARY PUBLIC

My Commission expires:

08 / 28 / 2013.



CURRICULUM VITAE

Kimberly Ann Gray

(07/12)

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Evanston, IL 60208-3109
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http://www.civil.northwestern.edu/EHE/HTML_KAG/Kimweb/

EDUCATION

- 1988 Ph.D., Department of Geography and Environmental Engineering
The Johns Hopkins University, Baltimore, MD
Thesis Title: The Formation, Characterization, and Use of Inorganic Iron(III) Polymers for
Coagulation in Water Treatment
Advisor: Dr. Charles R. O'Melia
- 1983 M.S., Department of Civil Engineering
University of Miami, Coral Gables, FL
Advisor: Dr. Thomas D. Waite
- 1978 B.A., Biology, Minor Biochemistry
Northwestern University, Evanston, IL

PROFESSIONAL EXPERIENCE

- 2012-2013 Senior Sabbatical Fellowship – Public Interest Scientist, Environmental Law and Policy
Center, Chicago, IL.
- 2006-present Professor, Department of Civil and Environmental Engineering, Northwestern University
- 2008-present Northwestern Institute of Sustainable Practices, Director.
- 2009 – present Global and Ecological Health Engineering Program, co-Director with Matthew Glucksberg
- 2003-2010 Director, Environmental Science, Engineering & Policy Program (WCAS); Coordinator of
Environmental Engineering and Science (MEAS), Northwestern
- 2002-present Member, Transportation Center, Northwestern University
- 1999-present Member, Institute of Policy Research Northwestern University
- 1998-2005 Associate-Director, Institute of Environmental Catalysis, Northwestern University
- 1997-present Member, Center for Catalysis and Surface Science, Northwestern University
- 1996-present Courtesy Appointment in the Department of Chemical & Biological Engineering,
Northwestern University

1995-2006	Associate Professor, Department of Civil and Environmental Engineering, Northwestern University
1989-1995	Assistant Professor, Department of Civil Engineering and Geological Sciences, University of Notre Dame (promoted to Associate Professor)
1987-1989	Research Engineer, Lyonnaise des Eaux, Laboratoire Central, Le Pecq, France.
1983-1987	Research Assistant, Department of Geography and Environmental Engineering, The Johns Hopkins University.
1984-1985	Instructor, Part-Time Engineering, The Johns Hopkins University.
1982-1983	Instructor and Research Assistant, Department of Civil Engineering, University of Miami.
1981-1982	Environmental Engineer, Carr Smith and Assoc., Coral Gables, FL.
1980-1981	Research Hydrologist, Everglades National Park, Homestead, FL.
1979-1980	Research Assistant, Smithsonian Institution Foreign Currency Program in India.

PROFESSIONAL MEMBERSHIPS

American Chemical Society
 American Society of Civil Engineers
 Association of Environmental Engineering and Science Professors

HONORS

2011 – Invitee, 9th Annual National Academies Keck *Futures Initiative* (NAKFI), *Ecosystem Services*

2009-2010, 2010-2011 Northwestern Faculty Honor Roll

2009 Distinguished Scientist, Trinity University, San Antonio, Texas

Aldo Leopold Leadership Fellow, 2008, Woods Institute for the Environment, Stanford University

Sigma Xi Distinguished Lecturer, 2008-2010

2007 McCormick Excellence Award in Research, Teaching, & Citizenship

Presidential Young Investigator, National Science Foundation, 1991-1996.

Graduate School Award for Best Dissertation in the College of Engineering; Dissertation Director of Roger J. Hilarides, 1994.

Second Place, Montgomery-Watson and Assoc. of Environmental Engineering Professors Master Thesis Award and Honorable Mention in AWWA Academic Achievement Award Competition, Thesis Advisor of David Widrig, 1993.

Stanley E. Blumberg Alumni Association Scholarship, The Johns Hopkins University, 1986-1987.

Hattie Strong Foundation Fellowship, 1986-1987.

American Chemical Society Graduate Student Award in Environmental Chemistry, 1986.

American Association of University Women Fellowship, Alternate, 1986.

American Water Works Association, Chesapeake Section, Student Paper Award, 1986.

PROFESSIONAL ACTIVITIES

Panel Moderator for Infrastructure, Policy and Regulatory Considerations at The Electrification of Transportation - A Look at the Road Ahead Workshop, NU Transportation Center, Allen Center, 18 April 2012.

2012 - Reach the Decision Makers Program, UCSF Program on Reproductive Health and the Environment

2011 – Consultant, Academic Affairs Division of the Texas Higher Education Coordinating Board, evaluation of the Environmental Engineering program at Texas A&M University at Kingsville

Member, Board of Directors, International Association for Urban Environment, 2009-present.

Member, Editorial Board, The International Journal of Sustainable Development & World Ecology, 2008-present.

Member, Panel Discussion on Energy: Chicago's Energy Needs in 2020, Major Donor Recognition Event with Ira Flatow for WBEZ, Chicago Public Radio, April 28, 2010.

Panel Member, *Environmental Racism: Poverty and Pollution in Minority Communities*, 2010 Martin Luther King Celebration, NU School of Law, January 12, 2010.

Science, Ethics, and Appropriate Uses of Technology: A U.S.-France-Iran Workshop, National Academy of Science, Fondation des Treilles, Tourtour, France, Nov. 7-12, 2009.

“Energy & Sustainability” symposium (Panel member with Thomas L. Friedman) as part of President Morton Schapiro's Inauguration, 9 October 2009.

Member, CBEN NSEC Site Visit Review Panel, Rice University, 29 July, 2009.

Member, Strategic Planning Panel for the Shedd Aquarium, Sustainable Place, Practices, People, Chicago Oct. 8, 2008.

Panel Member, Sustainable Water and Land Management, Clean Technologies & Sustainability: Global Perspectives & Opportunities, Federal Reserve Bank of Chicago, Sept. 9, 2008.

Member, Steering Committee, International Institute of Nanotechnology, Northwestern University, 2008-present.

Panel Moderator, Sustainable Manufacturing: Balancing Environmental Benefits with Economic Costs, 2007 Manufacturing Business Conference, Evanston, IL, May 12, 2007.

Invited Participant, Business, Engineering, & Sustainability: Collaborative Programs for Innovation, 2007 Planning Workshop, University of Maryland, College Park, MD, Feb. 16-17, 2007.

Panel Moderator, Next Generation Strategies for Creating Value through Sustainable Product Design and Manufacturing, 2006 Net Impact Conference, Oct. 28, 2006.

Panel Member, University of Chicago Review of Environmental Science Division, Argonne National Laboratory, Sept. 18-20, 2006.

International Association for Great Lakes Research, Session Organizer and Chair, Integrative Approaches to Ecosystem Modeling, May, 2005.

Canadian Foundation for Innovation, Review panel, October, 2003.

Board of Directors, Chicagoland Redevelopment Initiative (REDI), 2002-2006; Community Advisory Board, Great Lakes Redevelopment Initiative Fund, 2004-present.

American Chemical Society, Division of Environmental Chemistry, Symposium Organizer and co-Chair (with Bruce Logan), Analysis of Environmental Phenomena at Molecular Scales, August, 2001.

Association of Environmental Engineering Professors, Board of Directors, 1996-2000; Vice-President, 1997-98; President, 1998-1999, Past-President, 1999-2000.

National Research Council Water Science and Technology Board, Member of Committee on USGS Water Resources Research, 1996-1999.

National Science Foundation Review Panels: Environmental Engineering, 2010, 2011; Career Award, 1998, 2004, 2005, 2006; NSF Young Investigator Award, 1992; IGERT, 2004, 2005, 2007; Small Business Innovation Research Grant Proposals, 1990, 1994, 1996; BES 2000, 2001, 2002; Division of Undergraduate Education (UCD & ILI), July, 1993, January & July, 1994; Advisory Panel, Environmental Technology, 1995; Committee of Visitors (BES review), 2002.

Organized Workshop at the AEESP Research Needs Conference, "Gender, Diversity and Family Issues," Pennsylvania State University, July 31, 1999.

Organized 1998 Annual Meeting of the Center of Catalysis and Surface Science, "New Frontiers in Environmental Catalysis," Sept. 9, 1998.

Panel Member, NSF-AEEP Frontiers in Environmental Engineering Workshop, Monterey, California, Jan. 14-16, 1998.

Panel Member for "Photodetoxification and Purification of Water and Air" at the DOE Workshop on Research Opportunities in Photochemistry, Estes Park, Colorado, 5-8 February 1996.

Panel Member for NSF Workshop, "Application of Ionizing Radiation for Decontamination of Environmental Resources," Miami, FL, June 1-3, 1994.

Environmental Protection Agency and American Academy of Environmental Engineers WASTECH Task Group 1992-1994, coauthor of monograph, "Chemical Treatment: Innovative Waste Treatment Technologies".

Environmental Protection Agency, Member of Bioremediation Education Subcommittee, 1991-1993.

American Water Works Research Foundation, Project Advisory Committee for "Destruction of Toxic Organics Using Adsorption and Photocatalytic Regeneration with Sunlight or Low Intensity Artificial Lights," 1991-1993.

American Water Works Association, Organic Contaminants Research Committee 1994-present, Coagulation Research Committee 1989-1991.

American Institute of Chemical Engineers, Session Chair and Organizer: Theory and Application of Radiation Processes for the Destruction of Hazardous Compounds, 1990, 1991, 1993; Chemical and Biological Treatment of Waste, 1992; Physical and Chemical Treatment to Enhance Bioremediation of Hazardous Waste, 1994; Photochemical and Radiolytic Treatment Processes, 1996.

Program Development Council and Superfund Subcommittee for Hazardous Materials Control Resources Institute 1994-1996; Session Chair, "Laboratory & Analytical Methods" at 1994 Superfund XV Conference and Exhibitor.

Midwest Environmental Chemistry Workshop, Conference Organizer, University of Notre Dame, October 17-18, 1993.

Fine Particle Society, Division of Aerosols, Health and Environment, Session Chair and Organizer, "Free Radical Processes for Contaminant Destruction in Heterogeneous Systems," 1993.

American Chemical Society, Symposium Organizer, "Polysaccharide Chemistry in Environmental Processes," April, 1992.

Reviewer: Chemistry of Materials, Journal of Catalysis, Applied Catalysis A & B, ACS Catalysis, Coordination Chemistry Reviews, Environmental Science & Technology, Angewandte Chemie, Journal American Chemical Society, Journal of Physical Chemistry, Langmuir, Physical Chemistry Chemical Physics, Energy & Fuels, Nanoscale, Carbon, Catalysis Communication, Catalysis Letters, Transportation Research, Thin Solid Films, Journal of Material Science, Journal of Colloid and Interface Science, Colloids and Surfaces, Journal of Membrane Science, Journal of Applied Microbiology, Aquatic Ecology, Chemistry and Ecology, Journal of Applied and Analytical Pyrolysis, Science of the Total Environment, Water Research, Water Quality Journal of Canada, Water Environment Research, Environmental Toxicology and Chemistry, Journal AWWA, Biodegradation, ASCE Journal of Environmental Engineering, CRC Critical Reviews in Environmental Science and Technology, Chemosphere, Waste Management, Industrial & Engineering Chemistry Research, Research on Chemical Intermediates, Israel Journal of Chemistry, Journal of Solar Energy Engineering, Biotechnology Progress, Environmental Progress, Solar Energy, Journal of Advanced Oxidation Technology, Journal of Hazardous Materials, ACS Symposium Series, New York Sea Grant Program, National Research Council, USGS - Water Resources Center, Dept. of Energy BES, DOD - DEPSCoR, Journal of Molecular Catalysis, Journal of Solid State Chemistry.

COURSES TAUGHT

Undergraduate: Sustainability: Issues and Action, Near and Far, CEE 395 (2006-present)
Energy and the Environment: The Automobile, Envr Sci 203 (2005-2010)
Community Based Design, CEE-398 - 1, 2 (1996 - present)
Urban Neighborhoods: Issues and Action, Soc-376 (co-taught, W. Espland; Cross School Initiative, 2002)
Environmental Engineering Analysis CE 261 (co-taught, B. Rittmann, J-F Gaillard)
Introduction to Water Chemistry and Treatment (UND)
Water and Wastewater Treatment Design (UND)
Water Quality Management (UM)

Graduate: Sustainability Practicum, CEE 395 (co-listed with Law School, PPTY TORT 616 SEC 1 Practicum: Sustainability Solutions & ISEN 440)
Sustainable Product Design and Development, DSGN 495 (2009, 2010)
Physicochemical Processes in Aquatic Systems, CE-444 (NU & UND)
Physical Principles in Environmental Systems CE-440 (co-taught, J-F. Gaillard)
Unit Operations in Environmental Systems CE-445
Environmental Analytical Chemistry CE-446 (co-taught, J-F. Gaillard)
Sustainable Manufacturing, IEMS-497-40 (2005, 2006, 2007, 2008 MMM)
Energy and the Environment IPLS -492 (2009)
Changing Views of Nature MALS- 403 (2006, 2012)
Cities and the Environment: Past, Present and Future, MALS-403 (2004)
The Environmental Legacy of Modern Industrialized Societies, MALS-403 (2001)
Aquatic Chemistry/Advanced Aquatic Chemistry (UND)
Water and Wastewater Treatment Design (JHU)
Water Supply and Drainage (JHU)

DOCTORAL STUDENTS ADVISED - CURRENT

Todd Eaton (2010 - present): TiO₂/SiO₂ Nanocomposites for CO₂ Photoreduction: Synthesizing and characterizing novel interfacial structures.

Kevin Schwarzenberg (2010 – present) – Characterizing adsorption affinity of CO₂ and its effect on photocatalytic reduction.

Tiezheng Tong (2010 – present): Unintended effects of nanotitania in benthic systems.

Sarist Macksasitorn (2010 – present): Biomagnification of persistent organic chemicals in the food webs of Green Bay.

Daniel Finkelstein-Shapiro (2008-present, Dept. of Chemistry): The effect of defect site structure on photocatalytic efficiency.

DOCTORAL STUDENTS ADVISED – COMPLETED

Katie Kalscheur (June, 2012): Characterizing the Effects of Organic Quality on the Structure and Function of Periphyton in Urbanized Streams.

Paul Desario (June, 2011): Cation Doped TiO₂ Thin Films Prepared by Reactive Sputtering: Synthesis, Characterization, and Applications for Environmental Catalysis.

Marshall Lindsey (December, 2010, Dept. of Chemical and Biological Engineering): Location, Vehicle Miles of Travel, and the Environment: A Chicago Case Study.

Shannon Ciston (June, 2009, Dept. of Chemical and Biological Engineering): Photo-active Ceramic Membranes for the Prevention of Biofouling: Synthesis, Characterization & Testing

Yuan Yao (Feb., 2009, Dept. of Mechanical Engineering; co-advised with Prof. Richard Lueptow): Synthesizing TiO₂-Carbon Nanotube Composite Materials for Photocatalysis.

Le Chen (September, 2008): "Synthesizing Mixed Phase Titania Nanocomposites by Reactive DC Magnetron Sputtering to Enhance Photoactivity and Photoresponse." (161 p.)

Carla Ng (May, 2008); Dept. of Chemical and Biological Engineering): "Integrative modeling of the cumulative effects of chemical and biological stresses on aquatic food web structure to predict contaminant transfer." (135 p.)

Jill Kostel (June, 2006): "Periphyton Community Structure in Lotic Systems: The Interactions of Metals, PCBs, and Environmental Variables." (451 p.)

Cari Ishida (September, 2005): "Strategies to Enhance Denitrification Rates in Restored Wetlands: Hydrology, Ecology, and Microbiology." (194 p.)

Mary Finster (May, 2005): "Phytoremediation of Lead in Urban Residential Soils: A Study of Application, Feasibility and Effectiveness in Chicago."

Alexander Agrios (May 2003): "Visible Light Photocatalysis: Adsorption, Complexation, and Reaction of Chlorophenols on Titanium Dioxide." (168 p.)

Tanita Sirivedhin (May, 2002): "Monitoring the Behavior of Organic Carbon in Surface Waters using Pyrolysis/GC/MS." (365 p.)

G. Adam Zacheis (August, 2000): "Degradation of Contaminants Adsorbed to Heterogeneous Surfaces Using Ionizing Radiation." (296 p.)

Allen Simpson (May, 1997): "Interpretation of PY-GC-MS Data to Evaluate the Behavior of Natural Organic Material in Aquatic Systems." (214 p.)

Daniel C. Schmelling (May, 1996): "The Photocatalytic Behavior of 2,4,6-Trinitrotoluene in Titanium Dioxide Systems: Photochemical, Electrochemical and Radiolytic Investigations." (138 p.)

Hong Wang (May, 1996): "The Response of a Laboratory Stream System to PCB Exposure: Study of Periphytic and Sediment Dynamics." (233 p.)

Melissa Dieckmann (May, 1995): "The Sensitized Photocatalytic Degradation of Colored Aromatic Pollutants using TiO₂." (192 p.)

Ulick Stafford (Oct., 1994): "Mechanistic Study of Photocatalytic Degradation of Chlorinated Phenols on TiO₂." (223 p.)

Roger J. Hilarides (May, 1994): "Destruction of 2,3,7,8-Tetrachlorodibenzo-p-dioxin on Soil using Cobalt-60 Gamma Radiation." (249 p.)

MASTER'S STUDENTS ADVISED – COMPLETED

Tracy Yang (March 2012): "Mobile Testing in the Thar Desert: Assessing water quality with limited resources."

Blake Chastain (June 2012, MALS): "The Creation Care Bubble and Evangelical Politics."

Ke Gong (March 2012): "Ecotourism"

Ritu Gopal (June, 2011): Aroclor analysis of Green Bay fish and sediments.

David Petrone (May, 2011; Dept. of Chemical and Biological Engineering): "An Application and Evaluation of the EPA Greenhouse Gas Inventory Reporting Rule."

Erin Himmelspach (Sept., 2010; Dept. of Chemical and Biological Engineering): "Investigation of Titania-Silica Nanocomposites: Probing Interfacial Catalytic Hot Spots for the Photocatalytic Reduction of Carbon Dioxide."

Kevin Schulte (June, 2009): "Synthesis and Characterization of TiO₂ Nanotubes for CO₂ Reduction."

Debra Weissman (June, 2006): "Nutrient Dynamics in Riparian Wetlands."

M. Christina Vicario (July, 2001, Dept of Chemical Engineering): "Novel VUV Photocatalytic Reactor."

Y. Mwendu Munyasya (November, 2000): "The Effects of Catalyst Loading, Light Wavelength, and Oxygen on the Photocatalytic Transformation of 2,4,5-Trichlorophenol."

Mary Finster (October, 1999, Dept. of Chemical Engineering): "The Urban Heat Island, Photochemical Smog, and Chicago: Local Features of the Problem and Solution."

David Widrig (November, 1992): "Preozonation to Enhance Coagulation: The Effect of Algal Species and Water Quality on the Removal of Dissolved Organic Carbon" (172 p.).

Jonathan Noris (August, 1994): "Treatment of High Selenium Waters" (102 p.).

POST DOCTORAL FELLOWS – CURRENT

Dr. Anas Shereef (2011 – present)

POST DOCTORAL FELLOWS - COMPLETED

Dr. Olga Lyandres (2009-2011)

Dr. Baiju Vijayan (2008-2011)

Dr. Gonghu Li (2005-2007)

Dr. Shai Arnon (2004-2006, co-advised with Aaron Packman)

Dr. Deanna Hurum (1999-2004)

Dr. Sung Il Chang (2001-2003)
Dr. Usha Rao (1997-1999, co-advised with Dave Hollander)
Dr. Robert Bornick (1995-1997)
Dr. Ann St. Amand (1990-1992)

RESEARCH GRANTS AND CONTRACTS – CURRENT or PENDING

“Northwestern University Superfund Research Center in Reproductive Health Hazards,” co-PI with Teresa Woodruff, Superfund Research Program, National Institute of Environmental Health Services, NIH, in preparation for April submission (approx. \$ 7M/4 years).

“The Energy Highway,” in collaboration with Dr. Gayathri Gopalakrishnan (ANL) to National Academy Keck Future Initiatives, \$100,000, 06/12 – 06/14.

“Ecological Goods and Services in Urban Development in the Asia Pacific Rim Countries,” Asia Pacific Economic Forum, Business Advisory Committee, Summa Capital, Ltd. \$162,000, 4/15/11 – 12/31/11.

“The Unintended Ecological Consequences of Nanomaterials: Effects of nanotitania in benthic systems,” NSF, \$357,539, 04/11-04/14.

“Science Master’s Program in Engineering and Global Health Technologies,” NSF (with Matt Glucksberg, PI), \$700,000, 09/01/10-9/01/13.

“Ecological Forecasting: Framework to evaluate the effects of multiple stresses in Lake Michigan foodwebs and guide remediation,” NOAA, \$999,000, 09/09-03/13.

“The Chicago Transformation Teacher Institutes,” NSF (with UIC), \$436,768, 01/10-12/14.

“Institute for Environmental Catalysis”, DOE, co-PI (CO₂ Reduction Subtask Leader) with Peter Stair (PI), \$4M, 09/05-09/12; individual allocation, ~ \$700,000;(currently under renewal review).

Dow Sustainability Innovation Competition, \$350,000, 12/08—06/15.

“Tailoring titania nanocomposites to LED illumination for gas phase reactions,” Honeywell Corporation, \$300,000, 8/1/08-12/31/11.

“TiO₂-based nanocomposites for solar fuel production: *Engineering the solid-solid interface for specialized photocatalytic function*,” NSF. \$400,000 09/08-09/12.

“Second Generation Photocatalysts: TiO₂-based nanocomposites by dc reactive sputtering,” National Science Foundation, \$240,000, 07/07-12/11.

“Collaborative Research. Mediation of denitrification by algal/bacterial interactions in stream periphyton: role of successional development and species identity,” National Science Foundation, \$292,240, 08/07-08/12.

RESEARCH GRANTS AND CONTRACTS – COMPLETED

“Reactor and Reaction Optimization for the Photocatalytic Reduction of CO₂,” Boeing Corporation, \$95,000, 08/08 – 12/08.

“Reactive Membrane Technology for Water Treatment,” National Science Foundation, \$400,000, 10/04-12/08 (PI, Richard Lueptow).

“Deterioration of Zinc Potassium Chromate Pigments: Elucidating the effects of pigment mixture and environmental conditions on changes in color and chemical speciation,” Mellon Foundation, \$29,716, 10/06-06/08.

“Engineering Riparian Flood Events: Baseline Monitoring,” U.S. Army Corps of Engineers, \$41,160, 05/05-01/07.

“GAANN: Community-Based Urban Environmental Issues,” Dept. of Education, \$ 495,850, 8/03-8/07 (PI, co-PIs – Aaron Packman and J-F Gaillard).

“Engineering an Artificial Substrate System to Accelerate the Denitrification of Agricultural Runoff by Periphyton,” \$324,000, 8/02-8/06 (PI, co-PI-Aaron Packman).

“Titania Coated Shikkui Tiles: Determining the Role of the Support,” Fukuoka University Institute for Recycling and Environmental Control Systems, \$30,000, 11/05-04/06, *FastScience*.

FastScience, Characterization of Titania Coatings by EPR for Sundecor and Professor Katsuyuki Nakano, Fukuoka University, and the Institute for Recycling and Environmental Control Systems, Phase I, \$10,000, Phase II, \$15,000, Phase III, \$10,000, 3/04-3/05.

“Hydraulic Effects on Biological Diversity in Wetlands,” U.S. Army Corps of Engineers, \$356,160, 11/01-11/04.

“The Fate of Carbon and Nitrogen in an Experimental Marsh,” The Wetlands Initiative, \$44,000, 01/99-08/02, \$25,005, 08/03-12/05.

“Collaborative Learning Communities,” Cross-School Initiative, Northwestern University, \$100,000, 09/00-6/03.

“Safer Yards – Phytoremediation of Lead-Contaminated Soils,” Housing and Urban Development, \$171,073, 02/00-02/03.

“Technical Assistance to Community Groups through the Chicago Legal Clinic,” USEPA, Region V, \$26,250, 9/00-1/02

“Radiolysis on Oxide Surfaces,” National Science Foundation, \$77,269, 2/00-3/01.

“Radiation-Induced Catalysis on Metal Oxide Surfaces: Preliminary Investigation of Basic Phenomena and Potential Applications,” Center for Catalysis and Surface Science, Seed Proposal, \$25,000/1 year 6/98-6/00.

“Pavement Analysis and the Urban Heat Island Effect,” USEPA, Atmospheric Pollution Prevention Division, \$111,121, 7/98-6/99.

“Institute of Environmental Catalysis”, NSF, Environmental Molecular Science Institute Program, Assoc. Director and co-PI with Peter Stair, \$7,982,692/5 yrs total; individual expenditure, \$516,000, 9/1998-12/2004.

“Community Based Projects for Teaching Environmental Engineering Design,” Murphy Society, \$40,916, 1/99-9/99, \$54,069, 01/01-01/02.

“Technical Assistance to Community Organizations: Brownfield Cleanup using Wetlands,” USEPA, Region V, \$15,000, 1/98-1/99.

“Community Based Projects for Teaching Environmental Engineering Design,” Mitsubishi Foundation, \$10,000, 1/98-1/99.

“Detached Plume Study in Portland Cement Manufacturing Plants-Part 1,” Portland Cement Association, \$122,500, 7/98-9/99.

“Carbon Cycling in a Riparian Wetland of the Des Plaines River,” Wetlands Research, Inc., \$13,000, 6/97-6/99; Evaluation of the Denitrification Potential of Wetlands, \$55,000, 6,99-6/00.

“Photocatalysis for Space Mission and Aircraft Applications,” Allied Signal, \$20,000/9/97-8/98.

“Environmental Stress in Ecosystems: Linking Ecology and Engineering”, Co-PI with Gary Lamberti (UND), NSF Research Training Group in Environmental Biology, \$537,500/(9/95-6/2000).

“Macrocosm Total Organic Carbon Analysis using Pyrolysis-GC-MS”, Orange County Water District, \$50,000 (8/94-3/96); Monitoring the Organic Quality of the Santa Ana River and Anaheim Lake by Pyrolysis-GC-MS, \$50,000 (8/96-6/97).

“The Use of Pyrolysis-GC-MS to Evaluate Drinking Water Treatment Processes”, U.S. EPA, \$232,813/2 years (1993-1995). Extended to 6/97.

“Instrumentation and Laboratory Improvement for Undergraduate Environmental Analytical Chemistry”, with Co-PI, Jean-Francois Gaillard, NSF, \$137,512/3 years (6/15/93-11/95).

“Removal of DBP Precursors by Granular Activated Carbon Adsorption”, American Water Works Research Foundation, \$40,000 (1/93-8/95).

“Radiolytic Destruction of Organic Compounds”, Occidental Chemical Corporation, \$65,138/1 year , with co-PI: R.L. Irvine (5/92-12/93), \$73,766 as sole PI (1/94 - 12/94), \$55,231 (1/95-6/97).

“Pilot and Laboratory Scale Studies of KDF Electrochemical Media”, KDF Fluid Treatment Inc., \$6,200/1 year (1994).

“Characterization and Performance of Polyferric Sulfate Coagulants”, Midland Resources, Inc., \$7,000 (1/91-12/91).

“The Role of an Attached Algae Mat in the Fate of PCBs in Artificial Stream Ecosystems”, The Jesse H. Jones Faculty Research Fund, \$8,500/1 year (7/91-7/92); NSF Planning Grant, \$26,182/1 year (4/91-4/92).

Presidential Young Investigator Award, “Physicochemical Processes in Aquatic Systems”, NSF, \$500,000/5 years (7/91-7/96), (\$312,500 from Sponsor/non Federal Matching Funds in excess of \$187,000 have been obtained). Extended to 12/97.

“Mechanistic Studies of Photocatalytic Degradation of Hazardous Organic Compounds in Semi-conductor Systems”, NSF, \$69,964/2 years, approved; declined due to PYI Award (1991).

“Coagulation Performance of Aqualenc”, Phone-Poulenc Chemical Company, \$20,000 (1/90-6/91).

“Removal of Algal Material: Treatment Techniques and Mechanisms”, Lyonnaise des Eaux, Paris, France, \$116,400 (4/90-12/93).

“Request for Purchase of Combined Electrophoresis and Submicron Size Analyzer”, Jesse H. Jones Faculty Research Equipment Fund, University of Notre Dame, \$19,050 (4/90-4/91).

INVENTION DISCLOSURES/PATENT APPLICATIONS

1. Photocatalytic Composite (TiO₂/SWCNT) for Organic Chemical Oxidation (provisional patent application NU 27068, filed), Y. Yao, R. Lueptow, K.A. Gray.
2. Mixed-phase nano-structured TiO₂ composite photocatalyst for energy and energy efficiency applications, (provisional patent application NU 27093) G. Li & K.A. Gray.
3. Reactively sputtered TiO₂ nanocomposite thin films for photoreduction and photooxidation applications under UV and visible light, (Patent No. US 8,202,820 B2 issued 06/19/12) L. Chen, M. Graham, K.A. Gray
4. Solvent-Exfoliated Graphene-Titania Nanocomposite Photocatalysts, (provisional patent application NU2011-059), Yu Teng Liang, Baiju Vijayan, Kimberly Gray, Mark Hersam.

JOURNAL and PEER-REVIEWED PUBLICATIONS

93. Daniel Finkelstein-Shapiro, Charlie Y.-H. Tsai, Shuyou Li, Kimberly A. Gray (2012). "Synthesis of high-energy anatase nanorods via an intermediate nanotube morphology," *CPLETT*, DOI 10.1016/j.cplett.2012.07.039.
92. Kathryn N. Kalscheur, Miguel Rojas, Christopher G. Peterson, John J. Kelly, Kimberly A. Gray (2012). "Algal Exudates and Stream Organic Matter Influence the Structure and Function of Denitrifying Bacterial Communities," *Microbial Ecology*, in press.
91. Olga Lyandres, Pongkarn Chakthranont, Daniel Finkelstein Shapiro, Michael Graham, Kimberly Gray (2012). "The effects of preferred orientation in sputtered TiO₂ thin films on the photooxidation efficiency of acetaldehyde," *Chemistry of Materials*, in press.
90. Y.T. Liang, B. Vijayan, O. Lyandres, K.A. Gray, M.C. Hersam (2012). "The effect of dimensionality on the photocatalysis of carbon-titania nanosheet composites: Charge transfer at nanomaterial interfaces," *Journal of Physical Chemistry Letters*, 3:1760–1765.
89. K.N. Kalscheur, R.R. Penskar, A.D. Daley, S.M. Pechauer, C.G. Peterson, J.J. Kelly, K.A. Gray (2012), "Effects of anthropogenic inputs on the organic quality of urbanized streams," *Water Research*, 46: 2515-2524 DOI: 10.1016/j.watres.2012.01.043.
88. K. Schwartzenberg, K.A. Gray (2012). "Nanostructured Titania: The Current and Future Promise of Titania Nanotubes," *Catalysis Science and Technology*, 2 (8), 1617 – 1624; DOI: 10.1039/C2CY00538G.
87. Baiju K. Vijayan, Nada M. Dimitrijevic, Daniel F. Shapiro, Kimberly A. Gray (2012). "Coupling titania nanotubes and carbon nanotubes to create photocatalytic nanocomposites," *ACS Catalysis* 2, 223–229.
86. P.A. DeSario, J. Wu, M.E. Graham, K.A. Gray (2012). "Nanoscale structure of Ti_{1-x}Nb_yO₂ mixed phase thin films: Distribution of crystal phase and dopants," *Journal of Materials Research*, 27:944-950 (DOI:10.1557/jmr.2011.449).
85. Alon Danon, Kaustava Bhattacharyya, Baiju K. Vijayan, Junling Lu, Dana J. Sauter, Kimberly A. Gray, Peter C. Stair, and Eric Weitz (2012). "The Effect of Reactor Materials on the Properties of Titanium Oxide Nanotubes," *ACS Catalysis*, 2 (1), 45–49.
84. D. Finkelstein-Shapiro, A.M. Buchbinder, B. Vijayan, K. Bhattacharyya, E. Weitz, F.M. Geiger, K.A. Gray (2011). "Elucidation of several types of binding sites for the adsorption of acetaldehyde on the surface of titania nanorods," *Langmuir*, 27, 14842–14848.
83. N.M. Dimitrijevic, T. Rajh, B. Vijayan, K.A. Gray (2011). "Photocatalytic Reduction of CO₂: Probing Structure of Photocatalysts and Mechanism of CO₂ Transformation," *ECS Transactions*, 35 (25) 167-171.
82. Y. T. Liang, B. Vijayan, K.A. Gray, M.C. Hersam (2011). "Minimizing Graphene Defects Enhances Titania Nanocomposite-Based Photocatalytic Reduction of CO₂ for Improved Solar Fuel Production" *Nano Letters*, 11, 2865–2870.
81. P.A. DeSario, K.A. Gray (2011) "Passive Systems: Using every surface in the built environment," in **Handbook of Metropolitan Sustainability: Understanding and Improving the Built Environment**. F. Zeman, ed. (Woodhead Publishing Ltd), Ch. 15, in press.
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70. F. Casadio, S. Xie, S. Rukes, B. Myers, K. Gray, R. Warta, I. Fiedler (2010) "Electron Energy Loss Spectroscopy elucidates the elusive darkening of zinc potassium chromate in Georges Seurat's A Sunday on La Grande Jatte – 1884," *Analytical and Bioanalytical Chemistry*, (DOI 10.1007/s00216-010-4264-9).
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MANUSCRIPTS (in review)

K.A. Gray, D. Farr, A. Hughes, D. Dana, W. Drucker, M. Lindsey, T. K. Kirkby, K. Gong, (2011). "Living Cities: Transforming APEC's Cities into Models of Sustainability by 2030." (under consideration by John Wiley).

B. Sikora, J. Sirk, M. Lestina, K.A. Gray, M. Morowitz (2011). "Estimate of the CO₂ emissions associated with care for pediatric appendicitis in the U.S.," *Journal of Pediatric Surgery*, in review.

Daniel Finkelstein-Shapiro, Sarah J. Hurst, Kimberly A. Gray, Nada Dimitrijevic, Tijana Rajh, Pilarisetty Tarakeshwar, Vladimiro Mujica (2011). "CO₂ pre-activation via the electronic coupling with the charge transfer state of TiO₂-aminosalicylic acid complexes," *JACS*, in review.

K. Bhattacharyya, A. Danon, B. Vijayan, K.A. Gray, P.C. Stair, E. Weitz (2011). "The role of the surface lewis acid and basic sites in the adsorption of CO₂ on titania nanotubes and platinumed titania nanotubes: An *in situ* FT-IR study," *Jour. Phys. Chem.*, in review.

T. Tong, C.T.T. Bihn, J.J. Kelly, J-F Gaillar, K.A. Gray (2012). "Cytotoxicity of commercial nano-TiO₂ to *Escherichia coli* using high-throughput analysis: The effects of environmental conditions," *Environ. Sci. Technol.*, in review.

Michael D. Marsolek, Mary Jo Kirisits, Kimberly A. Gray, and Bruce E. Rittmann (2012). "Coupled photocatalytic-biodegradation of 2,4,5-trichlorophenol: effects of photolytic and photocatalytic effluent composition on bioreactor

process performance, community diversity, and resistance and resilience to perturbation," *Water Research*, in review.

Jie Sun, John Janssen, Kimberly A. Gray, and Adilson E. Motter (2012). "Historical Data Reveal Regular Growth Rate Fluctuations Despite Seemingly Erratic Population Abundances," *Nature Communications*, in review.

MONOGRAPHS AND BOOK CHAPTERS (*indicates Peer Review)

A. Agrios, K. Gray, (2005) "Beyond Photocatalytic Environmental Remediation: Novel TiO₂ Materials and Applications," in *Environmental Catalysis*, V. Grassian, ed. (Marcel Dekker), Ch. 15, 369-390.

M. Starkey, K. Gray, S.I. Chang, M. Parsek, (2004) "A Sticky Business: The EPS Matrix of Bacterial Biofilms", in *Microbial Biofilms*, M. Ghannoum and G. A. O'Toole, eds. (ASM Press), Chapter 10.

B.A. Ankenman, K.A. Gray, (2001) "The Detached Plume Study: Statistical Analysis of Causative Factors in Portland Cement Manufacturing Plants." (Portland Cement Association, Skokie, IL) 112 pages.

K.A. Gray, (2000) "The Establishment of Stream Standards for Total Organic Carbon: Scientific and Engineering Basis," testimony before Colorado Water Quality Board.

* K.A. Gray, A.H. Simpson and K.S. McAuliffe, "Use of PY-GC-MS to Study the Nature and Behavior of NOM in Water Treatment." In *Water Disinfection and Natural Organic Matter*, Roger Minear and Gary Amy, eds. (ACS Symposium Series 649, Washington, D.C., 1996) 159-181.

*R.J. Hilarides, K.A. Gray, J. Guzzetta, N. Cortellucci, and C. Sommer, "Degradation of Chlorinated Dioxins on Soil using ⁶⁰Co Gamma Radiation: Considerations and Optimization," in *Chemical Oxidation: Technology for the 90's*, Vol. 4, J. Roth and A. Bowers, eds. (Technomics, Lancaster, PA, 1996) 205-218.

*D.C. Schmelling and K.A. Gray, "Photocatalytic Transformations of TNT in Titania Slurries: An Analysis of the Role of Interfacial Nitrogen Reduction Utilizing g-Radiolysis," in *Chemical Oxidation: Technology for the 90's*, Vol. 4, J. Roth and A. Bowers, eds. (Technomics, Lancaster, PA, 1996) 173-184.

*U. Stafford, K.A. Gray, and P.V. Kamat, "Photocatalytic Oxidation of 4-Chlorophenol on Titanium Dioxide: A Comparison with g-Radiolysis," in *Chemical Oxidation: Technology for the 90's*, Vol. 4, J. Roth and A. Bowers, eds. (Technomics, Lancaster, PA, 1996) 193-204.

*L. Weitzman, K.A. Gray, R.W. Peters, F.K. Kauahara, and J. Verbicky, (1994), *Innovative Site Remediation Technology, Vol. II: Chemical Treatment*, American Academy of Environmental Engineers, Annapolis, MD, 200 p.

*K.A. Gray, P. Kamat, U. Stafford, and M. Dieckmann, "Mechanistic Studies of Chloro- and Nitrophenolic Degradation on Semiconductor Surfaces," *Environmental Aspects of Surface and Aquatic Photochemistry*, D. Crosby, R. Zepp, and G. Heltz, eds., (Lewis Publishers/CRC Press, 1994) 399-408.

D.C. Schmelling and K.A. Gray, "Feasibility of Photocatalytic Degradation of TNT as a Single or Integrated Treatment Process," *TiO₂ Photocatalytic Purification and Treatment of Water and Air*, David Ollis and Hussain Al-Ekabi, eds., (Elsevier Publishers, 1993), 625-632.

K.A. Gray, U. Stafford, M.S. Dieckmann, and P. Kamat, "Mechanistic Studies in TiO₂ Systems: Photocatalytic Degradation of Chloro- and Nitrophenols," *TiO₂ Photocatalytic Purification and Treatment of Water and Air*, David Ollis and Hussain Al-Ekabi, eds., (Elsevier Publishers, 1993), 455-472.

*C.R. O'Melia, K.A. Gray, C. Yao, *Polymeric Metal Coagulants*, American Water Works Association Research Foundations, Denver, CO, 1989.

T.D. Waite, K.A. Gray, "Oxidation and coagulation of wastewater effluent utilizing the ferrate(VI) ion," in *Chemistry for Protection of the Environment*, L. Pawlowski, A.J. Verdier, and W.J. Lacy, editors (Elsevier Science Publishing Co., 1984) pp. 407-420.

CONFERENCE PROCEEDINGS

D.L. Widrig, K.A. Gray and K.S. McAuliffe, 1996. Removal of Algal-Derived Organic Material by Preozonation and Coagulation: Monitoring Changes in Organic Quality by Pyrolysis-GC-MS, in Proceedings of AWWA 1996 Annual Conference.

K.A. Gray, A.H. Simpson and K.S. McAuliffe, 1995. Use of PY-GC-MS to Study the Nature and Behavior of NOM in Water Treatment, in Proceedings of the 210th ACS National Meeting, 35:2:635-638.

U. Stafford, K.A. Gray and P.V. Kamat, 1995. Kinetic Modeling of 4-Chlorophenol Degradation in Titania Slurries, in Proceedings of the 210th ACS National Meeting, 35:2:563-566.

D.C. Schmelling, K.A. Gray and P.V. Kamat, 1995. The Role of Nitrogen Reduction in the Photocatalytic Degradation of Nitroaromatic Compounds, in Proceedings of the 210th ACS National Meeting, 35:2:484-486.

K.A. Gray, 1995. Use of Ionizing Radiation to Destroy Pollutants, in Transactions of the American Nuclear Society, 1995 Annual Meeting, Philadelphia, PA, 72:132-133.

K.A. Gray, 1994. Treatment of Soils and Sediments: Radiolytic Destruction of Chlorinated Dioxins Using Cobalt-60, Pages in Proceedings of NSF Workshop on Applications of Ionizing Radiation for Decontamination of Environmental Resources, Miami, FL .

M.S. Dieckmann, K.A. Gray and P.V. Kamat, 1994. The Sensitized Photocatalysis of a Mixed Reactant System of 4-Chlorophenol and 4-Nitrophenol. Pages 726-732 in Proceedings of the 1994 National Conference on Environmental Engineering "Critical Issues in Water and Wastewater Treatment" (J.N. Ryan and M. Edwards, eds.) American Society of Civil Engineers.

K.A. Gray and R.J. Hilarides, 1994. Innovative Treatment of Soil Contamination: Radiolytic Destruction of Dioxin and Co-Contaminants by Cobalt-60. Pages 733-736 in Proceedings of the 1994 National Conference on Environmental Engineering "Critical Issues in Water and Wastewater Treatment" (J.N. Ryan and M. Edwards, eds.) American Society of Civil Engineers.

D.C. Schmelling and K.A. Gray, 1994. Photocatalytic Transformation and Degradation of 2,4,6-trinitrotoluene (TNT) in TiO₂ Slurries. Pages 751-755 in Proceedings of the 1994 National Conference on Environmental Engineering "Critical Issues in Water and Wastewater Treatment" (J.N. Ryan and M. Edwards, eds.) American Society of Civil Engineers.

K.A. Gray, A. St. Amand, and H. Wang, 1993. "Role of a Periphytic Biolayer in the Fate of PCBs in Artificial Stream Systems," Proceedings of the First International Specialized Conference on Contaminated Aquatic Sediments: Historical Records, Environmental Impact, and Remediation, (IAWQ), 271-280.

K.A. Gray and K. McAuliffe, 1991. "Use of Pyrolysis-GC-MS to Study the Organic Matrix of Surface Waters," Proceedings of Water Quality Technology Conference, AWWA, Part II, November, 1991, 1219-1231.

PUBLISHED REVIEWS

Book review of Radioactive Waste Management (Y.S. Yang and J.H. Saling) for *Environmental Progress*.

"Report on the First International Conference on TiO₂ Photocatalytic Purification and Treatment of Water and Air," published in European Photochemistry Association Newsletter (47:50-53) and the Inter-American Photochemical Society Newsletter.

RESEARCH REPORTS

K.A. Gray (2008) "Hydrologic and Environmental Effects of Hydraulic Control Structures: Baseline Monitoring," Technical Report, The Wetlands Initiative, Chicago, IL.

C.K. Ishida, K.A. Gray (2005) "Hydraulic Effects on Biological Diversity and Water Quality in Constructed Wetlands," Final Report to U.S. Army Corps of Engineers, February, 2005.

K.A. Gray (2001) "Physical, Chemical, & Biological Characterization of Swam Lake Sediments," Technical Report, The Wetlands Initiative, Chicago, IL.

M.E. Finster, K.A. Gray (1999) "The Urban Heat Island, Photochemical Smog, and Chicago: Local Features of the Problem and Solution." Technical Report, Atmospheric Pollution Prevention Division, U.S.E.P.A.

"Characterization of the Organic Matrix of the Missouri River by Pyrolysis/GC/MS," Burns and McDonnell, February, 1997.

"Removal of DBP Precursors by Optimized Coagulation and Precipitative Softening: Use of PY-GC-MS to Monitor Coagulation Effectiveness," American Water Works Research Foundation, October, 1996.

"Evaluation of Organic Quality in Prado Wetland and Santa Ana River by Pyrolysis-GC-MS" Orange County Water District, April, 1996.

"Removal of DBP Precursors by Granular Activated Carbon Adsorption: PY-GC-MS Characterization of Organic Quality," American Water Works Research Foundation, Nov. 1995.

"Monthly Monitoring of Prado Wetland Using PY-GC-MS," Orange County Water District, May, 1995.

"Pyrolysis-GC-MS Analysis of Various Contaminated Groundwater Samples," Institut für Wasserversorgung, Universität für Bodenkultur, (Vienna, Austria), February, 1995.

"Metal Ion Concentrations in KDF Treated Ground-Water," KDF Fluid Treatment Inc., March, 1994.

"Safety Kleen Refinery Waste Water Evaluation," Safety Kleen Corp., March, 1992.

"Jar Test Results for Polyferric Sulfate: Comparison of Various Waters and Other Coagulants," submitted to Midland Resources, February, 1992.

"The Role of Water Hardness in Performance of Aqualenc for the Coagulation of Clay Turbidity," submitted to Rhone-Poulenc Chemical Company, July, 1991.

"Characterization of Polyferric Sulfate Solutions," submitted to Midland Resources, Inc. and Kemiron Inc., May 1991.

"Radiolytic Destruction of Organics," submitted to Occidental Chemical Company, October 1991.

SIGMA XI DISTINGUISHED LECTURES

Mercer University, Macon GA, Oct. 2, 2008

Pennsylvania State University, Erie, PA, Oct. 16, 2008

University of Northern Iowa, Oct. 23, 2008

Michigan State University, Nov. 6, 2008

Syracuse University, Nov. 13, 2008

University of Wisconsin-Fox Valley, Nov. 17, 2008.

Army Research Lab, Adelphi, MD, Dec. 11, 2008

Trinity University, Jan. 26, 2009 (2 talks)

Purdue University, Feb. 3, 2009.

Western Washington University, Feb. 24, 2009 – 2 lectures given.
Western Kentucky University, March 2, 2009
University of Tennessee, March 17, 2009.
Eastern Illinois University, April 2, 2009 – 2 lectures given.
Cornell University, April 7, 2009
Portland State University, April 21, 2009.
Southern Oregon University, May 14, 2009.
Nalco, June 4, 2009
SUNY-Purchase College, Oct. 29, 2009
University of Nebraska, Nov. 19, 2009
Mayo Clinic, Rochester, MN, Jan. 19, 2010
South Dakota State University, February 25, 2010 (2 talks)
Youngstown State University, March 4, 2010
Tarleton State University, March 11, 2010 (2 talks)
University of Northern Michigan, March 18, 2010 (2 talks)
Rollins College, March 25, 2010 (2 talks)
University of Louisville, April 15-16, 2010 (2 talks)
Rockford College, April 20, 2010 (2 talks)

INVITED LECTURES

“Why the energy issue is fundamentally an environmental issue. . .and why this doesn't seem to matter” State of the Nation: Election 2012, Alumnae Continuing Education Lecture Series, 6 Nov. 2012.

“Living Cities: A vision to sustain the exploding megacities of Asia and the shrinking cities of the North America,” Vision Seminar, Dept. of Civil Engineering, Purdue University, 25 April 2012.

“Living Cities: The redesign of cities inspired by ecological principles,” keynote address at the Mid-west Environmental Leadership Summit, 15 April 2012.

“Living Cities: A vision to sustain the exploding megacities of Asia and the shrinking cities of the Midwest,” Environmental Engineering seminar series, Marquette University, 6 March 2012.

“Living Cities: Transforming APEC Cities into Models of Sustainability by 2030,” presentation to the Asia Pacific EC Business Advisory Committee, Hong Kong, 24 February 2012.

“Potential Effects of Nanotitania in Benthic Systems,” presented at IMI-SEE workshop, “Developing sustainable nanotechnologies: Maximizing Functionality while Minimizing Health Impact,” at Sichuan University, Chengdu, China, Sept. 14, 2011.

“Potential Effects of Nanomaterials on Human and Ecological Health,” seminar at Geosyntec Consultants, Chicago, IL, 23 June 2011.

“Sustainable Strides in Urban Design: Lessons from Chicago,” Sci-Tech Seminar, USEPA Region V Science and Technology Council, 20 April 2011.

“The potential effects of nanotitania in benthic systems,” in Reactivity, Transformation and Detection of Natural and Engineered Nanomaterials in the Environment Symposium (Division of Colloid & Surface Science), 241st ACS National Meeting, Anaheim, CA, March 27-31, 2011.

“Sustainable Strides: Lessons from Chicago” plenary presentation at the 2nd Xiamen International Forum of Urban Environment, Xiamen, China, Dec. 11-13, 2010.

“Green Cities/Brown Lakes: The Challenge of Great Lakes Restoration,” seminar, Memorial University of Newfoundland, Canada, Oct. 29, 2010.

“Transforming our Cities: Sustainability and the Post Fossil-Fuel Future,” Keynote presentation, Dialogue on Advancing Global Sustainability, Memorial University of Newfoundland, Canada, Oct. 28, 2010

“Sustainable Cities and the Many Dimensions of a Post-Fossil Fuel Future,” Carbon and Climate: Lessons from the Past, Solutions for the Future, 2nd Annual Climate Change Symposium, NU, Oct. 18, 2010.

“Green Cities/Brown Lakes: The Challenge of Great Lakes Restoration,” The Women’s Board of Northwestern, Sept. 21, 2010.

“The Debate on the Scientific Evidence of Climate Change” Judicial Symposium on Public Nuisance Litigation sponsored by the Northwestern Law Judicial Education Program, Searle Center on Law, Regulation, and Economic Growth, Northwestern University School of Law, 27 April 2010.

“Chemical and physical synthesis of TiO₂-based nanocomposites for solar energy production and other environmental applications,” seminar in Dept. of Chemical Engineering, University of Louisville, 15 April 2010.

“Fabricating Titania-based Nanocomposites for Solar Fuel Production: TiO_{2-x}, Ti_{1-x}Nb_xO₂, & Titania Nanotubes,” NIMS International Workshop on Photocatalysis and Environmental Remediation, Tsukuba, Japan, 22-24 February 2010.

“Tailoring Nanomaterials for Probing Environmental Systems: React, Identify, and Monitor,” Workshop on Nano-Enabled Sensing Microsystems for Geosciences, Organized by the NSF National Nanotechnology Infrastructure Network (NNIN), Ann Arbor, MI, 4 February 2010.

“Chemical and physical synthesis of TiO₂-based nanocomposites for solar energy production and other environmental application,” Nebraska Center for Materials and Nanoscience and Physics colloquium, University of Nebraska, Lincoln, NE, 19 November, 2009.

“The Nanotechnology Revolution and its Unintended Environmental Effects,” Encouraging appropriate use of the products of scientific research: U.S.-Iran-France Workshop, sponsored by NAS, Academie des Sciences, 7-12 November, 2009, Fondation des Treilles, France.

“Progress on Synthesizing Photoactive Nanocomposite Materials to Produce Solar Fuels,” Sino-U.S. Workshop on Nanostructured Materials for Global Energy & Environmental Challenges, Changzhou, China, Oct. 15-18, 2009.

“What will finally spark that the Green Revolution?” One Book Science Café, 7 Oct. 2009.

“Five Myths about Nanotechnology in the Current Public Policy Debate,” CEE Seminar, 25 Sept., 2009.

“Chemical and physical synthesis of TiO₂-based nanocomposites for solar energy production and other environmental application,” Dept. of Civil and Environmental Engineering, Rice University, Houston, TX, 21 September, 2009.

“Ecology and the Green Revolution,” 61st Annual Meeting of the Association of American Universities, Chicago Botanical Gardens, 20 September 2009.

“The Feasibility of Achieving Sustainability Goals in the Near-Term,” Annual Meeting of North American Management Team, Veolia Energy, 27 Aug. 2009.

“Secrets of the Art World Unlocked: Le Grand Jatte,” Chicago Council on Science and Technology, Art and Science, 8 June 2009.

“Sustainable Water Use in Cities and Industry: Future Challenges and Promising Strategies,” Metropolitan Water Reclamation District of Greater Chicago, Lue-Hing R&D Laboratory Seminar Series, 29 May 2009.

“Five Myths about Nanotechnology in the Current Public Policy Debate,” Searle Center Research Roundtable on *Environmental, Health, and Safety Risks of Emerging Technologies*, Northwestern University School of Law, April 23 - 24, 2009.

“Sustainable Solutions to Energy, Water & Climate Challenges” in Globalization: The Next Stage, Ryan Learning for Life 2008 Lectures, Robert H. Lurie Medical Research Center, NU, Nov. 19, 2008.

“The Effects of Climate Change on Transportation,” Transportation Center Business Advisory Committee Meeting, NU, Oct. 22, 2008

“Progress in developing photoactive nanocomposites to improve the efficiency of artificial photosynthesis,” seminar in the Department of Geography and Environmental Engineering, Johns Hopkins University, October 21, 2008.

“Energy & the Environment - Election 2008: Inside the Issues”, *Classes without Quizzes*, Panel moderated by Les Crystal, NU, Oct. 17, 2008.

“Energy & the Environment: The Central Challenge of Sustainability,” NU Club of Milwaukee, Oct. 7, 2008.

“Photoactive Nanocomposite Materials to Produce Solar Fuels,” Sino-U.S. Workshop on Nanostructured Materials for Global energy & Environmental Challenges, Sept. 22, 2008.

“Sustainable Water Use in Cities and Industry: Future Challenges and Promising Strategies,” 2008 International Open Lecture Series on Business, Technology and Urban Life for a Sustainable Future, Fukuoka University, Japan, July 18, 2008.

“How sustainable does business need to be?” Environmental Sustainability Business Club, Kellogg Business School, Northwestern, 29 May 2008.

“Solar fuel generation: Engineering photocatalytic “hot spots” in TiO₂-based nanocomposites,” Physics Colloquium, Northwestern University, 9 May 2008.

“The Sustainability Imperative: The need for interdisciplinary learning, teaching and research,” Center for Environmental Studies, Brown University, 15 April 2008.

“Second generation TiO₂-based nanocomposites for solar fuel generation,” Division of Engineering, Brown University, 14 April 2008.

“Second generation TiO₂-based nanocomposites for solar fuel generation,” Department of Civil Engineering, Duke University, 21 April 2008.

“The Green Wave: Is there really anything to the sustainability buzz?” Science Café, Sigma Xi Scientific Research Society at Northwestern, April 16, 2008.

“The modern American city: Can we ever make it sustainable?” seminar in Civil and Environmental Engineering at Temple University, February 27, 2008.

“What does Sustainability mean for teaching, learning and living at a university?” Keynote address to Residential College Domain Dinner, Northwestern University, February 5, 2008.

“Structuring Highly Active Nanoscale Photocatalytic Films using Reactive Sputtering,” presented in an Advanced Surface Engineering Division Session at the 54th AVS Symposium, 14-19 October, 2007, Seattle, WA.

“Progress in synthesizing photo-active titania-based nanocomposites for CO₂ reduction and fuel production,” seminar, Honeywell Aerospace & Environmental Quality Group, July 3, 2007.

“Probing the effects of light, humidity and acidity on the deterioration of a zinc potassium chromate pigment,” Photochemical Processes in Art and other Standards, Seminar Series on Conservation Science, June 7, 2007.

“Nanotechnology, Energy, and the Environment,” inaugural seminar sponsored by the McCormick Graduate Student Leadership Council, Northwestern University, March 8, 2007.

“Progress in synthesizing photo-active titania-based nanocomposites for CO₂ reduction and fuel production,” seminar, Dept. of Civil and Environmental Engineering, Duke University, 21 March 2007.

“The feasibility of developing sustainable energy sources for transportation,” 2007 SWE Regional conference, Chicago, IL, 27 January 2007.

“Navigating the Choppy Seas of Science: Reflections on Careers in Environmental Science and Engineering,” Women in Science & Engineering Symposium, Loyola University, July 27, 2006.

“Energy and The Environment: The Central Challenge of Sustainability,” Keynote address at the 2006 Environmental Engineering Spring Symposium, University of Illinois, Urbana-Champaign, March 31, 2006.

“Determining Structure/Function Relationships for Organic Carbon in Surface Waters: Application to Water Reuse,” presented to the Department of Hydraulics and Environmental Engineering at Pontificia Universidad Catolica de Chile, Oct. 26, 2005.

“Ecological Restoration in Aquatic System: The importance of understanding molecular scale phenomena in the big picture,” Seminario Internacional, “*Transporte, Reacción y Destino de Contaminantes en Sistemas Acuáticos Naturales Impactados*” presented to Center for the Environment at the Pontificia Universidad Católica de Chile, Oct. 24, 2005.

“Synthesizing and Characterizing Highly Active TiO₂ Nanocomposite Photocatalysts” presented at TiO₂-10, Chicago, IL, October, 2005.

“Hurricane Katrina: An Ecological Perspective,” presented in seminar Hurricane Katrina: Preparation, Response and Rebuilding, Northwestern University, Oct. 17, 2005.

“Energy and Environmental Chemistry,” presented at the Midwest Environmental Chemistry Conference, October 16, 2005.

“Nanostructured photoactive materials for environmental applications”, presented in Environmental Nanotechnology at the 230th ACS National Meeting, in Washington, DC, Aug 30, 2005.

“Radiation induced catalytic transformation of organohalide contaminants”, presented in Strategies and Molecular Mechanisms of Contaminant Degradation Chemistry at the 230th ACS National Meeting, in Washington, DC, Aug 29, 2005.

“Future Cities,” plenary lecture at the NSF Summer Institute on Nano Mechanics and Material, Nanotechnology, Biotechnology and Green manufacturing for Creating Sustainable Technologies, Northwestern University, June 22, 2005.

“Nanocatalysis,” presented at the NSF Summer Institute on Nano Mechanics and Material, Nanotechnology, Biotechnology and Green manufacturing for Creating Sustainable Technologies, Northwestern University, June 21, 2005.

“New Directions in Environmental Engineering and Chemistry: Catalysis, Analysis, Restoration,” presented at Fukuoka University, Kitakyushu, Japan, February 22, 2005.

“New Advances in the Study of Photoactive materials for Environmental Applications,” seminar presented at the SPEA, Indiana University, October 13, 2004.

“Impacts of Urban Development on Soil and Water Quality: Characterization and Remediation,” seminar presented in the Department of Environmental Science at the University of Illinois-Urbana, March 12, 2004.

“Environmental Engineering and Chemistry: Catalysis, Analysis, Restoration,” seminar presented at Gas Technology Institute, Des Plaines, IL, May, 2003.

“Structure and Function of Environmental Biofilms: Three Examples,” seminar presented in the Department of Civil Engineering at Case Western University, March, 2003.

Tracking Organic Carbon Quality: Fingerprinting Techniques to Trace the Origins of Organic Material,” seminar presented in 2003 Environmental Engineering Seminar Series, “Barriers and Incentives to Wastewater Reuse in Illinois,” IIT, March 26, 2003.

“The Impact of Metal and Organic Contaminants on the Structure of Periphyton in Lotic Sediments,” presented at the NSF funded US-Chinese Joint Workshop on Sediment Transport and Environmental Studies, July, 2002.

“Feasibility of Applying Phytoremediation in Urban Residential Communities,” presented at the 130th Annual Meeting of the American Public Health Association, Philadelphia, PA, November 13, 2002.

“Radiolytic Dechlorination of Adsorbed Pollutants in Various Matrices,” presented in the Symposium on Radiation Chemistry at the 222th Annual Meeting of the American Chemical Society, Chicago, IL, Aug. 2001.

“Monitoring the Impact of Organic Quantity and Quality in Surface Waters: Two Case Studies,” presented at IL AWWA Annual Meeting, Springfield, March, 2001.

“The Influence of Organic Quantity and Quality in Aquatic Systems,” seminar presented in Dept. of Chemistry, Purdue-Calumet, April, 2001.

“The Combined Effects of Metal and Organic Contaminants on a Periphytic Assemblage in Lotic Sediments” presented in the Symposium on: The Influence of Hydrosphere-Biosphere Interactions on the Speciation and Transport of Metals at the Fall Meeting of the American Geophysical Union, San Francisco, December, 2000.

“Radiation-induced processes in the treatment of contaminated materials. Successes and Challenges,” Gordon Research Conference on Radiation Chemistry, Plymouth, New Hampshire, June 27, 2000.

“Mechanistic Insight into Soil Radiolysis,” presented in NSF Workshop, Determination of Optimum Radiolytic Treatment Methodologies for Remediation of PCB Contaminated Sites, University of Maryland, Nov. 15-17, 1999, College Park, MD.

“Molecular Tools to Study Chemical Phenomena in Environmental Systems,” presented at the AEESP Research Needs Conference, Penn State University, Aug. 1, 1999.

“Jumping Through Hoops: The Promotion and Tenure of Women and Minorities,” presented at the AEESP Research Needs Conference, Penn State University, July 31, 1999.

“Photobiocatalysis: Optimized Treatment Strategy for Recalcitrant Pollutants,” seminar presented to BP-Amoco researchers, June 1, 1999.

“Detached Plumes and Visible Emissions in North American Portland Cement Plants,” presented to MTC Semi-annual Meeting, Roanoke, VA, April 12, 1999.

“Photobiocatalysis: Integrating Chemical and Biological Catalysis for the Treatment of Hazardous Chemicals,” presented at the 21st Midwest Environmental Chemistry Workshop, University of Michigan, Ann Arbor, MI, Oct. 17, 1998.

“Photobiocatalysis: Integration of Photocatalysis and Biocatalysis,” presented at the Center for Catalysis and Surface Science Annual Meeting, Evanston, IL. Sept. 9, 1998.

"Environmental Applications of Radiolysis," plenary lecture at DOE Workshop Research Needs and Opportunities in Radiation Chemistry, Chesterton, IN, 19-22 April 1998.

"NOM Structure: Pyrolysis/GC/MS versus ^{13}C -NMR," presented in Sunday Seminar, New Developments in Characterizing and Monitoring NOM in Water Treatment, AWWA Water Quality Technology Conference, Denver, CO, Nov. 9, 1997.

"Probing Dissolved Organic Carbon Dynamics in Natural Waters with Pyrolysis/GC/MS," presented to the Department of Geological Sciences, Northwestern University, Nov. 7, 1997.

"Probing Dissolved Organic Carbon Character in Surface Waters," presented to the Department of Environmental Engineering and Science, University of North Carolina, Chapel Hill, May, 28, 1997.

" TiO_2 Photocatalysis: Transformation of Aromatic Pollutants in Particulate Semiconductor Systems." presented to the Catalysis Center, Northwestern University, May 9, 1997.

"Probing the Organic Carbon Cycle in Wetlands using Pyrolysis-GC-MS" presented in Natural Organic Matter in Aquatic Systems Session at American Geophysical Union 1996 Fall Meeting in San Francisco, CA, 15-19 December 1996.

"Photocatalytic Behavior of Nitroaromatic Compounds in TiO_2 Systems," presented to Environmental Engineering at University of Illinois, 25 April 1996.

"Radiolysis at Environmental Surfaces: Radiolytic Transformation of Chlorinated Dioxins and Other Aromatic Compounds in Soils," presented at the 44th Annual Scientific Meeting of the Radiation Research Society, April 17, 1996, Chicago, IL.

"A Comparison of Electron Beam and Gamma Irradiation to Destroy Halogenated Aromatic Contaminants on Soils," to be presented at the Second International Symposium, Environmental application of Advanced Oxidation Technologies, sponsored by EPRI and U.S. DOE, February 28-March 1, 1996, San Francisco, CA.

"Photocatalytic Interactions of Nitroaromatic Pollutants in TiO_2 Systems," presented to Pritzker Department of Environmental Engineering at the Illinois Institute of Technology, 24 January 1996.

"Use of Ionizing Radiation for Reductive Dechlorination: Chemistry, Design and Economics," presented at the 1995 International Chemical Congress of Pacific Basin Societies, December 17-22, 1995, Honolulu, Hawaii.

"Predicting the Course of 4-Chlorophenol Photocatalytic Degradation: Model Development and Design Implications," presented at the World Environmental Congress, Sept. 17-22, 1995, London, Ontario.

"Use of Ionizing Radiation to Destroy Pollutants," presented at American Nuclear Society 1995 Annual Meeting, June 25-29, 1995, Philadelphia, PA.

"Organic Chemical Transformations," presented at the Groundwater Recharge with Reclaimed Water Workshop sponsored by the WaterReuse Association of California, 25 May 1995.

"Photocatalysis: Theory, Experiments and Models," presented to the Dept. of Civil Engineering, University of Texas at Austin, April, 1995.

"Inorganic Polymers: Fundamental Aspects Related to their Use for Particle Removal and Dewatering," presented at the Annual Meeting of the Society of Mining Engineers, March 6-9, 1995, Denver, CO.

“Radiolytic Transformation of Soil Contaminants: A Comparison of Gamma and Electron Beam Irradiation,” presented to National Institute of Standards and Technology, Ionizing Radiation Division, Gaithersburg, MD, Dec. 1, 1994.

“The Wetland Environment: The Biogeochemistry of Inland and Coastal Systems,” presented at the Fall Meeting of the Indiana Academy of Sciences, Nov. 5, 1994.

“Photocatalytic Oxidation of a Model Halogenated Aromatic Compound: A Mechanistic Study,” presented to Photocatalysis, Catalysis and Environment Group, Ecole Centrale de Lyon, Lyon, France, Oct. 27, 1994.

“Organic and Inorganic Transformation Products of TNT Photocatalysis,” presented at “Emerging Technologies in Hazardous Waste Management VI,” ACS, I&EC Division Symposium, Atlanta, GA, Sept. 19-21, 1994.

“Radiolytic Treatment of Dioxin Contaminated Soils,” presented at the 9th International Meeting on Radiation Processing, Istanbul, Turkey, Sept. 11-16, 1994.

“Use of PY-GC-MS to Fingerprint the Influences of Algal Material on NOM,” presented in the seminar entitled “Natural Organics and Drinking Water-From Ecology to Engineering,” at the 1994 Annual Meeting of the American Water Works Assoc., New York, NY, June 1994.

“Gamma Radiolysis of Dioxin on Soils: Theoretical and Practical Considerations,” presented at the First International Conference on Advanced Oxidation Technologies for Water and Air Remediation, London, Ontario, June, 1994.

“Treatment of Soils and Sediments: Radiolytic Destruction of 2,3,7,8-TCDD,” presented at the NSF Workshop on Applications of Ionizing Radiation for Decontamination of Environmental Resources, Miami, FL, June 2, 1994.

“Free Radicals and Excited States in Environmental Engineering: Photocatalysis and Radiolysis,” presented to the Department of Civil Engineering, Northwestern University, April 12, 1994.

“Environmental Applications of Semiconductor Photocatalysis,” presented at 3M Corp., St. Paul, MN, March 28, 1994.

“Pyrolysis-GC/MS Analysis of Natural Organic Material in Water,” presented to Orange County Water District and National Water Research Institute, Feb. 24, 1994.

“Characterization of Natural Organic Material Using Pyrolysis-GC-MS: Applications in Water Treatment,” presented at the U.S. Environmental Protection Agency and University of Cincinnati, Feb. 11, 1994.

“Radiolytic Destruction of Dioxin on Soils Using Cobalt-60: Theoretical and Practical Considerations,” presented at Environmental, Ocean and Water Resources Division, Dept. of Civil Engineering, Texas A&M University, Feb. 3, 1994.

“Radiolytic Destruction of Dioxin on Soils: Its Potential as a Pretreatment Method to Enhance Bioremediation,” presented at the 1993 Annual Spring Meeting of AIChE in Houston, TX.

“Photocatalysis for Environmental Applications: General Aspects and Mechanistic Insights,” presented at Dept. of Environmental Science and Engineering, Rice University, March 29, 1993.

“Advanced Oxidation: Photocatalytic Destruction of Aromatic Compounds,” Dept. of Civil Engineering, Northwestern Univ., 3 March, 1993.

Symposium on Environmental Applications of Advanced Oxidation Technologies, sponsored by Electric Power Research Institute and the National Science Foundation,” San Francisco, CA, Feb. 22-24, 1993.

“Water Treatment Studies at the University of Notre Dame” presented at the Central Research Laboratories of the Lyonnaise des Eaux-Dumez, Le Pecq, France, December 21, 1992.

“The Role of Oxygen in the Photocatalytic Degradation of 4-Chlorophenol,” presented at the First International Conference on TiO₂ Photocatalytic Purification and Treatment of Water and Air, London, Ontario, November, 1992.

“Photocatalysis on Semiconductor Surfaces: Novel Applications for Hazardous Chemical Destruction,” presented at the RadTech '92 North America, Boston, MA, April 29, 1992.

“The Raging Dioxin Debate: Scientific and Social Factors,” Center for Social Concerns, University of Notre Dame, January 31, 1992.

“Science and Emotion: The Dioxin Debate,” Institute for International Peace Studies, November 7, 1991.

“Inorganic and Organic Polymeric Coagulants: Theory and Application,” Association of Environmental Engineering Professor Seminar, presented at Annual Meeting of American Water Works Association, Philadelphia, PA, June 24, 1991.

“Alternative Uses of Semiconductor Systems: Photocatalytic Degradation of Halogenated Organic Compounds,” presented in a symposium, *Common Problems in Imaging Science and Photocatalysis*, at the 44th Annual Conference of the Society of Photographic Scientists and Engineers, St. Paul, MN, May 12-17, 1991.

“Influences of Natural Organic Material on Water Treatment Processes,” J.M. Montgomery Consulting Engineers, November, 1990.

“Direct Filtration and Natural Organic Material,” Department of Civil Engineering, Duke University, October 1990.

PRESENTATIONS

Paul A. DeSario, Le Chen, Michael E. Graham, Kimberly A. Gray, “Visible Light Activated TiO₂: Oxygen Vacancies and Cation Substitution,” 239th American Chemical Society Meeting, San Francisco, CA, March 21-25, 2010.

Baiju K. Vijayan, Paul Desario, Nada Dimitrijevic, Kimberly Gray, “Photocatalytic reduction of carbon dioxide to fuel using hydrothermally Synthesized Titania Nanotubes”, 239th American Chemical Society Meeting, San Francisco, CA, March 21-25, 2010.

S. Ciston, Y. Yao, R.M. Lueptow, K.A. Gray, Fouling Prevention in Rotating Reactive Membrane Filtration, Annual AIChE Meeting, Philadelphia, PA, November, 2008.

L. Chen, M. Graham, K.A. Gray, Photoreduction of CO₂ over reactive DC magnetron sputtered TiO₂ thin films, 234th ACS National Meeting, Boston, MA, August 19-23, 2007.

G. Li, K.A. Gray, Solar Fuel Applications of Titania Nanocomposites: Solid-Solid Interfaces for Photoreduction of Carbon Dioxide, 234th ACS National Meeting, Boston, MA, August 19-23, 2007.

S. Ciston, G. Li, L. Chen, R.M. Lueptow, K.A. Gray, Biofouling Prevention through Reactive Ceramic Ultrafiltration Membranes, North American Membrane Society, May 14, 2007.

Y. Yao, K.A. Gray, R.M. Lueptow, Titanium Dioxide/Carbon Nanotube Composites for Photo-reactive Filtration, North American Membrane Society, May, 2007.

C. Ng, K.A. Gray, Predicting Bioaccumulation in Dynamic Food Webs: *Ontogeny, Seasonality, Invasional Successions*. Session Title: Environmental Fate and Transport Processes II. AIChE Annual Meeting, Thursday

November 16, 2006, San Francisco.

Shannon Ciston, Le Chen, Gonghu Li, Martina Hausner, Richard M. Lueptow, Kimberly A. Gray, "Effects of TiO₂ nanostructure and various ceramic supports in photocatalytic membranes for water Treatment." AIChE Annual Meeting, November 16, 2006. San Francisco, CA.

Le Chen, Michael E. Graham, Gonghu Li, Kimberly A. Gray, "Fabricating Highly Active Mixed Phase TiO₂ Photocatalysts by Low Angle Reactive DC Magnetron Sputter Deposition." 2006 AIChE Annual Meeting, Nov. 15, 2006. San Francisco, CA.

G. Li, L. Chen, S.M. Ciston, T. Rajh and K.A. Gray, "Titania-based Nanocomposite Materials as Highly Active Photocatalysts", *Fundamentals of Environmental Catalysis*, The AIChE 2006 National Meeting, San Francisco, CA; November 14, 2006.

A.I. Packman, S. Arnon, and K.A. Gray, Structure, Transport, Transformation: Hydrodynamic controls on redox conditions and microbial metabolism in surficial sediments, invited presentation at the Geological Society of America Annual Meeting, Philadelphia, Oct. 2006.

G. Li, L. Chen, S.M. Ciston, T. Rajh and K.A. Gray, "TiO₂-based Nanocomposite Materials as Highly Active Photocatalysts: The Role of Adlineation Sites", *Fundamentals of Metal Oxide Catalysis*, The 232nd ACS National Meeting, San Francisco, CA; September 10, 2006.

Shannon Ciston, Le Chen, Gonghu Li, Martina Hausner, Richard M. Lueptow, Kimberly A. Gray, "Effects of TiO₂ nanostructure and various ceramic supports." ACS National Meeting, September 10, 2006, San Francisco, CA.

A.I. Packman, J.D. Newbold, S. Arnon, and K.A. Gray, Implications of hyporheic structure and biophysicochemical process coupling for modeling nitrogen dynamics in rivers, presentation at the North American Benthological Society Annual Meeting, Anchorage, Jun. 2006.

S. Arnon, A. I. Packman and K. Gray. "Flow conditions and substrate geometry strongly influence benthic denitrification." North American Benthological Society, Anchorage, AK, USA, June, 2006.

L. Chen, K.A. Gray, M. Graham, "Developing photocatalytically active mixed phase TiO₂ by magnetron sputtering deposition," to be presented in the New Horizons in Coatings and Thin Films Symposium at the International Conference on Metallurgical Coatings and Thin Films, May, 2006.

A.I. Packman, S. Arnon, and K. A. Gray, Structure, Transport, Transformation: A framework for analysis of denitrification and other microbially mediated processes in aquatic systems, presentation at the American Geophysical Union Fall Meeting, San Francisco, Dec. 2005.

S. Arnon, A. I. Packman and K. A. Gray. "The effect of flow on periphyton structure and nitrate removal." 2005 American Geophysical Union, New Orleans, LA, USA.

C. Liu, K. Nakano, E. Obuchi, T. Oike, N. Yukihiro, D. Hurum, K. Gray, "Photocatalytic decomposition of formaldehyde using titania coated lime tile," to be presented TiO₂-10, Chicago, IL, October 24, 2005.

C. Ng, M.B. Berg, K.A. Gray, L.A.N. Amaral, "Complex trophic dynamics in an invaded food web," presented at the 90th Annual Meeting of the Ecological Society of America, Montreal, Canada, Aug. 2005.

C. Ng, M.B. Berg, D. Jude, J. Janssen, K.A. Gray, L.A.N. Amaral, "Complex trophic dynamics in a 'simplified' food web: Implications for contaminant transfer," IAGLR 2005, May 25, 2005.

C. Ng, M.B. Berg, K.A. Gray, L.A.N. Amaral, "Network-centered modeling of bioaccumulation in freshwater foodwebs," 228th ACS National Meeting, Philadelphia, PA, Aug., 2004.

C. Ishida, K.A. Gray C. Ng, "Cultivating periphyton to accelerate rates of denitrification in wetlands," 228th ACS National Meeting, Philadelphia, PA, Aug., 2004.

J.A. Kostel, K.A. Gray. "The Impact of Metal and Organic Contaminants on the Structure of Periphyton in Lotic Sediments." 228th ACS National Meeting, Philadelphia, PA, Aug., 2004.

D.C. Hurum, A.G. Agrios, K.A. Gray, T. Rajh, M.C. Thurnauer, "Mixed-Phase titania photocatalysis: EPR studies of catalytic mechanisms," 228th ACS National Meeting, Philadelphia, PA, Aug. 22, 2004.

T. Rajh, M.C. Thurnauer, K.A. Gray, D. Hurum, "Mechanisms of semiconductor photocatalysis revealed via electron paramagnetic resonance," 227th, ACS Annual Meeting, March, 2004.

Hurum, D.C.; Agrios, A.G.; Gray, K.A.; Rajh, T.; Thurnauer, M.C "EPR Studies of Degussa P25 Photochemistry: Insights into Mixed Phase TiO₂ Catalytic Activity" TiO₂-8 Conference, Montreal, Canada, Oct. 27, 2003.

T. Sirivedhin, K.A. Gray. "Assessment of Anthropogenic Influence in Indirect Potable Water Reuse." Water Reuse Annual Symposium XVIII, San Antonio, TX, 2003.

S.I. Chang, K.A. Gray. "Chemical composition and Cu complexation of the extracellular polymeric substances from pseudomonas aeruginosa biofilms," 225th ACS National Meeting, New Orleans, LA, March, 2003.

Finster ME, Gray KA, Binns HJ. Lead levels of vegetables grown in contaminated residential soils: a field survey. American Public Health Association Annual Meeting, Philadelphia, PA, November 11, 2002.

Finster ME, Gray KA, Binns HJ. Factors influencing the creation of turf grass barriers on lead-contaminated residential soils. American Public Health Association Annual Meeting, Philadelphia, PA, November 11, 2002.

Binns HJ, Peneff N, Gray KA, Fernandes J, Finster ME; for the Safer Yards Project. Effect of an intervention to reduce soil lead contamination in urban residential yards. American Public Health Association Annual Meeting, Philadelphia, PA, November 13, 2002.

Hurum, D.C.; Agrios, A.G.; Gray, K.A.; Rajh, T.; Thurnauer, M.C "EPR Studies of Degussa P25 Photochemistry: Insights into Mixed Phase TiO₂ Catalytic Activity" 222nd ACS National Meeting, Chicago, IL, Aug. 27, 2001.

Agrios, A.G., K.A. Gray. "Detailing Visible Light Effects of 2,4,5-Trichlorophenol on TiO₂ Surfaces." 222nd ACS National Meeting, Chicago, IL, Aug. 27, 2001.

M. Bonifacic, K-D. Asmus, K.A. Gray. "Time-resolved pulse radiolysis studies on the reaction of free radicals and hydrated electrons with halogenated phenols," 222nd ACS National Meeting, Chicago, IL, Aug. 27, 2001.

T. Sirivedhin, K.A. Gray, "The Influence of Organic Carbon Quality on Denitrification Rates at the Des Plaines River Wetland Demonstration Project," Society of Wetlands Scientists, 22nd Annual Meeting, Chicago, IL May, 2001.

Agrios, A.G., K.A. Gray. "Enhanced Adsorption and Degradation on TiO₂ Due to Visible Light." Second International Conference on the Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 22-25, 2000.

T. Sirivedhin, K.A. Gray, "Anthropogenically Influenced Wetlands at the Des Plaines River Wetland Demonstration Site," IAGLR Conference, Cornwall, Ontario, May, 2000.

Jill A. Kostel and K.A. Gray, "The Influence of Periphyton on the Bioavailability of Contaminants in Lotic Sediments," IAGLR Conference, Cornwall, Ontario, May, 2000 [IAGLR/Hydrolab 2000 Best Student Presentation Award].

T. Sirivedhin, K.A. Gray, "Identifying Anthropogenic Markers in Dissolved Organic Matter using Py/GC/MS." Natural Organic Matter in Soils and Water, North Central Region Workshop, St. Paul, MN, January, 2000.

T. Sirivedhin, K.A. Gray, "Seasonal Effects on the Enhancement of Low Quality Surface Water by a Restored Riparian Wetland," Annual Conference, American Water Works Association, Chicago, IL, June, 1999.

K.A. Gray and Robert M. Bornick, "Use of PY-GC-MS to Characterize Natural Organic Material in an Artificial Wetland: Issues Related to Drinking Water Quality," presented at the Natural Organic Matter Workshop 18-19 September 1996, Poitiers, France.

D.L. Widrig, K.A. Gray and K.S. McAuliffe, "Removal of Algal-Derived Organic Material by Preozonation and Coagulation: Monitoring Changes in Organic Quality by Pyrolysis-GC-MS," at the AWWA 1996 Annual Conference, Toronto, Canada, June, 1996.

D.C. Schmelling, K.A. Gray and P.V. Kamat, "The Importance of Reductive Transformations in the Photocatalytic Destruction of Nitroaromatic Compounds," presented at the 1996 AIChE Spring National Meeting, Feb. 25-29, 1996, in New Orleans, LA.

K.A. Gray, "Radiolytic Destruction of Hexachlorobenzene on Soils: Comparison of Gamma and High Energy Electron Radiolysis," presented at the 1996 AIChE Spring National Meeting, Feb. 25-29, 1996, in New Orleans, LA.

A.H. Simpson, K.A. Gray and K.S. McAuliffe, "Statistical Analysis of PY-GC-MS Data to Improve Understanding of NOM Chemistry in Water Treatment Processes," presented at AWWA Water Quality Technology Conference, Nov. 11-14, 1995, New Orleans, LA.

Ulick Stafford, Kimberly A. Gray and Prashant V. Kamat, "Kinetic Modeling of 4-Chlorophenol Degradation in Titania Slurries," presented in Mechanistic Environmental Photochemistry Symposium at the 210th ACS National Meeting, Chicago, IL, August 24, 1995.

K.A. Gray, A.H. Simpson and K.S. McAuliffe, "Use of PY-GC-MS to Study the Nature and Behavior of NOM in Water Treatment," presented in NOM Isolation and Characterization Symposium at the 210th ACS National Meeting, Chicago, IL, August 23, 1995.

K.A. Gray, K.S. McAuliffe and A.H. Simpson, "Monitoring Organic Removal for a Variety of Enhanced Coagulation Processes Using Pyrolysis-GC-MS," presented at AWWA Enhanced Coagulation Workshop in Charleston, SC, Dec. 6, 1994.

R.J. Hilarides and K.A. Gray, "Destruction of Dioxin on Soils: Radiolysis of Model and Real Soils," presented at the 1994 AIChE Summer Meeting, August 14-17, Denver, CO.

J.M. Noris, K.A. Gray and J-F. Gaillard, "Treatment of High Selenium Wastewaters," presented at the 1994 AIChE Summer Meeting, August 14-17, Denver, CO.

M.S. Dieckmann, K.A. Gray and P.V. Kamat, "The Sensitized Photocatalysis of a Mixed Reactant System of 4-Chlorophenol and 4-Nitrophenol," presented at the 1994 National Conference on Environmental Engineering, July 11-13, Boulder, CO.

K.A. Gray and R.J. Hilarides, "Innovative Treatment of Soil Contamination: Radiolytic Destruction of Dioxin and Co-Contaminants by Cobalt-60," presented at the 1994 National Conference on Environmental Engineering, July 11-13, Boulder, CO.

D.C. Schmelling and K.A. Gray, "Photocatalytic Transformation and Mineralization of TNT in TiO₂ Slurries," presented at the 1994 National Conference on Environmental Engineering, July 11-13, Boulder, CO.

P.V. Kamat, K. Vinodgopal, U. Stafford and K.A. Gray, "Semiconductor Particulate Films for the Photocatalytic Degradation of Organic Contaminants," presented at the 185th Electrochemical Society Meeting, San Francisco, May 25, 1994.

U. Stafford, K.A. Gray, and P.V. Kamat, "Photocatalytic Oxidation of 4-Chlorophenol on Titanium Dioxide: A Comparison with γ -Radiolysis," presented at the 4th Annual Symposium on Chemical Oxidation, Nashville, TN, Feb. 1994.

R.J. Hilarides and K.A. Gray, "Gamma Irradiation of Soils Contaminated with 2,3,7,8-Tetrachlorodibenzo-p-dioxin using ^{60}Co ," presented at the 4th Annual Symposium on Chemical Oxidation, Nashville, TN, Feb. 1994.

D.C. Schmelling and K.A. Gray, "Photocatalytic Destruction of TNT Contaminated Waters," presented at the 4th Annual Symposium on Chemical Oxidation, Nashville, TN, Feb. 1994.

K.A. Gray and K.S. McAuliffe, "Pyrolysis-GC-MS Characterization of the Natural Organic Matrix of Waters and Soils: New Insights into Organic Influences on Treatment Performance," presented at the 20th Annual Water Quality Technology Conference, Miami, Florida, November 14-18, 1993.

D.C. Schmelling and K.A. Gray, "Photocatalytic Degradation of TNT," presented at the 24th Annual Meeting of the Fine Particle Society, Chicago, IL, August 1993.

R.J. Hilarides and K.A. Gray, "Radiolytic Destruction of Dioxin on Soils: Optimal Conditions and Economic Consideration," presented at the Summer Meeting of the American Institute of Chemical Engineers, Seattle, WA, August 1993.

K.A. Gray, A. St. Amand and Hong Wang, "Role of a Periphytic Biolayer in the Fate of PCBs in Artificial Stream Systems," presented at the First International Specialized Conference on Contaminated Aquatic Sediments: Historical Records, Environmental Impact, and Remediation, sponsored by the International Association on Water Quality, Milwaukee, WI, June 14-16, 1993.

K.S. McAuliffe and K.A. Gray, "Characterization of Natural Organic Matrix Using Pyrolysis-GC-MS," presented at the 26th Great Lakes Regional Meeting of the American Chemical Society, May 27, 1993.

K.A. Gray, R. Barreto, P. Yocum, and K. Anders, "The Influence of Photocatalytic Pretreatment on the Biodegradation of MTBE," presented at the Summer Meeting of AIChE, Minneapolis, MN, August, 1992.

K.A. Gray, "Mechanistic Studies of Photocatalysis on Semiconductor Surfaces," poster presentation at the Gordon Conference on Environmental Sciences: Water, June, 1992.

K.A. Gray, P. Kamat, U. Stafford and M. Dieckmann, "Mechanistic Studies of Chloro- and Nitro-phenolic Degradation on Semiconductor Surfaces," presented at The Annual Meeting of the American Chemical Society, San Francisco, April, 1992.

K.A. Gray and K.S. McAuliffe, "Application of Pyrolysis-GC-MS to Characterize a Variety of Surface Waters: Influence of Algal Dynamics," presented at the Annual Meeting of the American Chemical Society, San Francisco, April, 1992.

K.A. Gray, "Use of Pyrolysis-GC-MS to Study the Organic Matrix of Surface Waters," presented at the 1991 Water Quality Technology Conference, American Water Works Association, Orlando, Florida, November, 1991.

U. Stafford, K. Gray, P. Kamat, A. Varma, "The Effects of Semiconductor Properties Upon Photocatalytic Rates for Organic Contaminant Degradation," presented at the 1991 Annual Meeting of the American Institute of Chemical Engineers; Los Angeles, CA, November, 1991.

J. Earley, K. Gray, P. Garrity, "Radiolytic Destruction of Dioxin," presented at the 1991 Annual Meeting of the American Institute of Chemical Engineers, Los Angeles, CA, November, 1991.

K. Anders and K. Gray, "Photocatalytic Degradation of Methyl-tert-Butyl Ether on Semiconductor Surfaces," presented at 2nd Annual Argonne Symposium for Undergraduates, Argonne National Laboratory, November 8-9, 1991.

M.S. Dieckmann, K.A. Gray, and P.V. Kamat, "Photocatalyzed Degradation of Adsorbed Nitrophenolic Compounds on Semiconductor Surfaces," presented at Waste Management in The Chemical and Petrochemical Industries, IAWPRC & Tulane University, New Orleans, June, 1991.

K.A. Gray, "Specific Chemical Effects of The Calcium and Bicarbonate Ions on Colloidal Destabilization by an Inorganic Aluminum Polymer," presented at the Mid-West Environmental Chemistry Workshop, October, 1990.

M.S. Dieckmann, P.V. Kamat, and K.A. Gray, "The Effect of Semiconducting Materials as Photocatalysts in the Degradation of Nitrophenols," presented at the Mid-West Environmental Chemistry Workshop, October, 1990.

K.A. Gray, "Direct Filtration of Model and Natural Waters: The Removal of Turbidity versus Dissolved Organic Matter," presented at the IAWPRC/IWSA Joint Specialist Conference on Coagulation, Flocculation, Filtration, Sedimentation, Flotation, Jonkoping, Sweden, 24-26 April, 1990.

K.A. Gray, "Direct Filtration on the Seine River: The Importance of Chemistry," presented at the 1st Macao Workshop on Water Treatment, 3-4 November, 1989, sponsored by the Macao Water Supply Co., Ltd. and the Lyonnaise des Eaux.

K.A. Gray, F. Bernazeau, C. Hubele, "Reduction of Total Organic Carbon by Direct Filtration: A Pilot Study on the Seine River," presented at the 7th Regional Conference of the Asian-Pacific Group of the International Water Supply Association (IWSA), 29 Oct.-2 Nov., 1989, Nagoya, Japan.

K.A. Gray, F. Bernazeau, C. Hubele, "Upgrading a Slow Sand Filtration Plant for Micropollutant Removal: Use of Direct Filtration Prior to Granular Activated Carbon for Reduction of Total Organic Carbon," presented at the IWSA/AIDE Specialized Conference "Organic Micropollutants," 19-21 Sept. 1989, Barcelona, Spain.

K.A. Gray, F. Bernazeau, C. Hubele, "Direct Filtration on the Seine River: A Pilot Study," presented at the Annual Conference of the American Water Works Association, Los Angeles, June, 1989.

K.A. Gray, C.H. Yao, C.R. O'Melia, "Polymeric Metal Coagulants," presented at the Annual Conference of the American Water Works Association in Kansas City, MO, June, 1987.

K.A. Gray, C.R. O'Melia, "Use of Inorganic Iron(III) Polymers for Coagulation in Industrial Water Treatment," presented at the 18th Mid-Atlantic Industrial Waste Conference, Virginia Polytechnic Institute, Blacksburg, VA, June, 1986.

K.A. Gray, C.R. O'Melia, "The Formation, Characterization and Use of Inorganic Iron(III) Polymers for Coagulation in Water Treatment," presented at the Annual Conference of the American Water Works Association in Denver, CO, June, 1986.

K.A. Gray, C.R. O'Melia, "The Use of Inorganic Iron(III) Polymers for Coagulation in Water Treatment," presented at the 37th Annual Meeting of the Chesapeake Section of the American Water Works Association, Ocean City, MD, Sept., 1985.

K.A. Gray, T.D. Waite, "Coagulation and Precipitation Studies of the Ferrate(VI) Ion," presented at the 186th National Meeting of the American Chemical Society, Environmental Chemistry Division, Washington, D.C., Aug., 1983.

T.D. Waite, K.A. Gray, "Oxidation and Coagulation of Wastewater Effluent Utilizing the Ferrate(VI) Ion," presented at the Fourth International Conference on Chemistry for Environmental Protection, Toulouse, France, Sept., 1983.

UNIVERSITY COMMITTEES AND RESPONSIBILITIES

Department:

Northwestern University:

Environmental Group Coordinator, 2002-2010.
Graduate Recruiting and Admissions, Environmental Program, 2002-present
Redesigned Website – 2001-2002
Environmental Faculty Search Committees (1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010)
Service Learning Pilot and Program Director, 1996-present
Strategic Planning – 2000, 2004-05
Undergraduate Curriculum Development, 1995-present

University of Notre Dame:

Departmental Seminar Coordinator, 1992-1995
Undergraduate Curriculum Committee, Chair, 1989-1993
ASCE Faculty Advisor, 1990-1993
Graduate Recruiting, 1990

College:

Northwestern University:

Promotion & Tenure Committee – 2007-2009.
Search Committee – Associate Director, Industrial Relations, 2005
Dean Search Committee, Spring, Fall 2004
Freshman Advisor - 1996-2001
McCormick Identity Committee, 2001-2002
MEOP – Summer EXCEL Program, Designed and Supervised Community Engineering course and integration into Leadership Program, 1998,1999.
Planning Committee for the Institute for Manufacturing and Design Technology, 1998
Speaker/Facilitator - McCormick Career Night, 1995

University of Notre Dame:

Grievance Committee, Alternate, 1994-1995
Committee on Undergraduate Studies, 1989-1993
Minority Mentor Program, Advisory Board (member, 1993-1995) and mentor, 1989-1995
Summer Program in Engineering for High School Women and Minorities; Seminar Speaker, 1990-1995

University:

Northwestern University:

Environmental Policy & Culture Faculty Advising Committee, Weinberg CAS, 2008-present.
School of Continuing Studies' Graduate Faculty Advisory Board, 2007-present
Program Review Committee (2002-2005); Member Geological Sciences Internal Review Subcommittee, 2001; Chair, University Services Internal Review Subcommittee, 2003; Chair, Department of Family Medicine, Internal Review Subcommittee, 2004; Chair, Department of French and Italian Internal Review Subcommittee, 2005
University Re-accreditation; Faculty Self-Study on Interdisciplinarity in Undergraduate Programs, 2003-2004.
Faculty Search Committees; Chemistry (2003-04), Mathematics (2004-05)
Director, Environmental Science, Engineering and Policy Program (formerly, Environmental Science Program, WCAS), 2003-present

Plant Biology and Conservation Graduate Program in WCAS, member of Oversight Committee

Environmental Science Task Force, 2001-02

Committee on Women in the Academic Community, 2001-2003

University Faculty Reappointment, Promotion and Tenure Denial Appeal Panel, 1999-2002

Master (1998-2002), *Associate Master* (1997-98) and *Faculty Associate of Public Affairs Residential College*, 1996-present.

University of Notre Dame:

Committee to Select Proposal to Henry R. Luce Professorship Program, 1994

Graduate Council, Appointed Member, 1991-1994

Planning Committee of Graduate Council, 1992, 1993

Freshman Year of Studies, Discussion Group Leader Freshman Orientation, 1991-1994

Notre Dame Science and Engineering Talent Search, Seminar Speaker, 1991

Program to Promote Minority Enrollment in Graduate School, Seminar Speaker, 1991

Center for Social Concerns, Pilot Workshop to consider Ethical Dimensions of Undergraduate Education, Discussion Leader, January 12-13, 1992

Reilly Center, Scholarship Review Committee, 1992, 1994, 1995

Conference on Business Leadership in the Environmental Crisis, Panelist, Sept., 1992

Institutional Animal Care and Use Committee, Member, 1991-1995

Selection Committee for Graduate Teaching Award, 1993

Speaker-Placement Office Graduate School Information Session, 1993, 1994

Environmental Issues Group, Kroc Institute of Peace Studies

Faculty Fellow and member of Undergrad Advisory Committee, Joan B. Kroc Institute for International Peace Studies 1993-1995

Panel Member: Women in a Catholic University: The Challenge and Promise, 1993

Participant, Information Session for Women in Science and Engineering; Freshman Year, 1993.

EDUCATIONAL and COMMUNITY OUTREACH

K-12 Educational Outreach:

- Designed, organized, and taught in Middle- and High-School Teachers Workshop, *Unlocking Nature's Secrets: Catalysis in the Environment and Industry*; at Argonne National Laboratory, 2000, 2001 & 2002. Total number of teachers was 91.
- Primary author of educational laboratory module, *Environmental Catalysis*; 10th in a series of *Material Worldwide Modules*; designed, tested, wrote series of activities for students to learn about various principles of catalysis and the importance of catalysis for environmental protection. Field-tested activities in various high schools (ETHS, New Trier, Schaumburg, etc.) in Chicago area and nationally.
- Mentored 7 High School Teachers participating in the NSF REST program (Research Experience for Science Teachers) since 1999, as well as over 26 REU or high school students working on summer research over the last 10 years.

Community Outreach

- Chicago Cross-Pollinator Project, panel member, 11 June 2012.
- *The Green City: A Field Study in Chicago*; organized and lectured in Summer Institute of School of Continuing Studies, Aug. 9-11, 2006, Aug 1-3, 2007, July 28-30, 2008.
- Technical Advisory Committee, Friends of the Chicago River, 2004-present.
- Advisory Board, Healthy Schools Campaign, 2004-present.

NU Alumni, Development, Student Group, and General University Talks

- "Living Cities: An urban model of sustainability," Fireside at Slivka Residential College, 10 May 2012.
- Undergraduate Research and Arts Exposition, Session Moderator, May 21, 2012.
- Guest lecture, Science of Climate Change, NU Law School, Seminar on Climate and Energy, Jan. 10, 2012.
- Panel member, Sustainability and Renewable Energy Panel, The Graduate School Centennial Celebration, Nov. 4, 2011.

- “Fabricating Titania-based Nanocomposites for Solar Fuel Production: TiO_{2-x} & $\text{Ti}_{1-x}\text{Nb}_x\text{O}_2$ Thin Films & TiO_2 Nanotubes,” Northwestern Undergraduate Chemistry Council, March 8, 2011.
- “Sustainable Strides in Urban Design: Lessons from Chicago,” SEED Green Cup Kick-off, 31 January, 2011.
- Panel: Environmental Justice and Hurricane Katrina for Undergraduate Lecture Series on Race, Poverty, and Inequality at Northwestern University & NU Conference on Human Rights – November 22, 2010.
- “The Modern American City: Can we ever make it Sustainable?” McCormick Engineering Week, McCormick Student Advisory Board, NU, May 20, 2010.
- Panel: Working with the Community, Community Research Workshop, NU, May 14, 2010.
- Panel: Environmental Racism: Poverty and Pollution in Minority Communities, in the Martin Luther King, Jr. Lecture Series, NU Medical and Law School, January 12, 2010.
- Panel: Infrastructure Now and Then: Seeing the Future At Another Level, in The Infrastructure Universe: From Highways to Molecules, Alumnae Continuing Education Course, Dec. 3, 2009.
- Domain Dinner on Sustainability, “The Elusive Concept of Sustainability,” 16 Nov. 2009.
- “Can you have a Green City on a Brown Lake,” Junior Science Café, Arlington Heights, 4 Nov., 2009
- “Making Chicago Sustainable: The Water-Energy Connection” in The Infrastructure Universe: From Highways to Molecules, Alumnae Continuing Education Course, Oct. 1, 2009.
- “Can you have a Green City on a Brown Lake,” Sigma Xi Junior Science Café, 21 March, 2009
- “Why this isn’t your father’s energy crisis,” Science Café, Wilmette Public Library, Nov 5, 2008.
- Women in Science and Technology Panel, POWER Dinner, Chicago, IL, May 22, 2008.
- “Sustainability: Fad or Necessity?” Fireside at CCS, May 12, 2008.
- “Who wants to be a billionaire? The mad dash to find sustainable alternatives to fossil fuels?” Northwestern University Circle, March 13, 2008.
- Survival Skills for Graduate Students and Junior Faculty, Women’s Center, NU, Feb. 20, 2008
- “Who wants to be a billionaire? Some thoughts on energy, geopolitics, economics, & technology.” Fireside at Slivka Residential College, Nov., 2007.
- “Are we ever going to be able to make modern American cities sustainable?” Twin Cities NU Club, May 23, 2007.
- “Opportunities in Environmental Science and Engineering,” SEED, May 1, 2007.
- “Design for the Environment – what that means” guest lecture, IDEA 398, Feb. 1, 2007
- “Environmental Engineering: Biology, Chemistry and Physics for Ecological and Public Health Protection,” Society of Hispanic Professional Engineers, Midwestern Expo, Nov. 1, 2006.
- “Energy and Sustainability: Business Opportunities,” Energy Club in Kellogg School of Management, Oct. 3, 2006.
- Domain Dinner on Energy and Environmental Issues, April 11, 2006, organizer, speaker.
- “Designing the Ecologically Sound City: New Orleans as a Case Study” Alumnae Continuing Education Lecture Series, Dreams, Designs, and Development, April 20, 2006.
- “Hurricane Katrina: Preparation, Response and Rebuilding,” Panel member, sponsored by MEAS, Oct. 17, 2005.
- “The Sustainable City: If we know what to do, why aren't we doing it?” NU Club of Virginia, Richmond, VA, March 18, 2005.
- “The Sustainable City: Ecology, Efficiency, Equity,” NU Engineers for a Sustainable World, May, 2004.
- “Urban Ecology and Technology: Opportunities for Sustainable Societies,” ARCS lunch, Norris Center, April, 2004.
- “Sustainability: Engineering the City of the Future,” Public Interest Alumni Assoc., John Evans Center, Evanston, IL, Oct., 2003.
- “Undergraduate Research and Project Based Learning,” New Student Visits, Norris Center, April, 2003.
- “Engineering the City of the Future: An Environmental Perspective,” NU Alumni Association, March, 2003.
- “Do Environmental Issues Really Matter,” NU Alumni Association, Classes without Quizzes, Nov. 12, 2001.
- “Do Environmental Issues Really Matter,” Provost’s Reception for Residential College Faculty Fellows, Hardin Hall, Sept. 25, 2001.
- “Environmental Issues of Urban Areas,” NU Alumni College Program, *The City: Past, Present*,

and Prospects. July 28, 1999.

- “PCB Contamination and Other Threats to the Ecological and Human Health of the Great Lakes Region,” Seminar Day, Northwestern Alumni Assoc., April 17, 1999.
- “Environmental Catalysis,” presented at Tech Review, March 23, 1999.
- “Community Service in Chicago Neighborhood,” Lunchtime Seminar, PARC, Sept. 15, 1998.
- “Local Pollution,” Earthday, SEED, NU, 23 April 1998.
- Member, Panel Discussions to Undergraduate and Graduate students on issues related to gender, environmental quality and justice, sustainability issues.

SERVICE LEARNING AND COMMUNITY BASED PROJECTS (students supervised in parentheses)

- Cook County Climate Change and Public Health Action Plan (Beau Garrett & Natalie Lake) 2012.
- Confined Animal Feed Operations (CAFO) Best Management Practices (Regan Radcliffe & Kaleb Tsang) 2012.
- Midwest Generation Trona Injection (Anusha Vadlamanu & Bingshu Li) 2012.
- Oxbow Corp. Calcined Petroleum Coke Facility –SO₂ Non-compliance (Lauren Lopez & Yufei Zhou) 2012.
- Hegewisch March (William Boulay & Xingcheng Lu) 2012.
- Air Quality Evaluation for Southeast Chicago with Respect to the Proposed Universal Cement Facility (Jeff Goto & Nopparat Chiangwong) 2012.
- Chicago Area Confined Disposal Facility (Adrienne Masterton, Yan Zou) 2012.
- Preliminary Phase II Remedial Investigation Report; OU3 Onsite Soils & Groundwater Assessment (Lauren Miller & Paige Humecki) 2012.
- Closure, Remediation, and Future Land Use at State Line Power Plant (Lauren Fleeer & Taylor Sweet) 2012.
- Clean Construction or Demolition Debris; Rule Making (Tina Wang & Sarist Macksasitorn), 2011.
- 2727 South Troy Street, Little Village: Site Remediation (Dustin Grossheim & Sasha Letuchy), 2011.
- State Line Energy Power Plant: New Source Review (Roshni Barot & Brian Kennedy), 2011.
- South Suburban Citizens Opposed to Polluting the Environment: Storm-water Management & Flooding in Longwood Farms (Michael Giannetto & Ke Gong), 2011.
- Understanding the EPA’s Greenhouse Gas Reporting Program (Ben Shorofsky & Boping Liu), 2011.
- Calumet CID Landfill: Future Use Recommendations (Walter Furness & Andrea Morgan), 2011.
- Methods for Attaining Aquatic Life Use A Standards in the Calumet Area Waterways (Sara Thomas & Susan Vescovi), 2011.
- Lake Depue Sediment Contamination: Evaluation of OU5 Ecological and Human Health Risk Assessments (Chelsea Baldino & Anjulie Cheema), 2011.
- Restoration of Miller Meadow (S. Katragadda, M. Roebuck, J. Young), 2010.
- Brownfield Redevelopment in Little Village: Assessing the extent of contamination, remediation strategies, and future use (E. Och, S. Pavlik), 2010.
- Zero Energy Buildings (for Doug Farr & Assoc. by M. James and E. McCarthy), 2010.
- HVAC & Boiler Systems: Proposal for the Robert H. Lurie Medical Center (for Earthwise Environmental, Inc. by B. Sikora, J. Sirk, R. Gophal), 2010.
- Sustainable Urban Infrastructure Systems: Lathrop Homes (for Doug Farr & Assoc. by E. Ulion, S. Bernard, P. Slevin, S. Chaturvedi), 2010.
- Installing an Inflatable Dam at Busse Woods - Assessing Environmental Impacts and Identifying Reasonable Alternatives (Robert Pickering, Mark Woodsum), 2009.
- Transforming the Former Celotex Industrial Site in Little Village to a Community Park - Design Features That Protect the Public and Create a Community Recreational Resource (Virginia Palmer, Nancy Shan), 2009.
- BP Whiting Refinery Permit Review (Christopher Trigg, Shuchi Talati), 2008.
- Robbins Community Power Plant (Maggie Fry, Erica Schleimer), 2008.
- Redesignation of the Calumet River System (Teri McClerklin, Carmen Shank), 2008.
- Revegetation of the Calumet Cluster Site (Ahmad Harake), 2007.
- The City of the Future Competition, sponsored by ASCE, IBM, The History Channel, selected for Chicago competition (Julia Hand, Caitlin Freehan, Jennifer Raber, Siti Abidin), 2007.
- Analysis of the Proposed Ford Heights Ethanol Plant (Siti Abidin, Jonathan Adams, Nur Atiah Ashar, Maya Jensen), 2006.
- USX Bike Path/Public Access (Duane Ambroz, Rosemary Bush, Eva Dubey, Kevin Lee), 2006.
- Lake Calumet Cluster Site: Future Land Use Proposal (Margaret Adsit, Allan Castillo, Douglas Groux, Megan Mann), 2006.

- Probing the photochemical aging of the Seurat's zinc yellow pigments in Sunday at La Grand Jatte with Francesca Casadio at the Art Institute of Chicago (Nirav Shah), 2004-2006.
- Natural Resource Damages for Indian Ridge Marsh (Sara Patrawala and Sohier Dane), 2006.
- Contamination of the Celotex Site at La Villita (Chris Lee and Melissa Mendez), 2006.
- Lucak-Berg Pit Project (Calista Fisher and Marshall Lindsey), 2006.
- Proposal for Quarry Shopping Center's Storm Water Runoff (Debra Weissman and Ori Sivan), 2004- 2005.
- Assessment of Opacity Issues at Five Midwest Generation Coal-fired Power Plants in the Chicago Area (Jonathan Flowers, Nyak Shidawati, Sharon Waller), 2004-2005.
- Methane Production and Energy Cogeneration Potential in the Sediments of the Chicago Sanitary Canal (Colin Barrett), 2003-2004.
- LEEDing the Redevelopment of Brownfields with Green Design (Betty Jurkowski), 2003-2004.
- Remediation of Thorium Contaminated Soils and Sediments: Kerr-McGee Kress Creek and Warrenville Retreat Center (Clare Frederick and Allison Walk), 2003-2004.
- Healthy and High Performing Schools: Economic Analysis of LEED Rated School Construction (Robert Kutter and Megan Johnson), 2003-2004.
- Urban Honey Production: Risk Assessment of Metal and Organic Contamination (Erin Jordan), 2003-2004.
- PM₁₀ Compliance in Southeast Chicago (Michael Goldrich and Ben Jewel), 2003-2004.
- Going Green: A Comprehensive Review of Green Roofs (Aarti Ramachandran) 2003-2004.
- Indiana Harbor/East Chicago CDF (Todd Waldrop), 2002-2003.
- Fort Sheridan Closure (Polina Liberman and Don Walsh), 2002-2003.
- PAH Contamination at Bridgeport Homes (Hilary Holmes), 2002-2003.
- Healthy and High Performance Schools (Se Jong Cho and Francis Wambi-Buesso), 2002-2003.
- Wastewater Disinfection Methods and Their Feasibility at the Metropolitan Water Reclamation Plants in the Greater Chicago Area (Kirsten Dickson), 2002-2003.
- An Investigation of Remediation Alternatives for Contaminated Sediments in the Vessel Slips of Wisconsin Steel Works and United States Steel South Works (Andrew Burnham and Travis Cobb), 2001-2002.
- The Suitability of Shallow Wells to Solve Lockport's Radium Problems (Cari Ishida, Todd Waldrop, Nathan Turner, Cody Prentice, Andrew Marcus), 2001-2002.
- Solar and Wind Renewable Energy Systems at the Southeast Chicago Cluster Site (Todd Waldrop), 2001-2002.
- The CTA's Forest Glen Bus Garage: The Air Pollution and Some Solutions (Jennifer Wilson), 2000-2001.
- Hazardous Air Pollutant Emissions from Natural Gas-Fired Peaking Power Plants in Northeast Illinois (Lynette Cheah), 2000-2001.
- Health Risks from Radioactive Emissions from Coal Burning Power Plants (Ben Porter), 2000-2001.
- Evaluation and Design of Enhanced Wetlands for the Lake Calumet Cluster Site (Jennifer Wendrowski), 1999-2000.
- A Guide to Identifying Communities with Health Hazards: Using the Tools of CCRI (Emily C. Anderson and Marlena M. Lacey), 1999-2000.
- A Characterization and Assessment of Vessel Slip Contamination: United States Steel South Works Site and Wisconsin Steel Works Site (Nuria Bertran-Ortiz and Christina Hemphill), 1999-2000.
- Resource Guide: The Phytoremediation of Lead in Urban, Residential Soils (Joseph Fiegl and Bryan McDonnell), 1999-2000.
- Pollution Prevention in the Metal Finishing Industry (Allison McCormick and Tracey Rissman), 1998-1999.
- The Chicago Cumulative Risk Initiative–Mercury Rising (Saba Fatima and Katie Sovik), 1998-1999.
- Lake Calumet Cluster Site: Site Characterization and Use of Experimental Wetlands for Reclamation (Michael Butler and Kim Sopocy), 1998-1999.
- Chicago Cumulative Risk Initiative – Hazard Mapping (Kelly Hirsch and Junaluska Williams), 1998-1999.
- Planting the Seed for Recovery: Altgeld Gardens (Angela Change and Mausami Desai), 1998-1999.
- Regional Air Quality and Chicago's Ground Level Ozone Problem (Terah Luchey and Shanthi Nataraj), 1998-1999.
- Wetland Remediation: Cleaning up the Lake Calumet Cluster Site (Beverly Ahoni), 1998-1999.
- Lake Calumet Cluster Site: An Analysis of Future Remedial Action (Sarah Bender and Ted Ekkers), 1997-1998.
- Risk Assessment and Site Characterization of the Wisconsin Steel Works Site (Emily Fahsl and Matthew Lamb), 1997-1998.

- PAH Contamination at Altgeld Garden's (Kimberly Mertz and Neal Steffan), 1997-1998.
- An Analysis of Natural Attenuation at the United States Steel South Works Site (Lisa Bongiovanni, Sanne Knudsen, Todd Wildermuth), 1996-1997.
- Assessing Wetlands Creation and Landfill Gas Reuse Projects at Site Adjacent to Indian Ridge and Big Marshes (Bob Cummings and Nikki Kryda), 1996-1997.
- Celotex Corporation Superfund Site (Pam Kearfott and Claire Hilger), 1996-1997.
- The Little Village Air Quality Analysis (Jaime Hardt and Kary Hisrich), 1996-1997.

CONSULTING

- Crowell & Moring, LLP (Intellectual property, photocatalysis patent analysis)
- Industrial Facilities Engineering (Disinfection of public drinking water supplies at a naval base)
- Cochran, Cherry, Givens, Smith & Montgomery, L.L.C. (environmental justice, investigated property and groundwater contamination from landfill in Michigan)
- Munday and Nathan (investigated suspected contamination of groundwater)
- Edward Scanlan Law Office (aquifer and soil contamination by TCE at Lockformer site in Lisle, IL)
- Levy and Leopold Law Office (PAH contamination at CHA facility, Altgeld Gardens)
- Sugar Law Center for Economic and Social Justice (Soil contamination and inadequate brownfield cleanup on Detroit public school site)
- City of Thornton, CO ((Organic Characterization & Surface Water Quality for Indirect Potable Reuse, testified before Colorado Water Board on the development of organic carbon control and in Water Court)
- The Wetlands Initiative (Various Restoration Projects along the Illinois and Chicago Rivers; wetland restoration, nutrient dynamics)
- Burlington, WI Giardia outbreak (Expert for Plaintiffs on Water Quality and Drinking Water Treatment)
- Cascino Vaughan, Chicago, IL (Milwaukee Cryptosporidium Outbreak, Expert for Plaintiffs on Coagulation Process and Use of Polymeric Coagulants)
- Employment Research and Development, Inc. Wilmette, IL (accreditation testing)
- Burns and McDonnell Consulting Engineers, Kansas City, MO (Organic Characterization and Surface Water Quality for Drinking Water Treatment)
- Orange County Water District (Organic Characterization and Surface Water Quality for Indirect Water Reuse)
- Safety Kleen (Waste Characterization & Treatment)
- KDF Fluid Treatment, Inc., MI (Pilot Testing Iron Removal Catalyst)
- Midland Resources, Inc., Lawrence, KS (Characterization and Use of Polymeric Iron Coagulant)