EMERGING ORGANIC POLLUTANTS IN WASTE WATERS AND SLUDGE (HANDBOOK OF ENVIRONMENTAL CHEMISTRY) pdf

1: Damia Barcelo (Author of Emerging Organic Pollutants in Waste Waters and Sludge, Volume 1)

*Emerging Organic Pollutants in Waste Waters and Sludge (The Handbook of Environmental Chemistry) [DamiÃ BarcelÃ³] on www.enganchecubano.com *FREE* shipping on qualifying offers. >The current volumes, 5/I and 5/O in the Handbook of Environmental Chemistry Series, cover the analytical.*

This goal will be accomplished through a series of laboratory and field scale interdisciplinary studies. Knowledge gained from this research will be provided to governmental decision-makers, WWTP managers, and the general public to help better assess the environmental risks of land disposal of biosolids and animal waste. The specific objectives include: To develop sensitive analytical methods for pharmaceuticals, PPCPs, and their metabolites in soil and animal waste samples. To investigate the transport and transformation of pharmaceuticals, PPCPs, and their metabolites in biosolids and animal wastes amended soils. To develop and evaluate biological treatments for reducing anthropogenic organic chemicals in biosolids and animal wastes. Project Methods Approach for objective 1: Biosolids samples will be collected, throughout the State of Georgia, from representative wastewater treatment plants serving rural communities, medium size city, and Atlanta metropolitan area. Specific compounds that will be analyzed in the biosolids samples include human antibiotics, prescription drugs, nonprescription drugs, nonylphenol, and flame retardants. Extraction and cleanup methods will be developed to increase detection sensitivity and to reduce matrix interferences. Approach for objective 2: The potential runoff losses of the target compounds will be assessed in a field-scale investigation using rainfall simulation on small plots amended with biosolids. Laboratory batch and column experiments will be conducted to investigate the important soil physicochemical factors that affect the interactions of the target compounds and their metabolites with soil organic and inorganic components. The biodegradability of selected target compounds and metabolites will be evaluated under a series idealized bench-scale laboratory experiments. Approach for objective 3: A wide range of operating conditions will be studied by altering the concentration of mixed liquor volatile suspended solids MLVSS , food-to-microorganism ratio, hydraulic detention times, sludge age, and redox conditions aerobic, anoxic or anaerobic. The annual production of biosolids in the United States is projected to increase sharply to 47 million tons within the next decade. Land application is becoming a major means for biosolids disposal because of its beneficial effects on agricultural productivity of soils. However, due to its close association with human activities, biosolids often serve as a sink for anthropogenic organic chemicals that cannot be degraded during the wastewater treatment processes. EPA currently has no regulations on the levels of organic chemicals in biosolids although land application and landfill of biosolids could have a high potential of continuously introducing organic contaminants into the water resource due to surface runoff and leaching. Wastewater treatment plants in the Unite States and world-wide are in urgent need for scientific sound information on the environmental fate of anthropogenic organic chemicals in wastewater and biosolids. Impacts A variety of anthropogenic organic chemicals were detected in biosolids from Georgia wastewater treatment plants. The levels of the detected anthropogenic organic chemicals in the biosolids ranged from parts per billion to parts per million. Nonylphenol, an endocrine disruptor, was detected up to parts per million in several biosolids from wastewater treatment plants servicing cities with heavy industry. The data suggest that sensitized photolysis reactions may play important roles in degrading NP in surface applied biosolids. The safest approach to avoid potential detrimental effects of biosolids-associated anthropogenic organic chemicals to the environment is to ensure that the compounds are adequately degraded before biosolids land application. A recent pilot laboratory-controlled composting study provided further evidence that nonylphenol can be effectively degraded during composting. High temperatures can significantly hasten nonylphenol degradation during composting, but composting for longer times at lower temperatures can yield similar results. The knowledge gained from the currently project investigating the movement of biosolids- and wastewater-associated anthropogenic organic chemicals will be shared with WWTP mangers, decision

makers, and the general publics by web communication, reports, presentations, and workshops Publications Ferrell, J. Chemodynamics, Toxicology, and Modeling. Sorption - Desorption of Organic and Inorganic Contaminants. The knowledge gained from the currently project investigating the movement of biosolids- and wastewater-associated anthropogenic organic chemicals will be shared with WWTP mangers, decision makers, and the general publics by web communication, reports, presentations, and workshops Publications Xia, K. In print Xia, K. Photodegradation of endocrine-disrupting chemical 4-nonylphenol in biosolids applied to soil. Anthropogenic organic chemicals in biosolids from selected wastewater treatment plants in Georgia and South Carolina. In Kathryn Hatcher ed. Athens, GA, April Occurrence and transformation of estrogenic nonylphenol polyethoxylates and their metabolites in three northeast Kansas wastewater treatment plants. The levels of a variety of organic chemicals were investigated in biosolids collected from 21 wastewater treatment plants, serving rural, industrial, and urban communities, across the State of Georgia. The potential for biosolids-associated organic chemicals to enter into the water environment through leaching is assessed. In collaboration with an agricultural engineer at UGA, a laboratory pilot-scale study is established followed by a commercial large-scale study to develop an aerobic bioprocess composting for enhancing degradation of organic chemicals in biosolids and to transfer the technology to users. A laboratory pilot-scale study is currently being conducted to develop an aerobic bioprocess to treat biosolids heavily contaminated with nonylphenol. Our results suggest that composting of biosolids with wood shavings can rapidly reduce nonylphenol levels within 20 days. The processes developed in this study will likely be effective to reduce other similar organic chemicals in biosolids. The knowledge gained will be shared with WWTP mangers, decision makers, and the general publics by web communication, reports, presentations, and workshops. The success of this research will not only have significant economic impact on wastewater treatment plants in the United States and world-wide but also have tremendous environmental impact. Anthropogenic Organic Compounds in Biosolids.

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2: Emerging Organic Pollutants in Waste Waters and Sludge, Volume 1 by Damia Barcelo

"Emerging Contaminants" correspond in most cases to irregulated contaminants, e.g. surfactants, pharmaceuticals and personal care products (PPCP), or gasoline additives. These two volumes, 5/I and 5/O, of this Handbook deal with the analytical, toxicological and environmental issues of these toxicants.

Establish a well-defined large scale field research site for studying and comparing the near-term and long-term agricultural impacts of four common organic amendments currently available in commerce dairy manure, sewage biosolids and both composted and alkaline-stabilized sewage biosolids products. Plots will be of sufficient size to answer current and emerging issues from a range of disciplines. Evaluate changes in biological, physical and chemical soil characteristics associated with the use of these different organic residuals. Assess the differences in the availability of sulfur, molybdenum, phosphorus and other nutrients between the treatments. Evaluate the potential impact of the copper antagonists in the residuals on ruminant animal health and management. Examine the effect of the different treatments on the mobility of pesticides and phosphorus. Project Methods Two sets of 5 large research plots will be established. They will be well separated so tillage and blowing will not transfer soil or amendments between plots. Each plot will be amended annually with an organic waste residual OWR. A no-amendment control will be established. The 4 OWR will be in common use in NYS like dairy manure, dewatered sewage sludge, composted sewage sludge and advanced alkaline stabilized sewage sludge. They will be tilled into the soil and a crop likely red clover will be grown. The OWR will be well characterized through testing for metals, organic chemicals, pH, organic matter, molybdenum, sulfur, N, P, pH and other parameters. Documentation of application rates and practices and archiving samples will enable future researchers to investigate emerging questions. We will conduct pre- and post-application physical, chemical and biological soil health studies including measuring various soil physical parameters such as aggregate stability , metals, organic chemicals, pH, organic matter, extractable and thus environmentally available P, organic matter degradation, and earthworm presence and avoidance behavior. In addition to the research plots, we will do soil health studies on sludge-applied plots at the U. These sites are well characterized in regard to soil chemical quality and will enable us to extend our research to additional soils and different OWR. Undisturbed soil cores taken from the periphery of the plots and will be used to study the movement of P and pesticides. Through workshops, conferences, consultation and media contacts, a wide stakeholder audience was reached on the subject of sewage sludge biosolids application to farmlands. Consultation on national projects allowed us to influence research conducted on health-implications of land application of sewage sludges, on the development of a protocol for local investigations, on USEPA research on methods to assess soil and air impacts of land application, on cost-benefit assessment of disposal alternatives and on multi-faceted research in Ohio. Consultation assisted more than 20 communities in evaluating sludge management options. Trainings and workshops reached more than wastewater professionals and many citizens. Through a collaborative effort led by Cornell, scientists from universities in the northeastern United States developed and published guidance on sludge use including recommendations to protect soil quality and productivity. Collaborations were formed with researchers to enhance Cornell bioassay research with chemical measurements performed by USGS and Colorado State University. Groups were convened to discuss the meaning of soil test results and of how different soil test methods reflect potential impacts on environmental and human health. Laboratories in the northeast use different methods for metals such as lead, zinc and cadmium, making interpretation across states difficult. Most soil tests presently in use do not reflect bioavailability to crops or to soil invertebrates. These discussions led to development of a research proposal, which has now been funded, and will result in more relevant soil test methods as well as guidance materials to help people interpret test results. Bioassay methods provide a way to assess the impacts of complex mixtures such as sewage sludge. Earthworms are one of several model organisms useful for toxicity assays because of their responsiveness to soil contaminants due to high soil

ingestion rates. To gain insight into the effect of sewage sludges on soil-living organisms, we conducted short-term lab bioassays with soil samples amended with different sludge concentrations and aged for different lengths of time. Heavy metals can affect microbial processes in soils that are critical to soil health, such as organic matter and pesticide decomposition. As part of a series of bioassays testing the impact of heavy metal contamination on plant growth and microbial functions, we measured urease enzyme activity as well as degradation rates of the commonly used herbicide, glyphosate Roundup , in variably Zn and Cu-contaminated soils. The results confirmed that certain critical levels of Zn and Cu in soils resulted in reduced urease function as well as reduced ability to decompose glyphosate. Not relevant to this project. Impacts Organic residuals such as sewage sludges are widely used in agriculture as sources of nutrients. However, they contain contaminants that may affect soil quality, impact soil processes, move to groundwater and surface water,or be taken up by plant. Answering questions about these processes that could degrade soil health is critical to enable stakeholders to make sound choices about residual use. Plant and earthworm bioassay conducted suring this project showed that sludge amendment of soils at several percent by weight could detrimentally affect seed germination and earthworm survival and reproduction. Interestingly, sludge-amended soils aged for 8 weeks had a more pronounced effect on reproduction than un-aged control soils. Despite including procedures to equalize pH, we observed a drift to lower pH at higher sludge concentrations, which may or may not have influenced these reproduction results. The failure to explain these effects on earthworms based on the known levels of metal contaminants in the sludge indicates a need to study the toxic effects of other sludge chemical contaminants. Incubation of Cu and Zn-contaminated soils 2 soil types, fine and coarse-textured containing Clabeled glyphosate Roundup was conducted with continuous monitoring of carbon dioxide release from the soil. The highest Cu treatment mg per kg caused substantial reduction in the rate of glyphosate degradation in the coarse-textured soil, but not in the fine-textured soil. Lower levels of Cu less than or equal mg per kg , and all levels of Zn tested mg per kg had only small effects on degradation rates. However, Zn had an antagonistic effect on Cu; high soil Zn reduced the impact of soil Cu in inhibiting glyphosate degradation. The results showed Cu to be more toxic than Zn to microbial processes of glyphosate degradation, with coarse-textured soil being more sensitive to these inhibitory metal effects than fine-textured soils. The soil urease enzyme assays similarly indicated that soil Zn and Cu in the concentration range of mg kg have detrimental effects on soil microbiological function, but the severity of these effects again vary depending on soil texture. The results point to the need for site and soil-specific recommendations for toxic metal concentration limits in soils, indicating that existing federal regulations on sludge application do not protect all soil types from harmful effects of metals. Urease activity in aged copper and zinc-spiked soils: Environmental Toxicology and Chemistry 27, Effect of composting on polycyclic aromatic hydrocarbons removal in sewage sludge. Water Air and Soil Pollution , Biomass and Cu and Zn uptake of two turfgrass species grown in sludge compost-soil mixtures. Through workshops, conferences, consultation and media contacts, a wide audience was reached. Consultation on national projects allowed us to influence research conducted on health-implications of land application of sewage sludges aka biosolids , on the development of a protocol for local investigations, on USEPA research on methods to assess soil and air impacts of land application, on cost-benefit assessment of disposal alternatives and on multi-faceted research in Ohio. Expert knowledge was provided to over 40 journalists across the US. Trainings and workshops reached more than wastewater professionals and 75 citizens. Groups were convened to discuss the meaning of chemical test results and of how different chemical test methods reflect potential impacts on environmental and human health. Laboratories in the northeast use different methods, making interpretation across states difficult. Most tests do not reflect bioavailability. These discussions led to development of a research proposal and will result in guidance materials to help people interpret test results. Understanding of the importance of colloidal transport of contaminants through soils and into groundwater was increased by research and publication of an article in a practitioner-oriented journal. Earthworms, one of several model organisms useful for toxicity assays, are ideal because they have a high tolerance to changes in temperature, moisture and acidity. Furthermore, their responsiveness to soil

contaminants due to high soil ingestion rates provides strong correlations between laboratory and field studies on terrestrial biota. We conducted inductively coupled plasma mass spectrometry ICP-MS metals analysis on CaCl2 extracts of the soil samples looking at copper and zinc levels. As part of a series of bioassays testing the impact of heavy metal contamination on plant growth and microbial functions, we measured degradation of the commonly used herbicide, glyphosate Roundup , in variably Zn and Cu-contaminated soils, testing the hypothesis that decomposition would be inhibited. Farmers, agricultural advisors, governmental agencies at local, state and national level, researchers, and journalists are the primary audiences. Impacts Organic residuals such as sewage sludges aka biosolids are widely used in agriculture. In addition to nutrients and organic matter these residuals contain chemical and biologic contaminants that may affect soil quality, impact soil processes, move to groundwater and surface water, be taken up by plants, or degrade in the environment. Answering questions about these processes is critical to enable stakeholders to make sound choices about residual use. Plant bioassay results showed that while lettuce germination rates were not different between unaged and aged sludge-amended soils, increasing concentrations of sludge showed a decrease in germination. Results of 25 percent germination at 4 percent sludge concentrations vs percent germination in control soil indicate a level of toxicity that is significant. Only 20 percent of the earthworms survived in the jars from the mixture containing the highest concentration of sludge 4 percent that had aged for 8 weeks. Some aestivation, a curling behavior that indicates stress, while not quantitative, was observed sporadically at the slightly lower sludge concentration of both unaged and 8-week aged sludged-soils. Reproduction assay results demonstrate that increased concentrations of sludge also had a corresponding detrimental effect on E fetida reproduction and suggest that sludge-amended soil, aged for 8 weeks, had a more pronounced effect on reproduction than unaged control. However, despite including procedures to equalize pH, we still observed a drift to lower pH at higher sludge concentrations, which may or may not have influenced these reproduction results. ICP metals analysis did not lend any insights into a correlation between copper and zinc levels and toxicity associated with sludge, aged or not. An day incubation of Cu and Zn-contaminated soils 2 soil types, fine and coarse-textured containing 14 C-labeled glyphosate Roundup was conducted with continuous monitoring of 14 CO2 release from the soil. The results indicate that the glyphosate degradation assay is less sensitive to soil Cu and Zn than the urease assay, reported on last year. The soil microbial bioassays indicate that soil Zn and Cu in the concentration range of mg kg have an array of detrimental effects, but the severity of these effects vary by soil type. The results are supportive of site and soil-specific recommendations for toxic metal concentration limits in soils, and indicate that existing federal regulations on sludge application do not protect all soil types from harmful effects of metals. Phosphate and glyphosate mobility in soil columns amended with Roundup, Soil Science, The long-term effect of sludge application on Cu, Zn and Mo behavior in soils and accumulation in soybean seeds, Plant and Soil, Z and Krogmann, U. Data on the concentration of organic chemicals in sludges were collected from the peer-reviewed literature and official reports. Data were found for organic compounds grouped into 15 classes. For 6 of the 15 classes, there were no SSLs. Thus analyses targeting these lists will detect only a small fraction of the organic chemicals in sludges. A collaboration with USGS to examine bioaccumulation of pharmaceuticals in sludge-exposed earthworms has been initiated. The biodegradation of pharmaceutical products found in sludges was investigated. Genes encoding enzymes for ibuprofen, deet, and octylphenols have been identified. The role of colloids in the transport of metals though soils. To investigate the role of colloids on the transport of metals in the subsoil we attached Cd ions to Na and Ca Montmorillonite clays and used synchrotron X rays to compare the movement of the Cd adsorbed on the clays and in solution. By measuring the fluorescence and attenuation of the X rays we obtained simultaneous in situ water saturations and Cd concentrations on time scales of tens of seconds. We studied the transport of colloids through a preferential flow path in uniform well-sorted sand. This flow path had both saturated and unsaturated zones that travel downward with time. Cd adsorbed to Na Montmorillonite clay showed little retention in the sand, while the Cd on the Ca Montmorillonite clay colloids and in solution were retarded with respect to the wetting front. The advantages and limitations of this X-ray fluorescence technique and the

implications for Cd transport were evaluated.

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Emerging and Recalcitrant Compounds in Groundwater. River Water Quality Calibration. Monitoring and Detection in Drinking Water. Lysimeter Soil Water Sampling. Regulatory and Security Requirements for Potable Water. An Example For Spanish Coasts. Remediation and Bioremediation of Selenium-Contaminated Waters. Shellfish Growing Water Classification. Quality of Water in Storage. Quality of Water Supplies. Algal Toxins in Water. Dose-Response of Mussels to Chlorine. Metallothioneins as Indicators of Trace Metal Pollution. Amphipod Sediment Toxicity Tests. Lead and its Health Effects. Development and Application of Sediment. Toxicity Test for Regulatory Purposes. Water Resource Development and Management. Water Resources Challenges in the Arab World. Effluent Water Regulations in Arid Lands. Lessons from the Rising Caspian. Institutional Aspects of Water Management in China. Water and Coastal Resources. Water Use Conservation and Efficiency. The Development of American Water Resources: Planners, Politicians, and Constitutional Interpretation. Transaction Costs and Institutional Options. Water Supply and Water Resources: Drought in the Dust Bowl Years. Drought and Water Supply Management. The Expansion of Federal Water Projects. Flood Control History in the Netherlands. Food and Water in an Emergency. Water Science Glossary of Terms. Urban Water Resource and Management in Asia: Ho Chi Minh City. Hydropower-Energy from Moving Water. Water Markets in India: Economic and Institutional Aspects. Water Resources of India. Overview and Trends in the International Water Market. Best Management Practices for Water Resources. Management of Water Resources for Drought Conditions. Transboundary Water Conflicts in the Nile Basin. Planning and Managing Water Infrastructure. Application of the Precautionary Principle to Water Science. Water Managed in the Public Trust. Water Recycling and Reuse: State and Regional Water Supply. River Basin Decisions Support Systems. Sustainable Management of Natural Resources. Water Use in the United States. Water-Here, There, and Everywhere in Canada. A Spatial Framework for Environmental Management. Flood of Portals on Water. Participatory Multicriteria Flood Management.

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Emerging Organic Pollutants in Waste Waters and Sludge, Volume 1 has 1 rating and 0 reviews. Over the past fifteen years regulatory agencies have relied.

Senior Scientist, Chief Scientist, present Dr. Pignatello leads the Environmental Chemistry group, which conducts research in several areas in the environmental chemistry of pollutants and the chemistry of natural processes, including: Their research covers both fundamental and applied aspects, and deals with a diversity of agrochemicals, legacy and emerging organic contaminants, and excess nutrients. Biodegradation of fumigants in soil and groundwater. Solvent extraction techniques for determining volatile organic compound and pesticide concentrations in soil. Field and laboratory studies to determine the causes of sequestration of pesticides and other chemicals in soil. Mechanistic modeling of sorption by soil organic matter. Rates of sorption and desorption in soil. Advanced oxidation process especially the Fenton reaction for degrading pesticides and many other types of compounds in soil and water. Driving forces controlling sorption of organic compounds to natural organic matter and pyrogenic carbons, including special interactions, application of a glassy polymer model to soil organic matter, and the causes of sorption hysteresis and irreversibility. Spectroscopic characterization of natural organic matter and chars. The chemistry of peroxide-based advanced oxidation processes AOPs for treating wastewaters. Sunlight-driven photolysis of organic pollutants and dissolved organic matter in marine and estuarine waters with emphasis on the influence of water chemistry. Bioavailability of pollutants sorbed to environmental black carbon particles. Electron-transfer and nucleophilic reactions mediated by pyrogenic carbons. Interactions between engineered nanoparticles and biochar particles. Trapping and degradation of fumigant emissions. Its research covers both fundamental and applied aspects of these areas, and deals with a diversity of compounds within the categories of legacy pollutants, emerging pollutants such as endocrine disrupting compounds and pharmaceuticals, and nanomaterials. Many of the projects are collaborative with individuals at CAES, Federal research laboratories, American and foreign universities, and private industry. Below is a brief description of current projects in the group. Adsorption of contaminants to pyrogenic carbons. Pyrogenic carbons include natural chars, biochars, activated carbons, and related models such as graphite, graphene, and carbon nanotubes. The group is investigating novel interactions of organic compounds on their surfaces, including, i formation of exceptionally strong hydrogen bonds with ionizable contaminants e. Carbons have a long history of use as adsorbents in water purification and sediment stabilization. We are modifying carbon structure and surface functionality to enhance binding capacity or to catalyze desired reactions with adsorbed pollutants. In addition, we are investigating the inherent reactivity of pyrogenic carbons to bring about hydrolytic, nucleophiic, free radical, and electron-transfer reactions of sorbed contaminants. Potential roles for biochar in environmental management. Biochar is the carbonaceous byproduct of anoxic pyrolysis of biomass waste that has potential beneficial applications as a soil amendment in agriculture and environmental remediation, partially as a consequence of its strong adsorptive properties. We are tailoring biochars with superior ability to capture nutrient ions in animal wastes into less leachable forms. We are studying the use of biochar to remediate marine and land spills of crude oil, relying on its efficient absorption of crude and its ability to stimulate microbial activity. And we are investigating the interaction of nitrous oxide with biochar following reports that biochare inhibits emissions of the potent greenhouse and ozone-depleting gas, nitrous oxide, in soil. Advanced oxidation processes for treating contaminated water. We are designing carbonaceous or inorganic nano-scale catalysts and photocatalyst for peroxides activation. Our emphasis is on the kinetics and mechanisms of these reactions, with special concern for the effects of water chemistry, since many treatable waters contain high levels of dissolved substances. Hydrogen bonds between weak acid groups with similar pKa values can be much stronger and shorter than ordinary hydrogen bonds. We are examining whether such bonds play a role in bonding between soil organic matter molecules or strands, between SOM and pyrogenic carbons, and between

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SOM and natural and anthropogenic inorganic weak acids. Recent publications available from the author, Joseph. Processes and Impacts, ; DOI: Pignatello, Science of The Total Environment, , Environmental, , Mitch, and Wenqing Xu, Environ. Degradation of p-Nitrophenol by Lignin and Cellulose Chars: Mann, and Joseph J. Hu, and Paulo J. Ferreira, Sci Rep-Uk, 7 1: Exposure of agricultural crops to nanoparticle CeO2 in biochar-amended soil, Alia D. Bioaccumulation of nanoparticle CeO2 by earthworms in biochar amended soil, Alia D. Pignatello, and Jason C. White, Scientific Reports, 7: Yanyan Zhang, Joseph J. Environmental fate of the fungicide metalaxyl in soil amended with composted olive-mill waste and its biochar: White, Environmental Science and Technology, Interactions of Triazine Herbicides with Biochar: Pignatello, and William A. Pignatello, Jun Ma, and William A. Mitch, Water Research, Influence of salinity on triplet-state natural organic matter loss by energy transfer and electron transfer pathways, Kimberly M. The role of black carbon conductivity in mediating hexahydro-1,3,5-trinitro-1,3,5-triazine RDX degradation on carbon surfaces by nucleophilic substitution in the presence of sulfides, W. Characterization of oil shale, isolated kerogen, and post-pyrolysis residues using advanced 13C solid-state nuclear magnetic resonance spectroscopy, Xiaoyan Cao, Justin E. Dynamic interactions of natural organic matter and organic compounds, J. Soils and Sediments, Chappell, Na Chen, Lesley F. Sorbic acid as a quantitative probe for the formation, scavenging and steady-state concentrations of the triplet-excited state of organic compounds, J. Mitch, Water Research, 45 Pignatello, Plant Disease Effect of halide ions and carbonates on organic contaminant degradation by hydroxyl radical-based advanced oxidation processes, Janel E. Katz, and Hui Li; J.

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The current volumes, 5/I and 5/O in the Handbook of Environmental Chemistry Series, cover the analytical, toxicological and environmental issues of unregulated contaminants including surfactants, pharmaceuticals and personal care products (PPCP), and gasoline additives, among priority pollutants identified by US and European environmental authorities.

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