Particulate Matter Affecting Air, Water, and Soil Quality

The availability and transport of nutrients, greenhouse gases, and toxic contaminants in agricultural systems depends on interactions with particulate matter (such as organic matter, silt, clay, microbes, and nanoparticles). These dynamics are critical to agricultural sustainability, environmental health, food safety, and climate change.

Scientists from land-grant universities in multiple states are working together to better understand the properties of particulates, how they behave and move through soil, air, and water, and how they affect agricultural production, air quality, human health, and climate over time and space. To do this, researchers are designing and using state of the art tools for molecular and microscopic analysis and conducting field studies. Better tools and information will help scientists, farmers, and regulators design, implement, and regulate agricultural systems that protect the human and environmental health without impairing production or the economy.

Particulate matter characteristics vary from area to area. Working across state borders allows researchers to address particulate matter in a comprehensive way. Working together also allows members to share cutting-edge tools and facilities as well as samples and data, making the work less expensive. Diverse expertise enables the team to use a variety of techniques for more thorough analysis.

Project Funding & Participation

This project, NC1187: The Chemical and Physical Nature of Particulate Matter Affecting Air, Water and Soil Quality (2015-2020), was funded in part by the Multistate Research Fund through USDA-NIFA and by grants to project members at participating institutions: Auburn University, University of California-Berkeley, University of Delaware, University of Idaho, University of Illinois, Kansas State University, Michigan State University, University of Missouri, Rutgers University, Texas A&M University, Virginia Tech University. In 2020, this project was renewed through 2025. Additional participants include University of Nebraska and University of Wisconsin.

Learn more: bit.ly/NC-1187

RESEARCH HIGHLIGHTS

Research on how soil structure affects the movement of water, gases, and chemicals is helping guide soil management practices. For example, University of Missouri scientists used tomographic imaging to show that cover crops increase levels of soil macropores and improve water transport, providing evidence to support state cost-share investments for cover crops. A Virginia Tech study found that precipitation has more impact than temperature on the composition of soil amino acids, which provide essential plant nutrition. Rutgers University showed that increased concentrations of atmospheric CO_2 could lead to changes in soil structure.

Research is helping develop better crop fertilization and irrigation practices that maximize yields while minimizing soil and water contamination from excess nutrients. University of Delaware scientists tested novel techniques using X-ray fluorescence and absorption to identify specific forms of phosphorus in soils. This will help scientists accurately predict the amount of phosphorus that will be transported to surface waters. University of Illinois looked at the impact of extreme weather conditions, like drought, on phosphorus loss. Long-term University of Idaho studies are helping confined animal feeding operations develop evidence-based waste management plans that reduce nutrient runoff. Using X-ray techniques, Kansas State University identified new fertilizer enhancement products and formulations that will make phosphorus and micronutrients more available to plants in various soil types. Increased uptake efficiency allows farmers to reduce total fertilizer application rates.

Research illuminated ways to improve water quality and reuse wastewater. University of Illinois scientists took more accurate measurements of the toxicity and transport of mercury in aquatic ecosystems. Researchers at Michigan State University identified factors that influence the levels of pharmaceutical residues in water, soil, and crops. Kansas State University advanced the use of anaerobic membrane bioreactors and microbial reverse electrodialysis cells to remove harmful substances from wastewater. University of Illinois studies found a way to make nitrate adhere to clay minerals so it can be more easily removed from water. Michigan State University showed that magnetite nanoparticles can help remove arsenic and biochar can filter antibiotics from contaminated water. Virginia Tech University used clay minerals saturated with iron ions to deactivate harmful microorganisms.

Research is improving soil quality by improving techniques for calculating and removing toxic metals from soils. Researchers measured uptake of cadmium by Pacific Northwest wheat (University of Idaho), cadmium availability in Ecuadorian cacao soils (Kansas State University), and arsenic availability in treated soils (Texas A&M University). University of Delaware demonstrated that sea level rise could speed up arsenic release from coastal soils. Washington State University showed that water and air flow can dislodge fluoranthene, a common industrial chemical, from soil particles.

Biochar is a charcoal-like particulate created by heating organic material like crop residues, woodchips, and manures. Research is guiding production and use of biochars. Washington State University analyzed how source material and firing temperature affect biochar water retention. Michigan State University showed that biochar can immobilize organic pollutants in soils to decrease their uptake by crops and their release to bodies of water. Auburn University studies suggest testing the polycyclic aromatic hydrocarbon (PAH) concentration of biochar before adding it to vegetable crop soils to reduce plant uptake and human health risks associated with PAH.

University of California scientists are developing new instruments and analysis techniques that will provide new insights into the sources and chemistry of atmospheric aerosols and the role they play in global climate and regional air pollution. So far, researchers have conducted field studies in California, the southeastern US, and the Brazilian Amazon. These insights help create models of human impacts on climate and help government agencies and others develop evidence-based pollution reduction policy and climate change mitigation strategies.

Researchers are assessing the potential health risks of nanotechnology, providing data manufacturers can use to make products safer. For example, Rutgers University showed that wearing nanotechnology-enabled clothing could release nanoparticles into the air where they could be inhaled and affect health.

In addition to sharing research results at well-attended national meetings, in widely cited journals, and through Extension materials and activities, group members prepared the next generation of agricultural and environmental scientists by providing hands-on laboratory research experience and training for high school and college students and giving graduate students experience with novel techniques and tools at large national and international laboratories.