**2022 Annual Meeting Report**

**Basic Information**

**Project No. and Title: NC1187: Particulate Reactivity and Cycling in a Changing Environment: Implications for Agriculture and Human Health**

**Period Covered: 10/01/2021 to 09/30/2022**

**Date of Report: 01/11/2023**

**Annual Meeting Dates: 11/07/2022 to 11/07/2022 (in person at Baltimore Convention Center, Baltimore, MD and virtual)**

**Participants**

Gloria Ambrowiak, Stephen Anderson, Francisco J. Arriaga, Tala Awada, Yucheng Feng, Jorge Guzman, Ganga Hettiarachchi, Eric Norland, Angela Possinger, Donald Sparks, Daniel G. Strawn, Joseph W. Stucki, Wei Zhang.

**Brief Summary of Minutes of Annual Meeting**

The group welcomed the new administrative advisor (Dr. Tala Awada). Dr. Awada gave a brief remark and the NIFA representative Dr. Eric Norland provided an update from NIFA. The group discussed extensively on planning of a workshop in conjunction with 2023 annual meeting at Brookhaven National Laboratory (BNL). For the meeting to take place on site at BNL, at least 9 months ahead of the meeting time will be needed to complete the application and approval by BNL. One alternative is to hold the meeting at a hotel off site near BNL and a facility tour could be scheduled at BNL. The meeting will feature a few invited speakers and short talks from our group members. The meeting will be open to students and early career researchers. An organizing committee is formed and is composed of Ganga Hettiarachchi (joined after the annual meeting), Angela Possinger, Donald Sparks, Daniel Strawn, Joseph Stucki, and Wei Zhang. The organizing committee will meet and plan for the meeting and provide timely update to the group.

All participants provided brief summary and update of research activities during last year. Additionally, our group members were active in organizing sessions in the ASA-CSSA-SSSA International Annual Meeting. The group decided to postpone the application of multi-state project research award to next year.

**Accomplishments**

The investigators of this multistate research project are committed to basic and applied research on physical, chemical, and biological processes in soils, as well as meaningful outreach activities in order to enhance agricultural productivity and protecting human and ecosystem health. In the past year the investigators studied the role of climate change (particularly flooding and sea level rise) on the cycling of contaminants and nutrients (P and N) in coastal soils, the effect of soil compaction on soil structure, processes and speciation of heavy metals in soils, speciation, bioavailability, and transport of P in soils, wind soil erosion, formation mechanisms of soil pore structure and its role in protecting soil organic matter, recovery of portable water and valuable nutrients from wastewater sources, and environmental processes and impacts of emerging contaminants (e.g., silver nanoparticles, per and polyfluoroalkyl substances [PFAS], pharmaceuticals, and prions) in soil, water, and plant systems, using a multitude of spectroscopic, molecular, experimental, and computational methods. The results suggest that sea level rise-induced flooding can increase the release of contaminants not only during erosion events but over longer timescales. This discovered release mechanism can contribute to improving the risk assessment of coastal water pollution under the influence of climate change and sea level rise. The mineralogical composition of the soils in the northern parts of the US Midwest developed on glacial deposits (Alfisols, Spodosols, Entisols) plays an important role in formation of soil pore structure and its role in protecting soil organic matter. Fundamental knowledge on P speciation, bioavailability, and transport help better utilize P fertilizers while avoiding the excess loss of P to water bodies. Improved understanding on environmental processes of conventional and emerging contaminants is important to remediating soil pollution and ensure water quality and food safety. Development of technology in reclaiming water from wastewater sources is key to agricultural water sustainability.

In terms of multi-state collaborative activities, Michigan State University and University of Illinois collaborated on joint analyses of soil pore structure with X-ray computed micro-tomography and soil mineralogy characterization via X-ray diffraction. Kansas State University and Texas A&M University collaborated on collection of STXM-NEXAFS data from several Martian analogs at the Canadian Light Source (CLS), Saskatoon, Canada. Michigan State University and Creighton University collaborated on investigating the environmental persistence, bioavailability, and infectivity of prions in soil and water systems. A session (Assessing Soil Pore Structure and Linking It to Microscale Processes ) was organized by our group members in the 2022 annual meeting of the Soil Science Society of America.

More State-specific research activities are detailed below.

At the University of Delaware, the Sparks Group continues to focus on the role of climate change, particularly, flooding and sea level rise, on the cycling of contaminants and nutrients (P and N) in coastal soils. Marginalized communities are coping with increasing flooding in areas where soils are contaminated with legacy pollutants such as arsenic and chromium. In the Mid-Atlantic region farmers are observing more salinization of soils along estuaries which is having a deleterious impact on plant growth.

Sea-level rise (SLR) has a vital influence on coastal hydrogeological systems, biogeochemical processes, and the fate of coastal contaminants. However, the effects of SLR-induced perturbations on the mobilization of coastal pollutants are not fully understood. In a recent study, the impact of SLR-induced flooding on the concentration and speciation of arsenic and selected hazardous chemicals was investigated using exceedingly contaminated sediments (5–6% As) collected from an urban coastal site in Wilmington, DE, USA which is populated by people of low socio-economic status. The release of contaminants from sediments was monitored before, during, and after flooding with different intensities (bottom shear stresses) through laboratory-based erosion chamber experiments. Significantly increased release of As (up to 150%) and NO3 (up to 50%) from sediments at shear stress levels typically measured in estuaries were found. The release of toxic chemicals from contaminated coastal sediments is thus not restricted to extreme flooding events but can occur throughout the year. The results also suggest that the dissolved concentrations of pollutants continue to be considerably high even after the flooding. SLR-induced flooding can hence increase the release of contaminants not only during erosion events but over longer timescales. The release mechanism proposed here contributes to improving the risk assessment of coastal water pollution as climate change and SLR continue to occur.

Repeated manure additions containing P in excess of crop needs have led to many agricultural soils with high levels of soil P (i.e., legacy P), particularly in the Delmarva region (USA). Due to the potential for P release, it is important to gain a better understanding of the mechanisms of P desorption and solubilization. Agricultural soils with high legacy P were collected from the Delmarva Peninsula, and soil P pools were determined using a suite of wet chemical and spectroscopic techniques, including a modified Hedley sequential extraction and X-ray absorption near-edge structure (XANES) spectroscopy. Five different desorption solutions were used to investigate P removal efficiency to assess release mechanisms. The results indicate that sulfate can have a stronger competition for P desorption than silicate, especially in the ditch sample with 21% labile P and 44% P adsorbed to iron and aluminum (via Hedley extraction). Additionally, linear combination fitting results of the ditch sample indicate 10.5% organic P and 73.9% P associated with iron and aluminum. This is an important finding because sulfate is a prevalent ion in sea water, and many agricultural soils with high legacy P in the Delmarva coastal area are threatened by sea level rise and inundation.

At University of Missouri Dr. Stephen Anderson’s group investigated the effect of soil compaction on soil structure, which affects water, heat, and gas exchange as well as root penetration and crop production. The objective of this study was to use X-ray computed microtomography (CMT) techniques to compare differences in geometrical soil pore parameters as influenced by compaction of two different aggregate size classes. Sieved (diameter < 2 mm and < 0.5 mm) and repacked (1.51 and 1.72 g m−3 ) Hamra soil cores of 5 by 5 mm (average porosities were 0.44 and 0.35) were imaged at 9.6 µm resolution at the Argonne Advanced Photon Source (synchrotron facility) using X-ray CMT. Images of 58.9 mm3 volume were analyzed using 3-Dimensional Medial Axis (3-DMA) software. Geometrical characteristics of the spatial distributions of pore structures (pore radii, volume, connectivity, path length, and tortuosity) were numerically investigated. Results show that the coordination number (CN) distribution and path length (PL) measured from the medial axis were reasonably fit by exponential relationships P(CN) = 10−CN/Co and P(PL) = 10−PL/PLo, respectively, where Co and PLo are the corresponding characteristic constants. Compaction reduced porosity, average pore size, number of pores, and characteristic constants. The average pore radii (63.7 and 61 µm; p < 0.04), largest pore volume (1.58 and 0.58 mm3 ; p = 0.06), number of pores (55 and 50; p = 0.09), and characteristic coordination number (3.74 and 3.94; p = 0.02) were significantly different between the low-density than the high-density treatment. Aggregate size also influenced measured geometrical pore parameters. This analytical technique provides a tool for assessing changes in soil pores that affect hydraulic properties and thereby provides information to assist in assessment of soil management systems.

Other studies at University of Missouri investigated the effects of land use management in the Missouri River floodplain on greenhouse gas emissions and soil microbial diversity, the performance of commercially-available planter-mounted sensors for estimating soil organic matter, the effects of incorporating soil health indicators with established phosphorus and potassium fertilizer recommendations for corn production, and the effects of vegetative buffers on adsorption of fluorescence labelled E. coli.

Dr. Anderson have been training 7 PhD students during past year with 4 PhD students completed the degrees during the year. The State of Missouri is investing more than $40 million per year in cost-share with farmers and ranchers to use cover crops to improve long-term soil health for enhanced crop production and to prevent soil erosion. Current research with tomographic imaging has shown increased levels of soil macropores and improved water transport with cover crop management compared to traditional management.

At University of Illinois, Dr. Yuji Arai’s group was dedicated to design and develop the prototype of the wind erosion and soil particle collectors for the field experiments in winter/spring. Our audiences will be educated in the important application of modern techniques to study the important soil nutrient transformation and translocation in agricultural systems affected by wind erosion. Dr. Joseph Stucki investigated redox-activated smectites as agents for scrubbing undesirable pollutants such as nitrate from aqueous solutions. Flow-through reactors are important devices for remediating large volumes of contaminated water, but the utility of redox-activated smectites in such systems is hindered by the very slow flow rates that happen because of the compaction of the clay (collapse of superimposed clay layers one upon the other), plugging the pores of filters. One possible way to overcome this problem is to prevent the compaction by irreversibly separating the clay layers by placing a pillar between them, thus increasing their particle size and porosity while preserving the high surface area of the clay. The objectives of the present study, therefore, were (1) to pillar Wyoming montmorillonite (Mnt) with Fe(III) and determine the optimum level of pillaring, (2) to reduce Fe from its 3+ state (Fe(III)) to its 2+ state (Fe(II)) in both the Mnt structure and in the pillar, and (3) to test the reactivity with nitrate in aqueous solution. Measurements using X-ray diffraction and X-ray fluorescence analysis confirmed that the pillaring technique succeeded in establishing pillars between the Mnt layers at levels of 0, 5, 10, and 15 mmole Fe/g Mnt. Chemical analysis also confirmed that the valence of the Fe was 3+, i.e. Fe(III). The pillars definitely increased the particle size of the Mnt. The surface charge of the pillared clays was calculated from the zeta potential, and the amount of nitrate adsorbed increased as the surface charge became more positive. Preliminary experiments also showed that the Fe(III) in the pillars could be reduced to the 2+ valence (Fe(II)), which should then enable the reduced, pillared Mnt to destroy nitrate by changing it to nitrogen gas or ammonium.

At Kansas State University, Dr. Hettiarachchi’s group collaborated with a team of researchers at the College of Engineering (Dr. Prathap Parameswaran and his team in the KSU Civil Engineering Department) to test the hypothesis that innovative wastewater treatment technologies can produce potable water from different sources (municipal or livestock wastewaters such as swine wastewater) while recovering nutrients and producing soil amendments for crop production and protecting the environment. The technology used was an anaerobic membrane bioreactors (AnMBR). The research is the first to demonstrate a new platform strategy to sequester nutrients (primarily ammonia-N and inorganic-P) from AnMBR treated swine wastewater in the form of a variety of tailored Recovered Nutrient Products, or RNPs (vivianite-like, hydroxyapatite-like, struvite - like) that are available for plant uptake under specific soil conditions (as shown by wet chemical analysis and XANES speciation), along with the production of high quality water that meets American National standards Institute (ANSI) reuse standards for potential in-situ utilization.

Kansas State University team employed synchrotron-based micro-scale X-ray techniques (µ-XRF, µ-XRD and µ-XANES) to investigate the effects of P-based soil amendments on contaminated soils with trace elements from El Paso, TX. Soils were alkaline or alkaline/mildly calcareous. An improved understanding of the fundamental mechanisms responsible for reductions in bioaccessibility will help determine under which circumstances particular P source(s) can reduce bioaccessibility of potentially toxic trace elements in situ. This information is crucial for designing effective in situ soil amendments.

X-ray amorphous phases have been inferred in all samples analyzed by the CheMin X-ray Diffractometer onboard the Mars Science Laboratory rover in Gale Crater. Although quantitation of amorphous phases using methods such as full-pattern quantitative X-ray diffraction (FULLPAT) and Rietveld refinement have been enhanced by constraining diffraction measurements with chemical mass balance calculations, analysis of natural samples are challenging because they are complex mixtures that produce averaged signals. This requires many standards and is difficult to model with typical spectroscopic techniques. The soft X-ray techniques such as STXM-NEXAFS (spectromicroscopy) enable simultaneous, spatially resolved speciation of lower energy Si, Al, and heavier elements (Fe). With Dr. Paul Schwab’s group, Dr. Hettiarachchi completed the collection of STXM-NEXAFS data from several Martian analogs at the Canadian Light Source (CLS), Saskatoon, Canada in the year 2022. This analysis will facilitate the synthesis of Martian soil analogues of the crystalline minerals and amorphous phases observed on Mars.

At Michigan State University (MSU) Dr. Wei Zhang’s group focused on studying the fate and transport of environmental contaminants in soil, water, and plant systems. Specifically, his group studied the interactions of infectious proteinaceous particles (prions, new groups of emerging contaminants) with soil geosorbents. This study aimed to understand environmental behaviors of chronic wasting disease prions and to develop novel cost-effective mitigation strategies. Molecular dynamics simulation was used to understand the interactions of amino acids and eventually peptides, poly peptides, and prions with aromatic carbon surfaces. The group investigated the foliar uptake of silver nanoparticles, the behaviors of silver nanoparticles in fresh produce washing water, and the effectiveness of washing practices in removing silver nanoparticles sorbed on lettuce leaves. The group also collaborated with Columbia University to develop the machine learning models to predict the plant uptake of organic contaminants, the chemical exotoxcity, and the pesticide dissipation in plants. Dr. Alexandra Kravchenko’s group collaborated with colleagues from the University of Illinois in assessing the role of soil physical and mineralogical characteristics on the micro-scale processes of soil carbon protection and accrual. Dr. Pentrak from the University of Illinois conducted X-ray diffraction analyses for the general mineralogy and clay mineralogy assessment of multiple soils representative of six experimental sites in Michigan and Wisconsin. The results will be combined with X-ray computed tomography analyses of the same soils conducted at MSU, along with their soil C and microbial biomass characterizations. PhD student Mr. Jin Ho Lee, at MSU, has reported the preliminary results at an international meeting and is currently preparing a manuscript summarizing the findings.

At the University of Idaho, Dr. Strawn worked on technology to remove P and N from dairy wastewaters and test the efficacy of the recovered nutrients for use as a beneficial soil amendment. By recycling phosphorus from waste streams, the mined phosphorus life-cycle loop will be closed. This will make phosphorus use more sustainable and reduce its loss to surface waters where it degrades water quality. The P was recovered from the wastewater on biochar and amended to soils in a greenhouse growth trail. Samples were analyzed for P speciation using selective extractions, P-NMR spectroscopy, X-ray spectroscopy (conducted at the Canadian Light Source and Stanford Synchrotron Radiation Laboratory (SSRL)). Results were compiled in a Master of Science Thesis and are being prepared for publication.

**Impacts**

The work at University of Delaware advanced the understanding of the mobility of contaminants in coastal soils subjected to flooding and sea level rise, related to climate change, which can provide valuable risk assessment data to protect human health. The use of tools such as chemical extractions coupled with state-of-the-art synchrotron-based techniques provides unique information on the fate of nutrient cycling in coastal soils subjected to the impacts of climate change.

University of Missouri developed a tool for assessing changes in soil pores that affect hydraulic properties and thereby provides information to assist in assessment of soil management systems. The efforts to incorporate perennial management systems in the Missouri River Floodplains will help increase organic matter content, which stimulates microbial diversity and soil enzyme activity as well as improving the performance of conservation buffers. The work on planter-mounted sensors provide insight into commercial sensor performance, repeatability, and potential for agronomic utility. Groundwork is needed to connect soil health with agronomic outcomes to support on-farm soil health interpretations. The study on the effects of vegetative buffers on adsorption of E. coli provided insights in understanding of adsorption of E. coliO157:H7-GFP under different management practices and demonstrated that the agroforestry buffer system practices can help in enhancing both soil and water quality.

The work at University of Illinois helps multistate members and scientific community members access and use advanced molecular and microscopic tools. The work also helps develop sample preparation methods used in pure systems for advanced molecular and microscopic analysis of soil-plant-water and air systems so that fundamental information on these complex systems can be discovered. The work advanced the frontiers of clay science and could help develop a filtration system with good flow rates and high redox reactivity with nitrate, which will provide more options for purifying drinking water while also decreasing environmental contamination.

The pilot-scale AnMBR at the K-State swine teaching and research unit was successfully started to treat swine lagoon wastewater achieving around 70% COD removal efficiency. Preliminary results also indicate that calcium phosphate-based Recovered Nutrient Products offer tunable plant availability as a function of soil pH and crystallinity and purity of the product. Collaboration between Kansas State University and Texas A&M University led to the development of soft X-ray techniques for simultaneous, spatially resolved speciation of Si, Al, and Fe, which will facilitate the synthesis of Martian soil analogues and contribute the Mars expedition mission.

Collaboration developed between Michigan State University and University of Illinois pursued joint analyses of soil pore structure via X-ray computed micro-tomography and soil mineralogy characterization via X-ray diffraction.

Collaboration between Michigan State University of Creighton University advanced the understanding on prion interactions with soil matrices and the persistence, bioavailability, and infectivity of prions in the environment, which could help understand prion disease ecology in wildlife and develop scientifically-sound mitigation strategy.

**Outputs**

**Publications**

**Peer-reviewed:**

1. Izaditame, F., Siebecker, M. G., & Sparks, D. L. 2022. Sea-level-rise- inducedflooding drives arsenic release from coastal sediments. Journal of HazardousMaterials, 423, 127161. <https://doi.org/10.1016/j.jhazmat.2021.127161>
2. Szerlag, Kathryn, Monica Elvarthi, Matthew G. Siebecker, Chunhao Gu, Conner McCrone, and Donald L. Sparks. 2022. Systematic study of legacy phosphorus (P) desorption mechanisms in high-P agricultural soils. Minerals. <https://doi.org/10.3390/min12040458>
3. Blanco, H., S. Kumar and S.H. Anderson. 2022. Soil hydrology in a changing climate. 262 pp. Australian Commonwealth Scientific and Industrial Research Organization Publishing, Clayton South, Victoria, Australia.
4. Alagele, S.M., S.H. Anderson, and R.P. Udawatta. 2022. Conservation buffers and soil water. pp. 133-156. In H. Blanco, S. Kumar, and S.H. Anderson (eds.) Soil Hydrology in a Changing Climate. Australian Commonwealth Scientific and Industrial Research Organization Publishing, Clayton South, Victoria, Australia.
5. Kumar, S., P. Chakraborty, and S.H. Anderson. 2022. X-ray computed tomography for studying solute transport in soils. In S.J. Mooney, I. Young, R. Heck, and S. Peth (eds.) X-Ray Imaging of the Soil Porous Architecture. Springer Nature, Wien, Austria (in press).
6. Udawatta, R.P., S.H. Anderson, and R.J. Kremer. 2022. Agroforestry for soil health. pp. 355-386. In H.E. Garrett, S. Jose, and M.A. Gold (eds.) North American Agroforestry: An Integrated Science and Practice (3rd Edition). American Society of Agronomy. Madison, Wisconsin.
7. Al-Awwal, N., M. Masjedi, M. El-Dweik, S.H. Anderson, and J. Ansari. 2022. Nanoparticle immune-fluorescent probes as a method for detection of viable E. coliO157:H7. J. of Microbiological Methods 193:106403. <https://doi.org/10.1016/j.mimet.2021.106403>.
8. Chakraborty, P., N. Singh, S. Bansal, U. Sekaran, P. Sexton, A. Bly, S.H. Anderson, and S. Kumar. 2022. Does the duration of no-till implementation influence depth distribution of soil organic carbon, hydro-physical properties, and CT-measured pore characteristics? Soil and Tillage Research 222:Article 105426 (pp. 1-13).
9. Conway, L.S., K.A. Sudduth, N.R. Kitchen, S.H. Anderson, K.S. Veum, and D.B. Myers. 2022. Soil organic matter prediction with benchtop and implement-mounted optical reflectance sensing approaches. Soil Sci. Soc. Am. J. 86:(in press).
10. Haruna, S.I., and S.H. Anderson. 2022. Influence of no-till cover crop management on soil thermal properties. In S. Jayaraman and R.C. Dalal (ed.) No-Till Farming: Prospects and Challenges – Productivity, Soil Health and Ecosystem Services Special Issue. Soil Research 60:580-589.
11. Mendis, S.S., R.P. Udawatta, S.H. Anderson, J. Ansari, and M. Salceda. 2022. Effects of cover crops on soil thermal properties of a corn cropping system. Soil Sci. Soc. Am. J. 86:1194-1205.
12. Mendis, S.S., R.P. Udawatta, S.H. Anderson, K.A. Nelson, and R.L. Cordsiemon. 2022. Effects of cover crops on soil moisture dynamics of a corn cropping system. Soil Security 8:100072. https://doi.org/10.1016/j.soisec.2022.100072
13. Mingyuan, J., M.C. Fleetwood, S.H. Anderson, and X. Xiong. 2022. Wetting agent effects on plant available water for hydrophobic USGA root zones. Agricultural Research and Technology: Open Access J. 2022; 27 (1): 556360. DOI: 10.19080/ARTOAJ.2022.27.556360
14. Rankoth, L.M., R.P. Udawatta., C.J. Gantzer, and S.H. Anderson. 2022. Cover crop effects on mCT-measured geometrical pore characteristics. Agrosystems, Geosciences & Environment 5:e20284. <https://doi.org/10.1002/agg2.20284>
15. Svedin, J.D., K.S. Veum, C.J. Ransom, N.R. Kitchen, and S.H. Anderson. 2022. An identified agronomic interpretation for potassium permanganate oxidizable carbon. Soil Sci. Soc. Am. J. 86:(in press).
16. Svedin, J.D., N.R. Kitchen, C.J. Ransom, K.S. Veum, and S.H. Anderson. 2022. Can soil biology tests improve phosphorus and potassium corn fertilizer recommendations? Agron. J. 114:(in press).
17. Veum, K.S., S.M. Zuber, C.J. Ransom, R.L. Myers, N.R. Kitchen, and S.H. Anderson. 2022. Reduced tillage and rotational diversity improve soil health in Missouri. Agron. J. 114:3027-3039.
18. Li, Y., Livi, K.J.T., Arenberg, M.R., Xu, S., Arai, Y. 2021. Depth sequence distribution of water-extractable colloidal phosphorus and phosphorus speciation in intensively managed agricultural soils. Chemosphere. 286, 131665.
19. Xu, S. and Arai, Y. 2022. Competitive sorption and accumulation of organic phosphorus in phosphate-rich soils and sediments. Advances in Agronomy. vol. 173. 38, 337-374.
20. Xu, S., Martin, N.F., Matthews, J.W. and Arai, Y. 2022. Accumulation and release of organic phosphorus (P) from legacy P-affected soils to adjacent drainage water. Environmental Science and Pollution Research. 22, 29, 33885-33899.
21. Xu, S., and Arai, Y. 2022. Adsorption mechanisms of inositol hexakisphosphate in the presence of phosphate at the amorphous aluminum oxyhydroxide-water interface. Science of the Total Environment. 837, 155525.
22. Kannan, A., J. Dillavou, K.H.H. Gamage, G.M. Hettiarachchi, and P. Parameswaran. 2023. Recovery of high-quality Calcium phosphate fertilizer products from anaerobic membrane bioreactor treated swine wastewater. Chem. Eng. J. 453, 139539 (published online Oct. 2022)
23. Gutiérrez, E., E. Chávez, K. H.H. Gamage, D. Argüello, M. B. Galkaduwa, and G.M. Hettiarachchi. 2022. Cadmium fractionation in soils affected by organic matter application: Transfer of cadmium to cacao (Theobroma cacao L.) tissues. Front. Environ. Sci. 19 Sep. 2022. <https://doi.org/10.3389/fenvs.2022.954521>.
24. Attanayake, C.A., D. Kumaragamage, G. Amarawansha, G. M. Hettiarachchi, S. P. Indraratne, and D. M. Goltz. Phosphorus release and speciation in manganese(iv) oxide and zeolite-amended flooded soils. Environ. Sci. Technol. 56: 8082-8093. <https://doi.org/10.1021/acs.est.2c01185>
25. Obeng, A. B., M. Del Rio, C. Costa, C. Chavarria, C. Rodriguez, M. B. Galkaduwa, C. Wekumbura, K. Gamage, G. M. Hettiarachchi, W. Hargrove, and C. Sobin. 2022. Validity of a portable X-ray fluorescence device for analyzing field dust wipe samples for lead. Int. J. Environ. Sci. Technol. <https://doi.org/10.1007/s13762-021-03898-8>.
26. Hu, X., Y. Zhang, Z. Chen, Y. Gao, B. Teppen, S.A. Boyd, W. Zhang, J.M. Tiedje, and H. Li. 2023. Tetracycline accumulation in biofilms enhances the selection pressure on Escherichia coli for expression of antibiotic resistance. Science of the Total Environment, 857, 159441. DOI: 10.1016/j.scitotenv.2022.159441.
27. Li, Y., J.B. Sallach, W. Zhang, S.A. Boyd, and H. Li. 2022. Characterization of plant accumulation of pharmaceuticals from soils with their concentration in soil pore water. Environmental Science & Technology, 56(13), 9346–9355. DOI: 10.1021/acs.est.2c00303.
28. Gunathilaka, G.U., J. He, H. Li, W. Zhang, and E.T. Ryser. 2022. Behavior of silver nanoparticles in chlorinated lettuce wash water. Journal of Food Protection, 85(7), 1061–1068. DOI: 10.4315/JFP-22-018.
29. Shen, Y., E. Zhao, W. Zhang, A.A. Baccarellia, and F. Gao. 2022. Predicting pesticide dissipation half-life intervals in plants with machine learning models. Journal of Hazardous Materials, 436, 129177. DOI: 10.1016/j.jhazmat.2022.129177.
30. Chen, Z., L. Yin, W. Zhang, A. Peng, J.B. Sallach, Y. Luo, and H. Li. 2022. NaCl salinity enhances tetracycline bioavailability to Escherichia coli on agar surfaces. Chemosphere, 302, 134921. DOI: 10.1016/j.chemosphere.2022.134921.
31. Gao, F., W. Zhang, A.A. Baccarelli, and Y. Shen. 2022. Predicting chemical ecotoxicity by learning latent space chemical representations. Environment International, 163, 107224. DOI: 10.1016/j.envint.2022.107224.
32. Wang, W., G. Rhodes, W. Zhang, X. Yu, B.J. Teppen, and H. Li. 2022. Implication of cation-bridging interaction contribution to sorption of perfluoroalkyl carboxylic acids by soils. Chemosphere, 290, 133224. DOI: 10.1016/j.chemosphere.2021.133224.
33. Gao, F., Y. Shen, J.B. Sallach, H. Li, W. Zhang, Y. Li, and C. Liu. 2022. Predicting crop root concentration factors of organic contaminants with machine learning models. Journal of Hazardous Materials, 424, 127437. DOI: 10.1016/j.jhazmat.2021.127437.
34. He, J., L. Zhang, S.Y. He, E.T. Ryser, H. Li, and W. Zhang. 2022. Stomata facilitate foliar sorption of silver nanoparticles by Arabidopsis thaliana. Environmental Pollution, 292, 118448. DOI: 10.1016/j.envpol.2021.118448.
35. Taslakyan, L., Baker, M. C., Shrestha, D. S., Strawn, D. G., & Möller, G. (2022). CO2e footprint and eco-impact of ultralow phosphorus removal by hydrous ferric oxide reactive filtration: A municipal wastewater LCA case study. Water Environment Research, 94( 8), e10777.
36. Yang, R.; Liang, X.; D.G. Strawn. 2022. Variability in Cadmium Uptake in Common Wheat under Cadmium Stress: Impact of Genetic Variation and Silicon Supplementation. Agriculture 2022, 12, 848.
37. Strawn, D. G., Mohotti, D., Carp, E., Liang, X., Chen, J., Schroeder, K., & Marshall, J. (2022). Cadmium concentrations in Idaho wheat grain and soil. Agrosystems, Geosciences & Environment, 5, e20288.

**Presentations/Abstracts:**

1. Sparks, D.L. 2022. The water, climate, soil, food nexus: Grand challenges in a changing environment. Combined Congress of South African Soil Science, Plenary Talk, South African Crop Science, and South African Horticulture Science Societies, Jan 25-27.
2. Sparks, D.L. 2022. Impact of redox dynamics on biogeochemical cycling of elements in a changing environment. Keynote Talk, Goldschmidt Conference, Honolulu, Hawaii, July 10-16.
3. Alagele, S., S.H. Anderson, and R. Udawatta. 2022. Long-term perennial management and cropping effects on soil microbial biomass for claypan landscapes. p. P-658. World Congress of Soil Science Book of Abstracts, 31 July – 5 August, Glasgow, Scotland.
4. Al-Awwal, N., S.H. Anderson, and M. El-Dweik. 2022. Selected conservation buffer systems effects on adsorption of fluorescent labeled E. coli. p. P-752A World Congress of Soil Science Book of Abstracts, 31 July – 5 August, Glasgow, Scotland.
5. Anderson, S.H., S. Zaibon, and A. Rachman. 2022. Vegetative buffer effects on soil structural assessed using water infiltration and tomography in selected landscapes p. P-523. World Congress of Soil Science Book of Abstracts, 31 July – 5 August, Glasgow, Scotland.
6. Ansari, J., S. Bardhan, F. Eivazi, and S.H. Anderson. Land management effects on soil enzyme activity and greenhouse gas emissions in the Missouri River Floodplain. p. P-724. World Congress of Soil Science Book of Abstracts, 31 July – 5 August, Glasgow, Scotland.
7. Udawatta, R., L. Rankoth, C.J. Gantzer, and S.H. Anderson. 2022. Cover crop effects on CT-measured geometrical pore characteristics. p. 486. World Congress of Soil Science Book of Abstracts, 31 July – 5 August, Glasgow, Scotland.
8. Conway, L.S., C.N. Vong, N.R. Kitchen, K.A. Sudduth, and S.H. Anderson. 2022. Predicting corn emergence rate with topgraphic features and on-the-go sensing technology. pp. 1-17. Proceedings of the 15th International Conference on Precision Agriculture, 26-29 June, Minneapolis, Minnesota.
9. Salceda, M., R.P. Udawatta, S.H. Anderson, and S.S. Mendis. 2022. Agroforestry buffers on nitrogen and phosphorus concentration in shallow groundwater on a hillslope. Abstracts of the 5th World Congress on Agroforestry. 17-20 July, Quebec City, Canada.
10. Gantzer, C.J., S.H. Anderson, and R. Reinbott. 2022. Sanborn Field long term findings: Soil erosion-soil water availability: Redux. p. 41. Soil and Water Conservation Society International Conference Abstracts, 31 July - 3 August. Denver, Colorado.
11. Al-Awwal, N., S.H. Anderson, and M. El-Dweik. 2022. Evaluation of adsorption processes of green fluorescent protein-expressing E. coli for selected buffer systems. 2022 American Society of Agronomy/Soil Science Society of America International Meeting Abstracts. 6-9 November, Baltimore, Maryland.
12. Anderson, S.H., L.M. Rankoth, and R.P. Udawatta. 2022. Micro-CT geometrical pore characteristics influenced by cover crops. 2022 American Society of Agronomy/Soil Science Society of America International Meeting Abstracts. 6-9 November, Baltimore, Maryland.
13. Ansari, J., S.H. Anderson, M.P. Davis, F. Eivazi, and S. Bardhan. 2022. Greenhouse gas emissions from conventional and alternate land use systems in floodplain soils. 2022 American Society of Agronomy/Soil Science Society of America International Meeting Abstracts. 6-9 November, Baltimore, Maryland.
14. Salceda, M., R.P. Udawatta, and S.H. Anderson. 2022. Trees and grasses on nitrogen concentration in shallow groundwater on a hillslope under grazing. 2022 American Society of Agronomy/Soil Science Society of America International Meeting Abstracts. 6-9 November, Baltimore, Maryland.
15. Svedin, J.D., N.R. Kitchen, K.S. Veum, C. Ransom, and S.H. Anderson. 2022. A proposed benchmark for interpreting potassium permanganate oxidizable carbon in Missouri corn systems. 2022 American Society of Agronomy/Soil Science Society of America International Meeting Abstracts. 6-9 November, Baltimore, Maryland.
16. Gutierrez, E.B., G.M. Hettiarachchi, E. Chavez, K.H.H. Gamage, M.B. Galkaduwa, and D. Arguello. 2022. Cadmium (Cd) fractionation in soils affected by organic matter application: Transfer of cadmium to cacao (Theobroma cacao L.) Tissues. ASA-CSSA-SSSA International Annual Meeting, Baltimore, MD. Nov. 6-9.
17. Gamage, K.H.H., G. M. Hettiarachchi, N.O. Nelson, K.L. Roozeboom, G.J. Kluitenberg and P.J. Tomlinson. 2022. Implications of management practices on sediment and soil phosphorus speciation in no-till corn and soybean rotation. ASA-CSSA-SSSA International Annual Meeting, Baltimore, MD. Nov. 6-9.
18. Gamage, K.H.H., G. M. Hettiarachchi, A.D. Kannan, and P. Parameswaran. 2022. “Green” P-based recovered nutrient products from swine wastewater: Fate and behavior in soils. ASA-CSSA-SSSA International Annual Meeting, Salt Lake City, Utah. Nov. 7-10.
19. Hettiarachchi, G.M., A. Roberts, and A. Bracker. 2022. Kansas City Soil Lead Study. Kansas Housing Conference, Wichita, KS, Aug. 30-Sep. 1.
20. Hettiarachchi, G.M., C. Wekumbura, K.G. Scheckel, A. Roberts, A. Bracker, E. Friedman, and C. Sobin. 2022. Reducing bioavailability of lead in urban residential neighborhood soils. 22nd World Congress of Soil Science, Glasgow, U.K., July 31- Aug. 5.
21. Lee, J. H. and A. N. Kravchenko. 2022. Organic carbon and pore characteristics in soils from restored prairie and monoculture switchgrass vegetation systems. The 8th International Symposium on Soil Organic Matter, Seoul, Korea.
22. Zhang, W. 2022. Mechanistic and machine learning of emerging contaminants in soil-water-plant systems. The 23rd Meeting of Soil Environment Committee of Soil Science Society of China and Symposium on Ecosystem Protection and High-Quality Development of Agricultural Land in the Yellow River Basin, Zhengzhou, China, August 12-14
23. Li, C., Y. Shen, T. Sotthiyapai, Y. Liu, L.K. Tiemann, S.I. Safferman, and W. Zhang. 2022. Effect of biosolids application on soil enzymatic activities, microbial biomass, and soil carbon mineralization. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD, November 6-9 (oral presentation).
24. Zhang, W., Y. Shen, and H. Li. 2022. Rhizosphere as a hotspot for contaminant interactions with plants and microorganisms. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD, November 6-9 (oral presentation).
25. Benedict, R.M., H. Li, J. Bartz, and W. Zhang. 2022. Exploring the effects of electrolytes on adsorption of amino acids to aromatic carbon materials. ACS National Meeting & Exposition, Chicago, IL, August 21-25 (poster presentation).
26. Banna, H., J. Siegenthaler, R. Benedict, W. Zhang, and W. Li. 2022. Heavy metal sensing in vegetable and soil solutions using carbon fiber electrode. Hilton Head Workshop 2022: A Solid-State Sensors, Actuators and Microsystems Workshop, Hilton Head Island, SC, June 5-9, 2022 (poster presentation).
27. Pentrak, M.P., Pentrak, L.A., and Stucki. J.W. 2022. Initial evidence for Fe(II)-pillared montmorillonite. 75th Jubilee Anniversary Meeting of the Clay Minerals Group of the Mineralogical Society of Great Britain and Ireland, London England, 25 May 2022.
28. Tietz, P., Strawn, D. G., Robichaud, P., & Brooks, E. (2022) Use of Hyperspectral Remote Sensing to Detect Forest Soil Phosphorus and Wildfire Ash Metal Content [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. <https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/142364>
29. Strawn, D.G., Kayler, G. Moller, M. Laan. 2022. Idaho Sustainable Initiative for Dairy (ISAID) annual meeting. 15 minute presentation to stakeholders and scientists. Phosphorus Speciation and Availability in Dairy-Amended Soils. October 7, 2022.
30. Peak, D., Zuin, L., Strawn, D. G., Chavez, C., & Bulmer, D. (2022) New Advances in Phosphorous Speciation Using L-Edge XANES [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/146342

**Training:**

The KSU team held a Soil Kitchen event in Oklahoma City, OK on August 13, Scissortail Park Farmers Market as part of preconference events, 2023 National Brownfields Conference. Soil samples were analyzed for lead using a portable-XRF.