2022 Shale Network Workshop

Abstracts

ABSTRACTS FOR ORAL PRESENTATIONS

Abandoned and orphaned oil and gas wells: well data, methane emissions, and broader environmental impacts

Mary Kang (McGill University)

Millions of oil and gas wells exist across the United States and abroad as legacies of the 160-year history of oil and gas production. Many of these wells are no longer in production and have been abandoned with technologies and practices of the time. Numerous studies show that abandoned and orphaned oil and gas wells are emitting methane to the atmosphere and likely contributing to broad environmental impacts to groundwater, soils, and ecosystems. In this talk, I will present data on abandoned and orphaned oil and gas wells, including field measurements of methane emissions, and discuss strategies for mitigating environmental impacts of abandoned and orphaned wells.

Large dataset investigation of groundwater contamination where unconventional gas development overlaps with extensive prior hydrocarbon extraction

Samuel Shaheen (Penn State, Dept. of Geosciences)
Tao Wen (Syracuse University)
Alison Herman (Penn State University)
Susan Brantley (Penn State University)

Many studies on the impacts of unconventional oil and gas development (UOGD) on water resources have primarily focused on regions, such as northeastern Pennsylvania (NEPA), in which UOGD was not predated by extensive legacy hydrocarbon extraction. Here we investigated whether contamination may be more common where UOGD overlaps with extensive coal and conventional oil and gas extraction using a dataset of ~7,000 groundwater analyses from southwestern Pennsylvania (SWPA). Corroborating the hypothesis, we discovered small, statistically significant regional correlations between proximity to UOGD and groundwater concentrations of chloride ([Cl]), strontium, and barium where legacy extraction was extremely dense (SWPA), but no such correlation where it was minimal (NEPA). However, no regional correlation was detected for methane concentrations, [CH4], in SWPA, suggesting legacy extraction of shallow gas in SWPA may have lessened gas leakage during UOGD. We identify hotspots where [Cl] and [CH4] increase by 3.4 mg/L and 1.2 mg/L, respectively, per UOG well drilled in SWPA. If the [Cl] correlations document contamination via brines leaked from wellbores, impoundments, or spills, we calculate that concentrations of some elements such as thallium could approach or exceed EPA limits in the most densely developed hotspots based on known compositions of UOGD produced waters. This could pose a potential human health risk.

Herculean Task: Residents Getting Regulators to Listen

Matthew Kelso (FracTracker Alliance)

Oil and gas development is a highly technical industry and the potential impacts to nearby residents are both numerous and varied. Theoretically, such concerns are evaluated and arbitrated by local, state, and federal authorities, but the burden of proof of harm or potential harm often falls onto neighbors most affected by these industrial activities. This talk explores how residents have to become educated in a variety of fields including chemistry, geology, medicine, and law in order to effectively communicate with regulators.

Surface Water Impacts and Data Gaps

Christian Leuz (University of Chicago Booth School of Business)

The impact of unconventional oil and gas development on water quality is a major environmental concern. We analyze surface water impact combining surface water measurements and geo-coded data on horizontally drilled wells stimulated by hydraulic fracturing (HF). We show that unconventional oil and gas development is related to increased salt concentrations in surface waters in many watersheds and across several U.S. shales. The concentration increases associated with new HF wells are small in magnitude but statistically significant for barium, chloride and strontium, though not bromide. All four ions show larger, but still small-in-magnitude increases 91-180 days after well spudding. Impact estimates are also more pronounced for wells with larger amounts of produced water, wells located over high-salinity formations, and wells closer and likely upstream from water monitors.

Our large-scale, statistical approach was constrained by the ions included in public databases as well as the sparsity of water quality data. The former means we could not examine other analytes in HF fluids or produced water that are potentially more dangerous than salts. The latter implies that we could not perform more granular analyses that would better identify the mechanism. Our analysis highlights that investigations of surface water impacts from unconventional O&G development would be greatly facilitated if there were more targeted water measurements of relevant analytes in close proximity to and timed around the development of new HF wells.

Evaluating the Impact of Oil and Gas Wastewater Dumps in the Permian Basin on Soil Biogeochemistry

Dr. Denise M. Akob (U.S. Geological Survey)
Dr. Mark A. Engle (University of Texas at El Paso)
Dr. Douglas. B. Kent (U.S. Geological Survey)
Ms. Terry Gregston (Bureau of Land Management)
Ms. Mitra Kashani (U.S. Geological Survey)
Dr. Isabelle Cozzarelli (U.S. Geological Survey)
Dr. Matthew Varonka (U.S. Geological Survey)

The Permian Basin, straddling New Mexico and Texas, is one of the most productive oil and gas (OG) provinces in the United States, and OG production yields large volumes of wastewater. Unpermitted OG wastewater dumping is occurring in southeastern New Mexico releasing ~4,000 barrels of fluid onto desert soils. Here, we evaluated the effects of unpermitted releases of OG wastewater on arid soils in southeastern New Mexico. Soil geochemistry and microbial communities differed between sites affected by OG wastewater releases compared to unaffected soil samples. The geochemistry of affected samples reflected the residual salts and hydrocarbons left behind by the OG wastewater release (e.g., enriched in sodium (Na), chloride (Cl), bromide (Br), and percent carbon). Microbial communities in OG wastewater affected soils had significantly lower diversity and differences in phylogenetic composition. This study elucidated changes in arid soil geochemistry and ecological responses of desert soil microorganisms due to OG wastewater exposure.

Methane emissions from the natural gas supply chain: Toward transparent monitoring and understanding

Kenneth Davis (Penn State University)

Methane, a potent greenhouse gas, is released to the atmosphere when oil and natural gas are extracted from the earth. Mitigation of greenhouse gas emissions requires quantification and understanding of these emissions. Atmospheric monitoring is needed to guide climate management, as emissions inventories have repeatedly been shown to underestimate emissions by an amount that is very significant for the purposes of climate management. What atmospheric monitoring methods are available? What technologies are emerging? What monitoring networks exist? What monitoring needs are well-served? Where are the gaps? I will present a brief synthesis of atmospheric monitoring methods and results, and provide my answers to these questions.

Shale Gas Development: Community-Focused Health Impacts and Solution

Alison Steele (Environmental Health Project)

This presentation will elevate health concerns EHP has frequently heard from frontline community residents over the past decade and place them in the context of both the sizeable body of research conducted regarding various health outcomes associated with shale gas development and the actions taken (or not taken) by the shale gas industry and the Pennsylvania government. Content will conclude with a look forward at potential community-informed, community-focused solutions that can help reduce health risks associated with the shale gas industry.

Wastewater Management

Amanda Veazey (Seneca Resources Company, LLC)

This presentation will discuss the evolution of wastewater management in the unconventional gas industry over the past decade.

Well Plugging

Harry Wise (PA Department of Environmental Protection)

On Monday, November 15, 2021, President Biden signed the federal Infrastructure Investment and Jobs Act (IIJA) into law. The IIJA allocates more than $1 trillion to advance various infrastructure projects across the nation. Among other things, this legislation has the potential to provide $400 million to Pennsylvania to plug abandoned and orphan (AO) oil and gas wells across the Commonwealth over the next 10 years. DEP welcomes well plugging opportunities associated with the IIJA.

The 2012 Oil and Gas Act (58 Pa.C.S. §§ 3201-3274) authorizes DEP to plug AO wells. DEP recognizes that plugging AO oil and gas wells is an important step toward not only addressing these historic potential risks to public health, public safety and the environment. Prior to the passage of IIJA, available funding under the 2012 Oil and Gas Act has limited well plugging activities for AO wells over the past several years.

Decommissioning Orphaned Oil & Gas Wells in Appalachia: A Contractor's Perspective

Luke Plants (Plants & Goodwin)

Decommissioning Orphaned Oil & Gas Wells in Appalachia: A Contractor's Perspective
Summary: Many orphaned wells have been abandoned for decades and now present unique P&A challenges compared to wells that have been recently abandoned. The Appalachian Basin magnifies the uniqueness of these challenges due to access constraints, downhole complications, and a challenging regulatory environment. This talk will discuss three key challenges in the Appalachian Basin from a contractor's perspective.

Carbon Wildcatting

Curtis Shuck (Well Done Foundation)

Lessons learned by the Well Done Foundation from locating, qualifying, monitoring, plugging and restoring the impacted surface areas of orphaned and abandoned oil & gas wells across the United States.

Shale and Renewable Energy Intersections

Dave Yoxtheimer (Penn State Marcellus Center for Outreach and Research)

Pennsylvania has experienced significant shale energy development over the last 15 years and is currently experiencing a solar energy boom. This presentation will provide an overview of the current amounts of shale and renewable energy being generated in Pennsylvania, their projected future growth, and opportunities for reducing our energy footprint while increasing energy security and grid reliability.

Is Pennsylvania Ready for RGGI? Economic, health, and political implications of joining the Regional Greenhouse Gas Initiatives

Emily Pakhtigian (Penn State University)

In 2005, seven northeastern states announced a framework for developing the Regional Greenhouse Gas Initiative (RGGI)—the first mandatory cap and trade program to reduce greenhouse gas emissions from the power sector in the United States. Since its inception, RGGI has expanded to include 11 states and has successfully implemented four emissions control periods; during these periods, power sector emissions have declined in RGGI states by 36 percent. On April 22, 2022, Pennsylvania became RGGI's newest, and largest emissions-generating, member. Despite the projected health and climate benefits of reduced emissions from the power sector cited as rationale for joining RGGI, the multi-year process Pennsylvania has undertaken to officially become part of this regional initiative has been fraught with political opposition and concerns about the possible consequences for Pennsylvania's economy and costs for energy consumers. In this session, we will discuss the potential economic and health impacts of Pennsylvania joining RGGI and the ongoing political and legal barriers to Pennsylvania's complete participation in this cap-and-trade program.

Environmental Justice

Justin Dula (PA Department of Environmental Protection, Office of Environmental Justice)

This talk will provide an overview of Pennsylvania's environmental justice policy, which will have just completed a public comment period on May 11 and is in review.

Methane Emissions from Unconventional Natural Gas Production in the Marcellus Shale

Longxiang Li (Harvard T.H. Chan School of Public Health)
Francesca Dominici (Harvard T. H. Chan School of Public Health)
Annelise J. Blomberg (Lund University; Harvard T.H. Chan School of Public Health)
Falco J. Bargagli-Stoffi (Harvard T. H. Chan School of Public Health)
Joel D. Schwartz (Harvard T.H. Chan School of Public Health)
Brent A. Coull (Harvard T.H. Chan School of Public Health)
John D. Spengler (Harvard T.H. Chan School of Public Health)
Yaguang Wei (Harvard T.H. Chan School of Public Health)
Joy Lawrence (Harvard T.H. Chan School of Public Health)
Petros Koutrakis (Harvard T.H. Chan School of Public Health)

Little is known about whether exposure to unconventional oil and gas development (UOGD) is associated with higher mortality risks in the elderly and whether related air pollutants are exposure pathways. We found that both living proximity to and downwind to UOGD wells were associated with a higher risk of all-cause mortality in Medicare beneficiaries, a national cohort. Our findings suggest primary air pollutants from UOGD wells are part of the exposure pathway.

ABSTRACTS FOR POSTER PRESENTATIONS

Environmental Health and Justice Impacts of Steam Cracker Facilities

Nicholaus P. Johnson (Yale School of Public Health)
Michelle L. Bell (Yale School of the Environment; Yale School of Public Health)
Robert Dubrow (Yale School of Public Health; Yale Center on Climate Change and Health)
Nicole C. Deziel (Yale School of Public Health; Yale Center on Climate Change and Health)

Background/Aim: Steam crackers (SCs) convert gas feedstocks into ethylene and propylene (the building blocks of plastics) at high temperatures and release toxic/carcinogenic chemicals and greenhouse gases (GHGs). The recent shale gas boom in the United States (US) has incentivized the expansion of SCs, but analyses of their potential environmental health and justice impacts are limited. We described SC operations, constructed a US SC emissions inventory, and evaluated socioeconomic characteristics of populations residing in proximity to SCs.

Methods: We searched peer-reviewed and gray literature to describe SC operations. We constructed an inventory using publicly available datasets from industry, government, and non-governmental sources. We used descriptive statistics and data visualization to summarize air, land, and water emissions from the US Environmental Protection Agency's (EPA's) Toxic Release Inventory (TRI) and EPA's GHG Reporting Program. We compared population characteristics from US Census block groups (BGs) less than versus greater than 5km of an SC, within counties with a SC.

Results: SC operations include: (1) pyrolysis, (2) quenching, (3) compression, cooling, and drying, and (4) fractionation. Major toxic emission sources include furnaces, fugitive emissions, and flaring. We identified 32 SC facilities across five states, with most in the Gulf Coast of Texas and Louisiana. TRI chemicals with the highest self-reported cumulative air-emission volumes from 1987-2019 were: ethylene, propylene, hydrochloric acid, benzene, n-hexane, 1,3-butadiene, ammonia, toluene, vinyl acetate, and methanol. SC facilities emitted >650 million metric tons (carbon dioxide equivalents) of GHGs in total from 2010-2019. We found that 752,465 people live in census BGs within 5km of an SC. BGs closer to SCs had higher proportions of residents who were Black, had non-professional occupations, lower educational attainment, and lower median household income.

Conclusion: SC operations have the potential for adverse human health impacts and environmental inequities, underscoring the need for additional research on hazards of petrochemical infrastructure.

Modeling clay mineral-carbon interactions in freshwater wetland soil at Presque Isle State Park

Lorena Tribe (Penn State Berks)
Lisa Emili (Penn State Altoona)
Sarah Allen (Penn State Altoona)
Anthony Foyle (Penn State Erie)
Tami Mysliwiec (Penn State Berks)
Shirley Clark (Penn State Harrisburg)

An understanding of the physico-chemical parameters impacting SOC stock and spatial distribution in freshwater coastal wetlands is a critical component in the sustainable management of these systems for the mitigation of climate change influencing carbon cycling. The Freshwater Environmental and Ecosystem Research Group at Penn State is providing data to further the understanding of the carbon sequestration potential of riparian soils and sediments in coastal environments. Our specific research objective is to determine the relative importance of soil physico-chemical condition versus hydrogeomorphic setting to the chemical nature and spatial distribution of SOC in a coastal riparian ecosystem. In this work, we present models of CO2 adsorption to clusters representing both Kaolinite (a non-swelling clay) and Montmorillonite (a swelling clay). In addition to the dry surfaces, models with a progressively increasing number of water molecules were prepared until a monolayer of hydration was achieved. The interaction energies were established and the results were analyzed both to determine trends based on the degree of humidity of the environment and to contrast the differences due to the nature of the clays.

Internalizing Externalities: Disclosure Regulation for Hydraulic Fracturing, Drilling Activity and Water Quality

Pietro Bonetti (IESE Business School)
Christian Leuz (University of Chicago & NBER)
Giovanna Michelon (University of Bristol)

The rise of shale gas and tight oil development has triggered a major debate about hydraulic fracturing (HF). In an effort to mitigate risks from HF in unconventional development, many U.S. states have introduced disclosure mandates for HF fluids. In this paper, we study the effects of this important regulatory initiative on HF activity and its environmental impact. We find significant improvements in water quality, examining salts that are considered signatures for HF impact, after the disclosure mandates are introduced. We document effects along the extensive margin (less HF activity) and the intensive margin (less per-HF well impact). Most of the improvement comes from the intensive margin. Supporting this interpretation, we find that, after the introduction of disclosure, operators pollute less per unit of production, use fewer toxic chemicals, and that there are fewer spills related to the handling of HF fluids and wastewater. We also explore possible mechanisms through which disclosure regulation can be effective and find that public pressure likely plays an important role. Taken together, our empirical assessment of a major regulatory initiative for HF provides novel evidence on how disclosure mandates can help to internalize negative and fairly widespread external effects. JEL classification: D62, G38, K22, K32, L71, L72, M41, M48, Q53
Key Words: Environmental regulation, Real effects, Transparency, Water pollution, Sustainability, Corporate Social Responsibility, Externalities, Unconventional oil & gas development, Fracking

Evaluating the Impacts of Unconventional Oil and Gas Drilling on Water Quality in Rural Area with Mixed Land Uses

Tao Wen (Syracuse University)

The rapid growth of unconventional oil and gas development (UOGD) over the last decade has sparked widespread public concern over groundwater quality and potential human health consequences, particularly among rural residents who rely on domestic wells for drinking water. Elevated salt content and methane (CH4) levels in groundwater have been the most prominent UOGD-related impairments, with methane being the most widely studied of the two. However, attributing these contaminants to UOGD can be problematic, especially in mixed-land-use settings. This study uses a large hydrogeochemistry dataset collected from four sources, which comprises 16 geochemical analytes for 17,794 groundwater samples in rural northern Appalachia, i.e. 19 counties on the Pennsylvania (UOGD is allowed) and New York (UOGD is banned) border. We applied statistical (non-parametric test Wilcoxon Mann Whitney or WMW; Principal Component Analysis or PCA; Non-negative Matrix Factorization or NMF) and geospatial (Sliding Window Geospatial Tool or SWGT) analyses to investigate the potential sources of inorganic solutes and methane in groundwater. UOGD counties had greater Cl and CH4 concentrations than non-UOGD counties, according to WMW. Furthermore, Fe and Mn concentrations rise from non-UOGD to UOGD counties, but sulfate concentrations decline. Appalachian Basin Brine (ABB) is the primary source of salinity in New York and Pennsylvania, with septic effluent serving as a secondary source of salinity in NY waters. Road salting and spills have been identified as potential sources of high chloride levels in the region, according to geospatial analysis.

Community-Based Participatory Research for Low-Cost Air Pollution Monitoring in the Wake of Unconventional Oil and Gas Development in the Ohio River Valley - Empowering Impacted Residents through Community Science

Dr. Yuri Gorby (FreshWater Accountability Project)

Belmont County, Ohio is heavily dominated by unconventional oil and gas development (UOGD) that results in high levels of ambient air pollution. Residents here chose to work with a national volunteer network to develop a method of participatory science to answer questions about the association between impact on the health of their community and pollution exposure from the many industrial point sources in the county and surrounding area and river valley. After first directing their questions to the government agencies responsible for permitting and protecting public health, residents noted the lack of detailed data and understanding of the impact of these industries. These residents and environmental advocates are using the resulting science to open a dialogue with the EPA in hopes to ultimately collaboratively develop air quality standards that better protect public health. Results from comparing measurements from a citizen-led participatory low-cost, high-density air pollution sensor network of 35 particulate matter and 25 VOC sensors against regulatory monitors show low correlations consistently $R2 < 0.55$. This network analysis combined with complementary models of emission plumes are revealing the inadequacy of the sparse regulatory air pollution monitoring network in the area, and opening many avenues for public health officials to further verify people's experiences and act in the interest of residents' health with enforcement and informed permitting practices. Further, the collaborative best practices developed by this study serve as a launchpad for other community science efforts looking to monitor local air quality in response to industrial growth.

Carbon Wildcatting

Curtis E. Shuck, Jr. (Well Done Foundation, Inc.)

Lessons learned by the Well Done Foundation from locating, qualifying, monitoring, plugging and restoring the surface areas of orphaned and abandoned oil & gas wells across the United States

Publicly available data reveals association between asthma hospitalizations and unconventional natural gas development in Pennsylvania

Anna Bushong (Centre College; Purdue University; University of Pennsylvania)
Thomas McKeon (University of Pennsylvania; Temple University)
Mary Regina Boland (University of Pennsylvania; Temple University)
Jeffrey Field (University of Pennsylvania)

Since the early 2000s, unconventional natural gas development (UNGD) has rapidly grown throughout Pennsylvania. UNGD utilizes an extraction method known as hydraulic fracturing (HF), which has been linked with asthma exacerbations. We sought to reproduce and extend these studies using publicly available data. We used publicly available data because of the briefly adopted "secret science" rule by the Environmental Protection Agency (EPA), which prioritized scientific studies that made their data publicly available when formulating regulatory action. This rule (if adopted) would have deemphasized most literature on HF because reanalyzing the studies requires access to Protected Health Information (PHI). Using publicly available data from the Pennsylvania Department of Health (PA-DOH) and the Pennsylvania Department of Environmental Protection, we constructed regression models to study the previously observed correlation between asthma exacerbation and HF. These data are at the county-level and were reportedly observed between 2001-2014. After considering multicollinearity, county-level demographics and area-level covariables were included to account for known asthma risk factors. We found a significant positive correlation between the asthma Hospitalization Admission Rate (HAR) and annual well density for all the counties in the state (3% increase in HAR attributable to HF, $p<0.001$). For a sensitivity analysis, we excluded urban counties (urban counties have higher asthma exacerbations) and focused on rural counties for the years 2005-2014 and found a significant association (3.31% increase in HAR attributable to HF in rural counties, $p<0.001$). An even stronger association was found between asthma hospitalization admission rates (HAR) and PM2.5 levels (7.52% increase in HAR attributable to PM2.5, $p<0.001$). As expected, asthma HAR was significantly higher in urban compared to rural counties and showed a significant racial disparity. We conclude that publicly available data at the county-level supports an association between an increase in asthma HAR and UNGD in rural counties in Pennsylvania.

The quality and origin of fluids leaked into the surface casings of oil and gas wells in the Wattenberg Field of Colorado

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Well integrity issues are widespread in the Wattenberg Field of Colorado. To manage these issues, operators in the region are required to test the outermost (surface casing) annulus of their wells for sustained casing pressure (SCP) – a well integrity indicator that suggests either a flaw in an internal well barrier (e.g., cement) or fluid invasion into the well from an intermediate. When SCP exceeds specified levels, operators must sample the surface casing fluids – the analyses of which are compiled in a publicly accessible online database. We analyzed 2,443 gas and 956 liquid samples collected from 2,576 surface casings to assess the origin of SCP-causing fluids in the Wattenberg Field. Through local comparisons of potential gas sources, we identified the presence of reservoir gas in the surface casings of 93% of 1,104 wells with sufficient data available. Surface casing liquids were predominantly water with a geochemical signature similar to groundwater (15.9%) or another (75.9%) source. These findings suggest that while fluids from intermediate formations do invade surface casings in the Wattenberg Field, in most cases gaseous SCP occurs because of a compromised well barrier. We also provide rare insight into the quality and characteristics of surface casing fluids.

Efficacy of Dirt and Gravel Road Dust Suppressants

Andrew Eck (Penn State University)

Fugitive dust emissions from dirt and gravel roads are the largest source of particulate matter smaller than 10 microns (PM10) in the United States. This dust poses a threat to human and environmental health and requires suppression. Oil and gas produced waters (OGPW) can have similar chemistry to commercially available dust suppressant products and are an inexpensive or often free alternative to commercial products for road managers. Elevated concentrations of calcium and magnesium contribute to high total dissolved salt (TDS) content which is predictive of better performing brines. However high sodium content is predictive of increasing fine material dispersion and can drastically reduce dust suppression efficacy. Pennsylvania and 12 other states have regulated OGPW for use as dirt and gravel road dust suppressants even though research examining efficacy is limited.

A study of 12 OGPW (10 from conventional wells, two from unconventional wells), 5 commercial hygroscopic products (calcium and magnesium chloride salts), and 5 commercial solidifiers was performed to evaluate dust suppression efficacy and effect on roadbed stability. Dust suppression efficacy was tested with an aerosol monitor by tumbling treated disks of roadbed material in mechanical drum inside of a humidity-controlled chamber. Roadbed stability was evaluated by measuring total suspended solids in runoff from a treated model roadbed during a simulated rain event.
Though OGPW can share some chemical characteristics (Ca/Mg concentrations, TDS) with commercial products, their efficacy is often no better to slightly worse than untreated roads or those treated with water alone. All OGPW from the Appalachian basin performed significantly worse than the ten commercial products tested. OGPW treated roads also lost up to 15% more mass (100 kg more per mile) in simulated rain events than water-treated roads. The high ratio of sodium content found in OGPW from the Appalachian basin makes them ineffective dust suppressants that contribute to dustier and less-stable roads over time.

Giving a "Frack" about Pennsylvanians' Health: Asthma Exacerbation, Natural Gas Development, & Public Data

Gabriella Daza (University of Pennsylvania)
Siddhi Deshpande (University of Pennsylvania)

Since the early 2000s, unconventional natural gas development (UNGD) has rapidly grown throughout Pennsylvania. UNGD extracts natural gas using a relatively new method known as hydraulic fracturing (HF). Here we addressed the association of HF with asthma Hospitalization Admission Rates (HAR) using publicly available data. Using public county-level data from the Pennsylvania Department of Health (PA-DOH) and the Pennsylvania Department of Environmental Protection for the years 2001–2014, we constructed regression models to study the previously observed association between asthma exacerbation and HF. After considering multicollinearity, county-level demographics and area-level covariables were included to account for known asthma risk factors. We found a significant positive association between the asthma HAR and annual well density for all the counties in the state (3% increase in HAR attributable to HF, $p<0.001$). For a sensitivity analysis, we excluded urban counties (urban counties have higher asthma exacerbations) and focused on rural counties for the years 2005–2014 and found a significant association (3.31% increase in HAR attributable to HF in rural counties, $p<0.001$). An even stronger association was found between asthma hospitalization admission rates (HAR) and PM2.5 levels (7.52% increase in HAR attributable to PM2.5, $p<0.001$). As expected, asthma HAR was significantly higher in urban compared to rural counties and showed a significant racial disparity. We conclude that publicly available data at the county-level supports an association between an increase in asthma HAR and UNGD in rural counties in Pennsylvania.

Radium Bioaccumulation in Freshwater Mussels in the Allegheny River Catchment

Katharina Pankratz (Penn State University)
Nathaniel Warner (Penn State University)

Adult freshwater mussels, Eurynia Dilatata, were examined along the Allegheny River in Franklin, Pennsylvania to investigate whether centralized wastewater treatment facilities (CWT) accepting oil and gas (O&G) wastewater impact radium concentrations in mussel soft-tissue. O&G production generates billions of liters of wastewater each year. A portion of this wastewater is sent to CWT for treatment and disposal to surface water under NPDES permits. These discharges impact downstream water quality and sediment by increasing the concentration of radium to concentrations significantly higher than background levels. Increased radium concentrations could be dangerous for benthic organisms as radium is capable of bioaccumulating in plants and animals. One such species of benthic organism, freshwater mussels, are the most endangered wildlife in North America and have experienced high mortality rates downstream of O&G discharges in Pennsylvania even after large dilution effects. In this study, radium-226 and radium-228 was measured in streambed sediment and the soft-tissue of adult Eurynia Dilatata freshwater mussel samples collected upstream, downstream, and at a historical NPDES permitted facility in Franklin, PA. Both radium-226 and radium-228 were significantly higher ($p<0.05$) in downstream mussel tissue (mean = 3.52 pCi/g) and sediment (mean = 1.38 pCi/g) samples than background levels taken upstream (mean = 1.96; 0.90 pCi/g respectively). 228Ra/226Ra did not show the same significance, but averaged lower than background levels as well - suggesting the influence of O&G wastewater. These increased radium concentrations often exceed aquatic and drinking water thresholds and could have a negative impact on aquatic and human health, as well as damage food security. This project helps quantify the impact O&G wastewater disposal has on freshwater mussels proving they can bioaccumulate radium disposed to surface water. This can help inform better regulations in the future for its treatment and disposal.

Exposure to Unconventional Oil and Gas Development and All-cause Mortality in Medicare Beneficiaries

Presenter: Longxiang Li (Harvard T H Chan School of Public Health)

Little is known about whether exposure to unconventional oil and gas development is associated with higher mortality risks in the elderly and whether related air pollutants are exposure pathways. We studied a cohort of 15,198,496 Medicare beneficiaries (136,215,059 person-years) in all major U.S. unconventional exploration regions from 2001 to 2015. We gathered data from records of more than 2.5 million oil and gas wells. For each beneficiary's ZIP code of residence and year in the cohort, we calculated a proximity-based and a downwind-based pollutant exposure. We analyzed the data using two methods: Cox proportional hazards model and Difference-in-Differences. We found evidence of statistically significant higher mortality risk associated with living in proximity to and downwind of unconventional oil and gas wells. Our results suggest that primary air pollutants sourced from unconventional oil and gas exploration can be a major exposure pathway with adverse health effects in the elderly.

A novel approach to characterize exposures and health risks to communities surrounding oil and gas operations in Colorado: utilizing real-time handheld air quality monitoring and analytical air sampling methods

Alison Bamber (CTEH, LLC)
Michael Lumpkin (CTEH, LLC)
Tami McMullin (CTEH, LLC)

Recent legislation has placed public health at center stage in upstream oil and gas (OG) development (”fracking”) in Colorado (CO). A previous analysis of existing ambient air measurements and findings from a modeling study indicate estimated exposure of OG-related volatile organic compounds (VOCs) near OG operations are below levels expected to cause long-term health effects to people living near OG wellpads. However, there exists data gaps in our understanding of how site-specific activities (primarily during pre-production) could result in transient changes in air concentrations and potential acute and subchronic exposures. The objective of the present studies was to use an innovative approach partnering high-resolution real-time monitoring with analytical air sampling near well pads and the surrounding communities to characterize public health risks of OG-related VOCs, if any, during specific pre-production and production phases (drilling, hydraulic fracturing, flowback, production). Data were collected at 13 wellpads across the Northern Front Range and Western Slope. Approximately 24,000 real-time measurements of benzene, total VOCs, and other specific VOCs were collected in communities surrounding the wellpads during all operational phases. Concurrent with the real-time monitoring, over 650 analytical air samples were collected continuously for 24-hour intervals at locations surrounding the perimeters of the wellpads and within nearby communities. The analytical data were used to conduct a screening-level public health risk evaluation to determine whether exposure to the measured concentrations of individual/cumulative VOCs could pose acute or subchronic health hazards. Benzene was never detected in any real-time measurements and 98% of total VOCs were non-detects (< 1 ppb). In addition, all individual and cumulative analyte concentrations from 24-hour average VOC analytical samples were below applicable health screening levels. These study findings indicate that VOC emissions during discrete pre-production and production wellpad activities in CO are not expected to 1) result in off pad migration of VOCs, including benzene, at levels expected to cause acute adverse health effects and 2) cause acute or subchronic adverse health effects to a maximally exposed hypothetical individual living at the perimeter of a wellpad.

Use of benzene measurements to evaluate the role of setback distances to protect public health from oil and gas wellpad emissions in Colorado

Alison Bamber (CTEH, LLC)
Michael Lumpkin (CTEH, LLC)
Tami McMullin (CTEH, LLC)

Currently, state regulations in Colorado (CO) require that all new upstream oil and gas (OG) well or production facilities must be located between 500-2,000 feet from building units, depending on the building type. Previous published evaluations of ambient air data collected across Colorado since 2008 have indicated that OG operations OG related VOC levels measured in areas near OG pre-production and production activities were consistently below acute or chronic non-cancer and cancer health guideline values. The main data gaps identified in these assessments included 1) limited wellpad-specific data, especially during pre-production phases that can produce highly variable VOC emissions and 2) short duration air measurements used to assess acute health risks. Additionally, a pivotal modeling study conducted by the State of Colorado in 2019 estimated that maximum benzene concentrations could exceed acute health guideline values at distances up to 2,000 feet from a wellpad during different pre-production phases, with the greatest exceedances occurring during flowback. Since then, state and local public health agencies and operators have generated thousands of new data points collected at varying distances from specific wellpads during different pre-production activities (drilling, hydraulic fracturing, flowback). This study analyzed these new air data to estimate potential exposures and acute health risks of benzene as a function of distance from wellpads and distinct pre-production phases. Over 6,500 benzene measurements collected across 23 different wellpads during each pre-production phase were identified from these studies. The maximum benzene concentration across all samples was compared to acute guideline values. Apart from a single measurement at 1,100 feet from a wellpad during flowback, all benzene measurements were below acute guideline values. The data from this study provides important information for evaluating the role of setback distances in public health protection from upstream OG operations in CO.

Something in the Water? Exploring Uncertainty and Knowledge Gaps around Drinking Water Contamination from Unconventional Oil and Gas Drilling Development

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The lack of a scientific consensus on UOGD's potential to contaminate drinking water and its potential modes of contamination, combined with increasingly political valences to discourses surrounding scientific topics related to fossil fuels and their relationship to the economy and the environment has created a markedly uncertain and intense international debate. Little research has been done previously to articulate emergent gaps between different stakeholder groups' bodies of knowledge on UOGD and how those form amidst this uncertainty. This presentation will consist of preliminary results from this ongoing study centered in Washington County in Southwestern Pennsylvania, which then seeks to understand how different groups form their knowledge of this topic. It will focus on the first component of this study, which consisted of interviews with two groups of elite stakeholders:1. Representatives of NGOs that engage with water and environmental concerns in Southwest Pennsylvania and 2. Research Scientists studying the potential effects UOGD may have on water. Preliminary analyses, conducted via discourse analysis, indicate a few major themes, among others : 1. more concern about waste disposal and radiation was discussed by NGO representatives than by scientists, who tended to focus more on possible underground migration of contaminants; 2. Perceived lack of Industry disclosure of information is seen as significant by both groups, which leads to different speculative positions, 3. Government sources were important to both groups, for the information which they did and did not report. Thus it forms an important scientific "boundary object," setting the metabolism for localized discourse on UOGD and water. 4. The ends different stakeholders seek to achieve through their work, as well the sources of validation their claims demand, is highly important in determining what sort of information different actors seek, and how they will communicate their claims. This work aims to articulate a better understanding of political and scientific knowledge formation at the individual level and of how macro-political discourse and policy manifests at a local level around a controversial issue.