

UNIVERSITY OF PENNSYLVANIA

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DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCE

COLLEGE OF LIBERAL AND PROFESSIONAL STUDIES

MASTER OF SCIENCE IN APPLIED GEOSCIENCES



ENVIRONMENTAL GEOLOGY ABSTRACTS

ASSESSING THE IMPACT OF AGRICULTURAL MANAGEMENT ON SOIL HEALTH AND DROUGHT RESISTANCE

Abdelrahman Alfahham (2019)

Readers:

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In 1981, the Farming System Trial (FST) was established at the Rodale Institute to compare organic and conventional grain cropping management systems encompassing tillage/no-tillage and synthetic/organic nutrient inputs. During moderate to severe drought years between 1984 and 1999, Rodale FST scientists observed conventional corn and soybean yield lower than organic yields. This observation highlighted the improved ability of organically farmed soil to absorb water, retain water and resist drought. In 39 years of FST experimental history, this project is the first to comprehensively measure soil water retention, and hydraulic conductivity properties using modern sensors. The objectives of this project were to determine which agricultural management system improves soil health and develops drought resistance. Soil cores and composite samples were collected from six different agricultural treatments at three different depths (0 – 10 cm, 10 – 20 cm, and 20 – 30 cm). The treatments include conventional no-till, conventional till, organic manure no-till, organic manure till, organic legume no-till, and organic legume till. The samples were analyzed for organic carbon and nitrogen using dry combustion, soil water retention using the METER HYPROP and WP4C, and saturated hydraulic conductivity using the METER KSAT. Results have indicated statistically significant variability in soil organic carbon and nitrogen between three main treatments (organic manure, organic legume and conventional). The organic manure system consistently had higher organic carbon and nitrogen. However, the variability between till and no-till was not statistically significant. Additionally, a statistically significant interaction between treatment and tillage at 10 – 20 cm and 20 – 30 cm was observed with the C:N ratio results. Soil hydraulic conductivity results show statistically significant differences between organic and conventional treatments at the 10 – 20 cm depth and significant differences in till vs. no-till systems at 0 – 10 cm and 20 – 30 cm. The organic manure system had the highest saturated hydraulic conductivity values from 0 – 20 cm and the tilled system had the highest saturated hydraulic conductivity values from 0 – 20 cm. Comparative analysis of soil water retention and agricultural treatments showed far more complex relationships between soil water retention and soil texture, rock content, soil type, and soil organic carbon. Scientific analysis of long-term experiments comparing agricultural management systems provides important predictive tools for scientists, farmers, and consumers. Analytical investigations of FST will provide the blueprint for future farm and crop management recommendations, subsequently reinforcing a resilient farm agro-ecosystem.

OVERVIEW OF AMBIENT OUTDOOR RADON AND GAMMA LEVELS IN PENNSYLVANIA

Megan Harkins (2019)

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Radon is a radioactive gas that forms from the decay of uranium. This gas can move upwards through soil via cracks and pore spaces. Regions with high uranium content near the surface of the Earth's crust are regions that have high radon potential. Recently, there have been several residential locations documented in Pennsylvania with highly elevated levels of indoor radon. Regarding outdoor ambient levels, the data has been very limited. This study serves to evaluate outdoor ambient concentrations of radon and gamma dose levels. Alpha Track Detectors (ATDs), a device which measures radon concentrations, and Optically Stimulated Luminescent Devices (OSLs), a device which measures gamma dose rates, were utilized for this purpose. Duplicate sets of these monitoring devices were deployed throughout the state. These devices were set in place in an outdoor area, 4-6 feet above ground surface for approximately one year. After the one-year period, the devices were analyzed for radon concentrations and gamma dose rates. The ambient radon on average was 0.30pCi/L with a range of not significantly detectable to 1.72pCi/L. The ambient gamma dose rate on average was 85.88mRem/year with a range of 54.75mrem/year to 118.00mrem/year.

ADVANCED STATISTICAL TECHNIQUES FOR FORENSIC EVALUATION OF CONTAMINATED SEDIMENTS

Elle Anzinger (2018)

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Langan Engineering and Environmental Services was retained by a confidential client to conduct sediment investigations in a series of tidally-influenced basins with legacy contamination of metals in the Mid-Atlantic Region. Preliminary statistical analysis of historic sampling data and distribution patterns suggested that contamination in at least one of the areas was attributed to an off-site secondary source. Correlation analysis combined with principal components analysis (PCA) was performed to evaluate relationships between metals concentrations and sediment characteristics (percent water, total organic carbon and percent fines). One area of elevated concentration of lead was associated with a high intensity mixing zone of high and low salinity creek waters. In addition, underwater video surveys in this area revealed large amounts of debris and evidence of fishing activities. Sediments were collected using polycarbonate cores and divided into sample intervals with a maximum depth of five feet. A total of seven cores were collected from four tidal basins for this evaluation and analyzed for select metals (mercury, lead, chromium and zinc), total organic carbon (TOC), percent fines, and percent water. Analytical results were statistically compared to previous data collected on sediment chemistry and characteristics to ensure representative samples for each basin.

Advanced statistical analysis was conducted using Microsoft Excel 2010 and JMP 12.1.0 (JMP) by SAS. JMP was used for principal component analysis and other multivariate analyses to evaluate relationships between metals and visual impacts. The statistical approaches were helpful in identifying a secondary source of metal contamination in conjunction with visual impacts, in an area of elevated concentrations (AEC). Multiple lines of evidence in conjunction with the multivariate associations were consistent with the explanation of lead contamination from a separate source and likely coming from the closest tidal basin. The evaluation of the AEC was complicated by the mixing of higher saline waters introduced by tidal gates maintained in an open position. Additional contributions of metals to samples from the AEC may be due to fishing and other debris in the same area.

SWAN CREEK RESERVOIR INVESTIGATION

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Swan Creek Reservoir is 23 acres in area and located within West Amwell Township, New Jersey. The reservoir serves as a source of public drinking water for residents of the surrounding area and is owned and operated by SUEZ Water New Jersey Lambertville, a public water utility. Prior to distribution, SUEZ Water New Jersey Lambertville treats reservoir water to applicable drinking water standards. This project was an investigation of current phosphorus levels in the reservoir to aid in the future management of algal blooms within the reservoir. To investigate, a monthly sampling program was developed whereby water from below the surface of the reservoir was collected from four locations during January, February and March 2018. Water quality parameters were of interest and were recorded at each location for appearance, dissolved oxygen, pH, oxidation-reduction potential, specific conductivity, temperature and turbidity. Also, ammonia-N, chlorophyll *a*, nitrate-N, soluble reactive phosphorus, total dissolved phosphorus, total particulate phosphorus, total phosphorus and total suspended solids were of interest. All collected data was compared to applicable historic data made available by SUEZ Water New Jersey Lambertville with results showing that the reservoir is hypereutrophic, similar to other nearby water bodies. Additionally, total phosphorus levels were found to have increased over time in the reservoir, and as overland flow is a primary mechanism for phosphorus transport, it was predicted that phosphorus was being carried via overland flow from neighboring agricultural lands where phosphorus containing fertilizers may have been applied. Therefore, the uses of properties within or adjacent to the reservoir's approximately 690 acre watershed were examined. Information regarding these properties was reviewed from EDR, Inc., government databases, the New Jersey Department of Environmental Protection, StateInfoServices.com and West Amwell Township. This review, however, did not identify a source of phosphorus to the reservoir as the majority of surrounding land is either undisturbed woodland/wetland habitat or land utilized for farming on a small-scale.

USING GLOBAL CLIMATE MODELS TO SIMULATE FUTURE EXTREME PRECIPITATION TRENDS IN THE PACIFIC

Andrew Shannon (2018)

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Hawai'i and the U.S. Affiliated Pacific Islands (USAPI) comprise more than 2000 islands that are home to nearly 1.9 million people of diverse cultures. Physical geography (low elevation above present mean sea level) and limited economic resources (low adaptive capacity compared to more developed nations) make this region particularly vulnerable and exposed to climate and weather-related stressors. Precipitation can exacerbate such stressors, so researchers and regional decision makers are interested in understanding the projected trends of extreme rainfall for management planning. Pacific island populations are underrepresented in the existing literature on projections of precipitation extremes. This study addressed the gap in knowledge for this region and provided an initial climate outlook for changes in the magnitude and frequency of extreme rainfall at the end of the 21st century. Leveraging model outputs from the Coupled Model Intercomparison Project Phase 5 (CMIP5), this study extracted precipitation data for historical and high greenhouse gas emissions scenarios to measure changes from present to future time periods. While CMIP5 model outputs displayed spread in values at point locations, this study demonstrated the ability of CMIP5 models to produce regional trends. Near-equatorial regions generally displayed increases in extreme rainfall of up to 12% in magnitude and up to 6 days year⁻¹ in frequency from the end of the 20th Century to the end of the 21st Century. These results will help inform the decision making processes for adaptation and management programs as Pacific island populations plan for future climate.

SUSTAINABILITY ASSESSMENT IN WEST BENGAL, INDIA: EVALUATION OF VILLAGE ARSENIC REMOVAL AND SCHOOL WASH PROGRAMS

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Sustainability assessments provide data to evaluate project success and pinpoint weaknesses so targeted improvements of water, sanitation, and hygiene (WASH) development projects can be implemented. The primary challenge with other sustainability assessments is how to identify what poor performing program elements are most critical. This report discusses a new sustainability assessment, the top, average, poor (TAP) critical indicator framework, that was designed to identify critical elements that are indicators of poor performance. This simple, straight-forward framework first identified one top, average, and poor performing program based on infrastructure functionality. Next, all indicators for the three programs were graphed. The indicators that scored low for the poor program, but high for the top and average program indicated a program element that needed to be improved. During a two-week period in November 2016, 27 total village arsenic removal and school WASH programs were assessed in West Bengal, India across four sustainability categories; institutional, technical, financial and social.

In impoverished areas of West Bengal, drinking water from community tube-wells supply ground water contaminated with arsenic, putting millions at risk. Amal arsenic removal filters were designed in 1996 to reduce dangerous levels of arsenic, and were installed in over 150 villages, along with a programmatic framework for sustainability. The results of the assessment indicated that all of the units were operating correctly, but 31% of the programs were not changing the filter media on time, and 23% of the programs were not conducting monthly arsenic water tests. Therefore, the biggest challenge facing programs was timely media exchange and regular water testing.

Lack of WASH infrastructure and hygiene education in West Bengal results in poor child health. National and local NGOs implemented WASH programs in schools by building water supply systems, latrines, hand-wash and drinking water stations. The WASH infrastructure was built with a programmatic framework for sustainability in around 100 schools since the early 1990s. The results of the assessment indicated that students and teachers are very satisfied with the programs, but 36% of programs had broken WASH infrastructure. Therefore, the biggest challenge facing the programs was regular and timely repairs of WASH infrastructure.

The TAP critical indicator framework effectively identified elements that indicated poor performance and that should be improved in both development projects. The TAP critical indicator framework could be applied to other WASH development projects outside of West Bengal.

USING GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY TO ANALYZE THE SPATIAL DISTRIBUTION OF ABANDONED COAL MINES AND THEIR RISK OF MINE SUBSIDENCE AT A SITE IN SCRANTON, PENNSYLVANIA

Taunee Werts (2017)

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Scranton, Pennsylvania is known for having an historically rich history in the coal mining industry. There are approximately 184,000 acres of abandoned coal mines that currently exist in the Scranton area. The coal mines in the region were mined via the “room and pillar” method. This method of mining had left un-mined coal as the structural component, which keeps the mine ceiling from collapsing. Unfortunately, the remaining pillars, with the exception of mine edges that were often left in place, were removed by “retreat mining”. This method of mining can create dangerous mine subsidence occurrences. In early March, after a large rain event, the Study Site experienced such an event. Due to this event, the Study Site was chosen to be the focus of this study. After speaking with DEP officials, the veins of concern were determined. The veins of interest are the Diamond vein, Bottom Split Rock vein, and the Fourteen-foot vein. The corresponding mine maps were downloaded from the Pennsylvania Mine Atlas website and were used to identify the rooms and pillars that were causing the subsidence. Geographic Information Systems (GIS) was used to determine that spatial relationship between the Study Site and the remaining room and pillars. Once the room and pillars were identified they were extruded in three-dimensions in AcrScene to have a better understanding of the spatial relationship between the Study Site and the abandoned coal mines. Current mine subsidence at the Study Site coupled with the three-dimensional spatial analysis confirmed that the Study Site is impacted by several veins of abandoned coal mines.

ASSESSMENT OF THE U.S. FOREST SERVICE SOIL SAMPLING PROTOCOL FOR ESTIMATING TOTAL SOIL CARBON AND NITROGEN STOCKS

Lukas Jenkins (2016)

Readers:

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Alain Plante, Earth & Env Science, University of Pennsylvania

Practical assessment of The U.S. Forest Service Forest Health Monitoring (FHM) soil sampling protocol to accurately measure carbon and nitrogen stocks in thousands of forest plots across North America. Twelve established research plots in the French Creek Watershed, of Berks and Chester Counties in Pennsylvania, were revisited in order to obtain sufficient data to compare FHM soil cores to quantitative soil pits on the basis of estimation of bulk density, coarse fragment, and total carbon and nitrogen stocks. 50 x 50 cm quantitative soil pits were dug at each plot to a depth of 20cm. A soil core was taken from inside each soil pit prior to excavation as well as another soil core within 1m of the soil pit. Additionally, two plot level soil cores were taken on two sub plots to increase the data pool and capture potential variability. Utilizing the Bland-Altman technique the two soil sampling methods were compared for statistical agreement. The investigation also assessed metric variation at multiple soil sampling distances in an effort to determine the feasibility of the soil core method vs. quantitative soil pit for forest health monitoring.

THE USE OF REMOTE SENSING TECHNOLOGY TO DISCOVER GROUNDWATER IN TURKANA COUNTY, KENYA: ACHIEVEMENT OF NATIONAL PRIORITIES AND IMPLICATIONS FOR FURTHER RESEARCH

Katherine Harrelson (2015)

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Reduced water supplies coupled with increasing demand are putting a strain on global water supplies. Global warming further threatens water supplies by increased evaporation of surface water, increased occurrence and severity of floods. UNESCO recognized this crisis by issuing Millennium Development Goal Number 7, Target 10, which gives governments the mandate to reduce by half the percentage of the population without access to safe drinking water. In Kenya, water shortages amount to a humanitarian crisis. Turkana County, in northwest Kenya, is the driest county in the country, and its residents are some of the poorest. UNESCO's GRIDMAP division, in conjunction with the Government of Kenya and funded by the Government of Japan, in 2013 commissioned Radar Technologies International to complete a comprehensive, high tech survey of groundwater resources in this county. This survey utilized the latest technique in combining remote sensing data with existing data on hydrology and geology to create models of potential for groundwater occurrence. The models were then tested by collecting field data and field samples to verify the conclusions and developed into maps of groundwater occurrence.

The RTI report reveals the potential for five major aquifers in this desert county. However, the potential for groundwater needs to be verified with more field studies to conclude the extent of the aquifers and their mechanisms for recharge. Further field studies are needed to measure local precipitation, evapotranspiration, hydraulic conductivity and other recharge mechanisms in the survey area. Water quality measurements, such as pH, salinity, and total solids, need to be collected. Assumptions are already being made about the potential for safe yield from the aquifer based on assumed rates of recharge. However, recharge to an aquifer does not equate to safe yield, as recharge mechanisms are poorly understood and it is actually the discharge from an aquifer that should be considered for capture. A more thorough concept is sustainable yield, which is the amount of water that can be pumped after all ecological and hydraulic-cycle needs are accounted for. Further research and development is also needed to begin to address the question of sustainable development and appropriate use of this important resource, considering that this area is not only home to a significant cultural legacy, but also a rich biodiversity and is listed as a UNESCO World Heritage Site. However, the area may not have the luxury of further research, as no ground data has since been collected, wells are already being pumped, and recent discoveries of oil deposits in the area may require drilling for water, in addition to agriculture competing for this resource.

ASSESSMENT OF THE U.S. FOREST SERVICE SOIL SAMPLING PROTOCOL FOR TOTAL CARBON AND NITROGEN METRICS

Lukas Jenkins (2015)

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Twelve established research plots in the French Creek Watershed, of Berks and Chester Counties in Pennsylvania, will be revisited in order to obtain sufficient data to compare U.S. Forest Service Forest Health Monitoring (FHM) soil cores to quantitative soil pits on the basis of bulk density and in turn total carbon and nitrogen. Two half meter quantitative soil pits will be dug at each plot to a depth of 20cm. Additionally, an array of four soil cores to a depth of 20cm will be taken in proximity to each soil pit ranging from 0-1m away in spacing. Regression analysis and tests of significant values will be utilized in order to determine the strength of a possible relationship between bulk density and distance as well as the bulk density accuracy of the soil core method vs. quantitative soil pit.

**CHLOROBENZENE BIOREMEDIATION IN GROUNDWATER AND SEDIMENTS;
PROCESSES AND METHODS IN A WETLAND AND UPLAND SYSTEM.**

Connor O'Loughlin (2015)

Readers:

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Robert Law, PhD, demaximis, inc.

The use of bioremediation and managed natural attenuation of chlorobenzene constituents in sediments and groundwater is a valid method for removal of chlorinated benzenes from contaminated environments. This research discusses the aqueous chemistry, management, and remediation of benzene constituents in a saturated wetland and shallow groundwater in the upland areas of an EPA Superfund site in New Castle County Delaware. This research is a theoretical discussion of the effect of injection of bioremediation constituents into wells onsite and the potential breakdown of chlorobenzene products to less harmful constituents.

SPECULATION ON THE FUTURE OF SHALE GAS IN CHINA THROUGH COMPARISON WITH THE U.S.

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This paper introduces the successful experience of shale gas exploration and development in the U.S. Through comparison with the U.S., the current situation of shale gas exploration and development in China is analyzed.

The comparison between the geological conditions include the depositional environment, geochemical and reservoir characteristics, gas content and prospective resource potential in China with the U.S. The distribution, geochemistry and mineralogy of three types of source rocks in China are compared with the gas shales that reached commercial production in the U.S. Among the three types of shale formations in China, marine shales are the most promising and realistic targets for shale gas exploration and development.

With the Silurian Longmaxi Shale in Sichuan Basin and the Carboniferous Barnett Shale in Fort Worth Basin as focus, a more detailed comparison on characteristics of sedimentation, geochemistry, evolution history and hydrocarbon generation processes of these two formations is made. The Longmaxi Shale and the Barnett Shale are similar in thickness, depositional environments (deep- water continental shelf), kerogen types (I ~ II₁), and hydrocarbon generation processes. TOC and brittle mineral content are relatively higher in the Barnett Shale; burial depth, thermal maturity, and clay mineral content are relatively greater in the Longmaxi Shale.

In the long term, shale gas has relatively good prospects in China due to the similarity of some geological conditions, but it will take a very long time for the shale gas revolution in China to reach an equivalent scale to the U.S.

EPIPHYTIC LICHENS AS BIOINDICATORS OF ATMOSPHERIC HEAVY METAL POLLUTION IN PHILADELPHIA, PENNSYLVANIA

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Epiphytic lichens have been utilized as bioindicators in many atmospheric pollution assessments in various countries. Lichens have an amazing advantage for allowing long-term atmospheric heavy metal pollution observation without the use of expensive and sophisticated equipment. Thalli of the Common Greenshield (*Flavoparmelia caperata*) and/or the Fluffy Dust Lichen (*Lepraria lobificans*) were collected and samples were tested for heavy metal accumulation by Inductively-Coupled Plasma Spectrography (ICP) and HCl Plant Tissue Digest Methods. The heavy metals of interest measured in Philadelphia, Pennsylvania were aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), mercury (Hg), nickel (Ni), and zinc (Zn). Measuring the heavy metal concentrations in lichens is important because of the biomonitoring potential, ecological impact assessment, and significance of reducing the cost of determining the impact of pollution in local and regional areas. The sampling sites chosen for the Philadelphia area were established from the Philadelphia Pennsylvania Air Monitoring Network Plan (2013-2014). The sites were chosen to compare and correlate heavy metal data with the Philadelphia PA Air Monitoring Network's sites, and to establish a baseline of heavy metal concentrations at specific sites in the city of Philadelphia. Other sites chosen were selected in regards to certain criteria and also randomly in Philadelphia to provide accurate widespread interpolated data over the city. Additional lichen sampling was completed and provided to the John Heinz National Wildlife Refuge's biology department. The heavy metal atmospheric pollution data in and around the refuge will act as a baseline for future sampling and data collection. This study also provides a baseline on heavy metal accumulation in epiphytic lichens in the city of Philadelphia for future research.