# The Power of Environmental Monitoring

*Anna Herman*

*The U School*

## Abstract

A main goal with this unit is to add to the corpus of materials available within Environmental Science and Agriculture, Food and Natural Resources (AFNR) CTE curricula, that is specifically relevant to students who live in cities; students who are exposed to a legacy of post-industrial environmental conditions, and who live in neighborhoods that have been long underserved and are potentially environmentally hazardous to health.

These real world issues – lead in water, high rates of asthma, poor indoor air quality in school and home settings, litter, climate change, community food security – are opportunities to engage students to participate in using their education to be part of meaningful change-making.

This unit uses the tools of citizen science in a series of project- and problem-based projects about monitoring, measuring and visualizing data about Air, Water & Soil Health and investigations into the connections of these issues and human health.

This *Power of Environmental Monitoring* unit consists of three overlapping problem-based sub-units: Air, Water, Soil. Each topic will be structured to introduce students to a key issue at the intersection of the environmental topic and environmental health such as asthma rates in Philadelphia and air quality; litter and water quality; legacy industrial pollutants and soil health, and then invites student engagement through a solutions-based presentation. Each sub-unit will also have a job discovery section, where the multiple jobs related to the topic that we encounter as we are learning are highlighted.

## Unit Content

### Rationale

The U School is an open admission school in the Innovation Network with a model that requires young people to demonstrate their learning through tangible performance tasks. We attempt to be transparent with expectations, and to offer numerous opportunities for independent and self-directed learning. The goal is to empower young people through challenging and scaffolded learning experiences. The U School Urban Agriculture, Food and Natural Resources (AFNR) Career and Technical Education (CTE) class is a unique one-year program designed to combine traditional expectations of the CTE model within the specific context of Philadelphia, and the model of The U School. Around the country, and in most of Pennsylvania, AFNR CTE programs focus on the sorts of skills and tasks that students in rural and suburban settings might utilize in traditional agriculture and horticulture career pathways such as large-scale food production and processing, nutrient management on multi-acre farms, or multi-state watershed management plans. It is not unusual for an AFNR high school course to include large animal management skills, and industrial food safety and production lessons.

Most existing AFNR curricular resources do not center black and brown students or practitioners, and ignore the policies, practices and systemic issues found in urban environments. What is missing might be described as issues around environmental justice, and opportunities for students to participate in assessing and making change on environmental issues that impact them directly.

A main goal with this unit is to add to the corpus of materials available within Agriculture, Food and Natural Resources (AFNR) CTE curricula, that is specifically relevant to students who live in cities; students who are exposed to legacy of post-industrial environmental conditions, and who live in neighborhoods that have been long underserved, and are potentially environmentally hazardous.

These real world issues – lead in water, high rates of asthma, poor indoor air quality in school and home settings, litter, climate change, community food security – are opportunities to engage students to participate in using their education to be part of meaningful change-making.

In AFNR at the U School students can explore the interconnections between increasing green space and decreasing gun violence and how pollution impacts our health, and how these impacts are as unevenly distributed as wealth is. This inverse relationship between economic circumstances and environmental conditions - i.e. the black and brown communities with little wealth have the most polluted or contaminated air, soil and water is a potent example of environmental injustice.

Despite the fact that this unit is written with a one-year urban AFNR CTE class in mind, it is robust enough to offer many resources that ANY environmental science teacher, AFNR CTE teacher, or general science teacher could use to support student engagement in the connection between a healthy environment and human health.

**Introduction**

This Tip Seminar, Topics in Environmental Health, was a deep dive into the many many ways that humans have interacted with the environment to the detriment of themselves, and now their progeny. The risks we all face from poor air quality -indoor and out; water quality - indoor and out, lead and other contaminants in the soil in most urban settings (mostly outside, but tracked inside with some frequency) and all the indoor pollutants such as lead paint, volatile organic compounds (VOC's), carbon monoxide (CO) and asbestos, are a testament to continued use of these chemicals, despite research and advocacy for several generations, around these issues. The many ways these issues cumulatively impact the very students most Philadelphia high school teachers teach brings additional urgency.

There are an almost overwhelming number of potential contaminants, pollutants and problems that affect our environment and public health. Providing students with the tools to start to make sense of the key issues of a degraded environment and the contributions these degradations have to our health gives us fodder to push together towards cleaning up and finding solutions to some of these issues.

This unit will merge tools of citizen science, requirements of our AFNR CTE program and project- and problem-based projects on Air, Water & Soil Health and the connection of these issues and human health.

Because my students are enrolled in a one-year CTE course of study they must complete 750 hours of CTE skills and tasks and so are rostered to me for 25 hours every week. This means I have many hours each day to learn, do, explore, and create. We have many specific skills and tasks related to Agriculture, Food & Natural Resources that must be addressed. This unit will serve to frame and connect three major natural resources management topics that are at the heart of our yearlong curriculum: air quality, water quality and soil health -with practical skills using tools of the trade, and the environmental justice issues that students may be motivated to advocate around. The lessons in this unit will be woven into and entire semester, each with an independent problem based project chosen by each student to demonstrate their learning. A final group project which will consolidate the full range of environmental monitoring skills learned and practiced throughout the unit will be shared with the wider school community. This unit is sufficiently robust that a class with a less intensive schedule could make use of portions as suits their needs.

The Power of Environmental Monitoring unit consists of three overlapping problem-based sub-units: Air, Water, Soil. Each topic will be structured to introduce students to a key issue at the intersection of the environmental topic and environmental health such as asthma rates in Philadelphia and air quality; litter and water quality; legacy industrial pollutants and soil health. Each will also have a job discovery section, where the multiple jobs related to the topic that we encounter as we are learning are highlighted.

With each topic students will dig into: the causes of pollution and contamination; the environmental health issues that are of specific concern; the tools of the trade for measuring and monitoring; the career pathways in monitoring and mitigating; and local, regional and national resources and potential partners. Each sub-unit will include: student-led research or field work; hands-on monitoring and testing paired with field trips; opportunities to interpret real-time results; and opportunities to learn from experts in the field.

These are all problem-based units, in which I identify a problem or choice of problems, spend several weeks engaging in learning and research about the issue in a structured way, and then support students to work collaboratively and independently to complete a project that relates to the problem. Problem based learning is defined here as: "a teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. In addition to course content, PBL can promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also provide opportunities for working in groups, finding, and evaluating research materials, and life-long learning" (Duch et al, 2001)

## Classroom Activities

This unit starts with students being assigned to work together to create a checklist healthy home/healthy school /healthy city on a shared google document. First, they will brain dump their initial ideas and first thoughts about what a healthy home/healthy school/healthy city entails, and

I will transcribe. Then they will engage with a short list of curated resources to support thinking deeper about what should be on this checklist. Resources that we will use here include Help Yourself to a Healthy Home, from the US Department of Housing and Urban Development, and City of Philadelphia Resources about Lead Paint and Water. Students will then spend a week using the checklist to evaluate, as best they can some of the items on the checklist we have created together.

This document will be organized into categories and each category will be organized within a shared google slide deck. This google slide deck will be shared with the class, and be used to add information and resources as we progress through the unit. Over the course of the months, as we work on this unit, this slide deck will be populated by students as they explore and engage. Each category will end up with facts, issues, solutions, and key community resources collected collaboratively, and available for students to use on their various independent projects. In an earlier unit students will have learned about environmental justice campaigns embarked on by local various organizations and we will connect the ability to have access to real time environmental monitoring data as an important aspect of their advocacy efforts.

**Air**

This introductory unit to the wider idea of environmental monitoring is on air. Air is the most ubiquitous natural resource, is difficult to see, touch or taste, and so is the perfect way to introduce monitoring with other tools than our own senses. This sub-unit is an outgrowth of my participation in a professional development research program on air quality, asthma and bioinformatics with researchers, educators, and physicians at the University of Pennsylvania. This collaboration has allowed my students access to a set of air quality monitors and comprehensive database of student collected local air quality data that my students have added to, will continue to add to, and can use. There are also student and teacher resources that I use in this unit that were curated during my engagement with this program. Access to the complete resources from this bioinformatic unit, including these data sets can be accessed by contacting the research team, listed below in the resources section.

This sub-unit uses the problem of asthma - what is it, who has it, how is it relevant to students and how has it become a disease prevalent in black and brown communities. The greatest rise in asthma rates was among black children (almost a 50% increase) from 2001 through 2009. (https://www.cdc.gov/vitalsigns/asthma/index.html)

The researchers I work with and I agree that by grounding air quality research with the problem of asthma we connect the tools, and this learning to a topic that is relevant to their lives.

We will use the air quality monitors to make a detailed exploration of air quality in and around our school building, in and around student homes and along their commute. We will discover what local environmentalists are working on air quality in Philadelphia, and what the Sustainability Plan for City of Philadelphia, and the Green Futures Plan of the Philadelphia School District has to say about air quality and asthma issues and goals. Students learn that asthma, like many diseases that are impacted by environmental factors are directly related to exposures over time. Students learn specifically about the small particulates in the air - PM 2.5 - which get deep into lungs and can trigger respiratory issues. Students will work with several

different air quality monitors to collect data indoors and out, aggregate, interpret and visualize this data, and collaborate with classmates to suggest solution-oriented proposals to mitigate air quality with some student-led change-making project. The resources garnered from this TIP seminar provide additional context, and a wider range of resources and potential partners for our AFNR team of students and I to engage with as we explore additional citizen science opportunities, learn about additional tools and partners for studying and impacting air quality. This unit will introduce a range of possible problem-based units students will work on with regard to environmental health. As we utilize the resources from this TIP seminar, and the research and exploration into community partners, students will also identify and research examples of career pathways in the realm of air quality monitoring, mitigation and asthma health services.

There are 10 detailed lessons in this air quality unit– including facts, figures, charts, images, and videos on slide decks that accompany this narrative in the resources section. Many of these were adapted from the bioinformatics unit, and any content I added to my AFNR lessons is used with the permission of the bioinformatics team. I have included several adapted lessons in the appendix section.

Our Problem: Asthma impacts many members of our school community. This turns out to be common in urban areas in the United States, where asthma rates are rising - particularly for black and brown children. Researchers believe air quality contributes to asthma rates. There may also be other causes such as a rise in smoking rates, pollution from industry and traffic, stress and other issues that come from a lack of access to resources. AFNR at the U School has funding to support projects that would likely reduce the risk of local asthma cases.

These projects could include planting more trees to purify the air, an anti-smoking campaign, or garden and greening projects that improve air and can alleviate stress.

You are invited to research this issue, collect information about air quality indoors and out, and 1. submit a proposal describing a project that your team would like to fund. You will use evidence that you collect during AFNR classes, and data and information from public health and environmental experts to support your proposal. And 2. Add two slides that detail ideas about improving air quality to our shared AFNR slide deck (or padlet tbd).

This sub-unit starts with a review of what air is, and the main causes of air pollution -in general and in Philadelphia. Students will be able to explain the exposome, which is a way of describing an individual's exposure to pollutants over time. Students will learn what outdoor air quality monitoring is currently being done in Philadelphia, by visiting EPA's airnow.gov website. Students will be able to explain how various pollutants, specifically particulate matter (PM) impacts human health and the environment, and why measurement of PM 2.5 – which are particulate matter that are very fine, 2.5 microns or less, have such a potential to cause health problems. Fine particles pose the highest health risk because these particles travel deep into human lungs and some can even get into the bloodstream. Students will be tasked with considering whether what is being monitored, and where, reflects the actual air quality of our school community. Why? Why not? Students will learn to use two or three air quality monitors which can measure particulate matter, volatile organic compounds (VOC's), CO, and NO2. Each of these measurements plays a role in the Air Quality Index (AQI). Students will

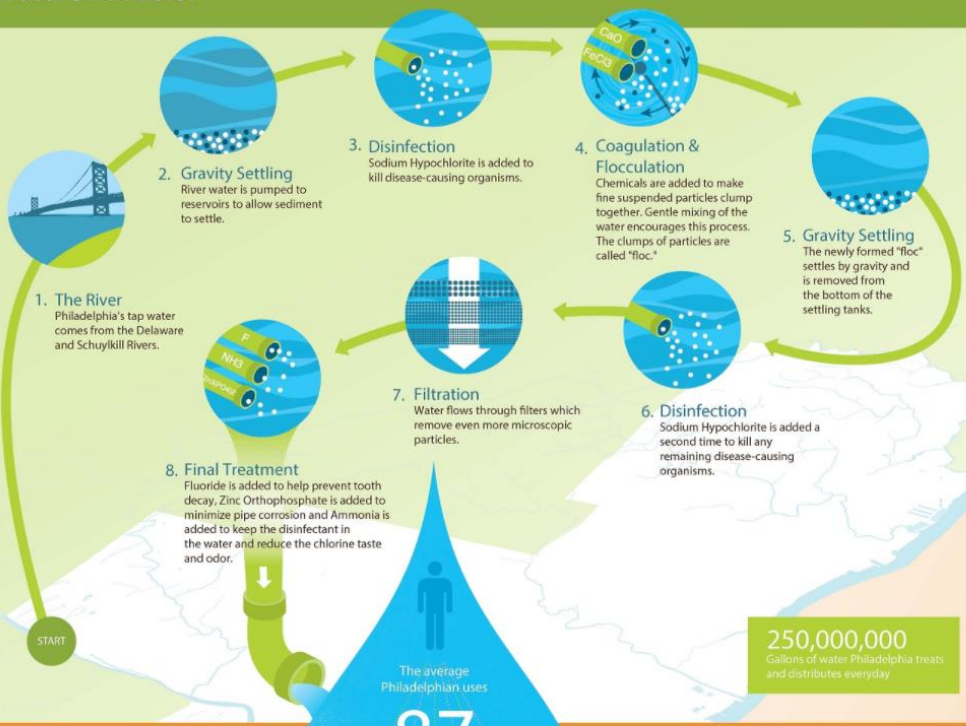
hypothesize where air quality will be high or low and will take dozens of measurements at multiple locations during neighborhood walks, field trips and commuting to and from school. Through this monitoring and measuring students will become familiar with sources of indoor and outdoor pollutants, key components of air pollution that can be measured, and how to visualize and present their air quality data. There are a number of carcinogenic pollutants that are in the air we breathe, in concentrations that are problematic. Students will research the health impacts of air pollution with a focus on asthma and identify strategies to improve air quality and reduce asthma risks. Resources to offer students as they engage in this work are shared in the resources section of this unit. Our air quality monitors will not be able to measure them, and this issue will be identified as a concern with ALL environmental monitoring – there are things that are easy to measure, and there are things that are important to measure, and they don't always line up. While this is an essential take away from this entire unit, I hope that students having some tools to catalogue and communicate about environmental hazards in their communities will spur them to dig deeper.

**Water**

The water sub-unit will start with students self-reporting everything they know about drinking water, what water they drink (tap/bottled etc.) and spend some time interviewing classmates, teachers and viewing and trying to explain the many signs in our school bathrooms that say "do not drink from this sink." As a whole class we will piece together an infographic chart that shows how water gets to a tap in our school, and where it goes from there, and look at the places along the way that the water quality might be impacted (for the better or worse). This activity will be made by cutting up and laminating parts of the chart (Fig 1.) from the Philadelphia Water Department that details this process. We will watch several short videos on the water cycle and the urban water cycle (see resources below). Students will complete an all about water worksheet. Students will add some information to an existing google map, created in an earlier unit, that identifies the watershed they live in, the watershed the school is in, using tools from the Philadelphia Water Department web-site. Students will be asked to draw the pathway from the school to the Atlantic ocean (via the Delaware River). We will head outside to view the storm drain markers which clearly state where the water from our school campus drains to.

# How Do We Make Water Drinkable?

Like the majority of water utilities in the U.S., we use a multi-step treatment process at all three of our drinking water treatment plants. This Water Treatment Process diagram provides a brief description of drinking water treatment in Philadelphia.




1. **The River**
Philadelphia's tap water comes from the Delaware and Schuylkill Rivers.

2. **Gravity Settling**
River water is pumped to reservoirs to allow sediment to settle.

3. **Disinfection**
Sodium Hypochlorite is added to kill disease-causing organisms.

4. **Coagulation & Flocculation**
Chemicals are added to make fine suspended particles clump together. Gentle mixing of the water encourages this process. The clumps of particles are called "floc."

5. **Gravity Settling**
The newly formed "floc" settles by gravity and is removed from the bottom of the settling tanks.

6. **Disinfection**
Sodium Hypochlorite is added a second time to kill any remaining disease-causing organisms.

7. **Filtration**
Water flows through filters which remove even more microscopic particles.

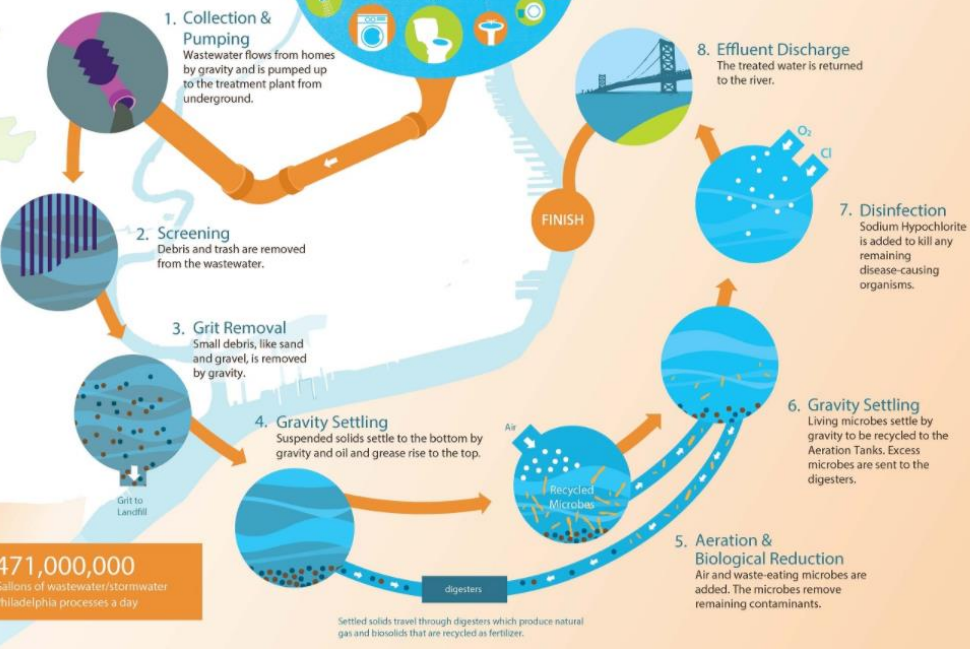
8. **Final Treatment**
Fluoride is added to help prevent tooth decay, Zinc Orthophosphate is added to minimize pipe corrosion and Ammonia is added to keep the disinfectant in the water and reduce the chlorine taste and odor.




**250,000,000**
Gallons of water Philadelphia treats and distributes everyday

# How Do We Process Wastewater?

After water is used, PWD is responsible for cleaning it before returning the water to the river. This is the Wastewater Treatment Process. We return about 98% of the water that we withdraw for our use to the river.




1. **Collection & Pumping**
Wastewater flows from homes by gravity and is pumped up to the treatment plant from underground.

2. **Screening**
Debris and trash are removed from the wastewater.

3. **Grit Removal**
Small debris, like sand and gravel, is removed by gravity.

4. **Gravity Settling**
Suspended solids settle to the bottom by gravity and oil and grease rise to the top.

5. **Aeration & Biological Reduction**
Air and waste-eating microbes are added. The microbes remove remaining contaminants.

6. **Gravity Settling**
Living microbes settle by gravity to be recycled to the Aeration Tanks. Excess microbes are sent to the digesters.

7. **Disinfection**
Sodium Hypochlorite is added to kill any remaining disease-causing organisms.

8. **Effluent Discharge**
The treated water is returned to the river.

**471,000,000**
Gallons of wastewater/stormwater Philadelphia processes a day

Settled solids travel through digesters which produce natural gas and biosolids that are recycled as fertilizer.

Next we will take a field trip to the Schuylkill River, the source of much of the water that runs through the taps in Philadelphia, specifically at the Fairmount Waterworks, a site steeped in history of water treatment and distribution. Students will get an overview of the history and the current state of the urban water cycle in Philadelphia, as well as a chance to do some source water quality testing. This lesson will focus on Philadelphia use of combined sewers, where wastewater and stormwater are co-mingled in many communities, leading to untreated wastewater ending up in our streams and rivers after large rain events. This leads to water quality issues both for use by humans for consumption and industry, as well as water as an essential component of local ecosystems. We will include a review of a healthy aquatic ecosystem, and an opportunity to monitor macroinvertebrates as bioindicators of water quality, as well as an overview of the testing procedures done as part of the water treatment process.

Back at school over the next days we will complete a series of hands-on water projects. Depending on student questions, existing knowledge, and timing there are many hands-on lessons we might do. Even taking a watering can outside and pouring water on the paved parking lot, in a tree pit and on packed soil can be very useful in demonstrating impervious, pervious, and what happens when soil is compacted. Pointing out trash in the storm drains on walks with students and asking them what they think and where it goes.

I choose from several lessons from a curriculum I co-wrote called "Climate Heroes" – which were written for rec center leaders (adults & teens) to do with elementary age students. I have found that all the activities and background information is a great resource for high schoolers to use in small groups or independently. with great success. I now provide my students the materials and the instructions, and invite them to try out the project, and then to produce short (tik-tok) videos that we can share with younger students to teach them about these topics. Often I ask various groups to work on, practice and then to share to the rest of the class the demonstration they have mastered and the explanation.

***Rain to Drain: Slow The Flow*** – adapted from a 4H project (link to curriculum) uses various materials such as sponges, gravel and plastic to demonstrate pervious/impervious and the benefits of plants to slow and clean water.

***Down the Drain*** – a simple disposable metal pan is turned into a streetscape with openings to stand in for sewers (see lesson with picture in the appendix). Students leave various things in the street, and the results go down the drain as sludge. Cocoa for dog poop, tea leaves for cigarette butts, pieces of plastic, etc.

***Soil Cleans Water*** –students use a variety of natural materials such as untilled quality soil, stones and sand to create water filters with plastic soda bottles. Water from the "Down the Drain" project is poured through, and we see how clean we can get it.

We continue this unit with three more field trips: first to the water treatment plant, second to large & small green stormwater infrastructure sites and third to the site of at least one sewage outflow. There are numerous videos about water treatment if a field trip is not possible for your class. In walks around the neighborhood to observe natural resources (which we do weekly) there is always something water related to point out – trash in storm sewers, a tree trench, a rain garden, a curb bump out, a clogged drain, a puddle etc. When it is raining while we are in school, I will try to remember to have the class check the CBO overflows on the website. https://water.phila.gov/maps/csocast/ on our classroom smart board. Students will review the details of how the water department tests our drinking water, what it tests for, and how often. Students will be asked to complete several checks for understanding (google forms and worksheets) which help me see what gaps in knowledge need to be reviewed.

Students will then choose between testing their home water, a specific sink at school for lead, or attending a Saturday event where we collect water from one of the local creeks to test for macroinvertebrates. Between us all the class will monitor and test residential, commercial indoor and outdoor water, and report back on their procedures, findings, and recommendations to the whole group. Some students will focus on indoor water, learn about the Drink Philly Tap project (https://drinkphillytap.org/) and share what they learned. Students will all be assigned to add several slides to our shared healthy home/city/school resource document based on the specific information they have learned about water.

In addition to adding information to the water quality checklist students will also complete a job discovery worksheet related to jobs in green stormwater infrastructure, technical/engineering & environmental protection type water jobs. All these responses, and some I will add, will become part of our Green Work Force Job board.

Students will review the Water Problem options (see below), and choose one to focus on the for the following 3-4 weeks.

***Choose One Problem to Tackle (or suggest another):***

***Down the drain:*** As we have seen from our neighborhood walks, there is a huge amount of litter and construction debris all over the sidewalks and streets around the U School. This is one example of non-point source pollution. When it rains many contaminants such as pet waste, cigarette butts and paper and plastic trash ends up going right down the drain. Much of this trash isn't light enough to flow down the stream and sits at the bottom of the drains and breeds bacteria. When there is a big rain, because of Philadelphia's combined sewer system, it ends up going straight into the region'streams and rivers. The Philadelphia Water Department, which provides clean water to all our homes, schools, and businesses, spends thousands of hours, and millions of

dollars cleaning litter out of the water.What do you propose to do to reduce litter around the U School? Come up with a campaign to curb litter, using the information you have learned to make your case.

***Slow the Flow:*** There is no denying that humans have radically altered the landscape, leading to an increase in stormwater runoff. We have paved over almost all surfaces making them impervious to rain. These roads, roof tops and sidewalks increase stormwater runoff, since water cannot infiltrate. Stormwater picks up pollutants such as fertilizers, pesticides, road salt, trash, sediment, animal waste and more carrying them to local streams and rivers. These pollutants are major stressors to fragile, aquatic ecosystems, and make it harder for our water treatment plants to clean the water that comes back to our homes to drink, cook with and bathe in. One way to combat water problems is to create green infrastructure that combines engineering and natural systems to slow and clean water. Rain gardens use plants and trees to create spaces that absorb excess water and clean it through natural filtration processes. Green roofs absorb water, and use it to grow plants that help insulate buildings and clean air. These sorts of projects are called green stormwater infrastructure or GSI. Building with nature not only addresses extreme weather events such as flooding, but it also simultaneously protects the environment and creates green spaces that serve as recreational areas for communities. Examples of green infrastructure include small rain gardens, or a tree trench on a sidewalk that helps absorb extra water and offers beauty, habitat for pollinators and cleaner air and shade on a hot day. Within a few blocks of the U School there are several GSI sites that need care, signage, and support. Work to Plan a GSI garden or figure out how you can help support one that exists already. You might create an educational campaign so others at the U School will help you.

***Flowing From the Pipes:*** Philadelphia is an old city, with many houses built over 70 years ago. Many of the building materials that were used are now known to be very toxic, such as lead in plumbing pipes and wall paint. According to the City of Philadelphia's Lead Guide, approximately 20,000 Philadelphia homes may have a water service line (a pipe running from the water main to the home) that is made of lead. Older brass fixtures, valves, and solder (where pipes are joined) may also contain lead. It can be confusing to figure out whether you have a lead service line, whether the water from your tap is safe to drink, who can help, what do do. If you choose this problem, you will research and create a pamphlet, infographic or video that helps people know how to make sure their drinking water is safe to drink. You will compare Philadelphia Water Department water to bottled water from an environmental perspective.

**Soil**

We have a unit early in the year "The Power of Soil," which looks at soil formation, degradation, soil health, the essential role of soil in gardens, farms, forests and carbon sequestration. This unit only touches lightly on lessons of urban soil contamination and legacy pollutants. In this initial soil unit we do learn how to do a basic soil test – which is looking at nitrogen (N), phosphorus (P), and potassium (K), as well as pH, and organic matter.

The soil sub-unit of this The Power of Environmental Monitoring will loop back around to what we have learned about soil's ability to hold and filter water, capture and sequester carbon, and serve as a source of growing healthy food. We will dig deeper into urban soils to address specifically the process of soil evaluation and testing for contamination, and overview the environmental health impacts of the numerous potential contaminants of urban soils. We will explore the strategies urban farmers utilize to mitigate the risks of soil contamination, which are very closely aligned with building soil health for growing healthy crops. Maintaining proper pH, adding organic matter, and keeping soil covered with mulch not only benefits plant growth, but also reduces many of the risks urban soils pose.

Among the specifics of this sub-unit will be to solve:

The Problem: We have identified a site near school that might be available to use as a garden or park. How do we know if it would be safe for us to make a garden there? For most of the last hundred years the neighborhoods of Fishtown, Kensington, and Port Richmond, had dozens of factories that made products using lead. It was a time when manufacturers used lead in products from paints to plastics. Lead dust spewed from the factory smokestacks, coating sidewalks, stoops, and yards.. Once in the soil, the heavy metal stays indefinitely. Even minuscule amounts can permanently lower a child's IQ and cause behavioral problems.

The lead plants have been gone for decades, but the pollution remains. In addition to lead that fell from the sky and stayed, there are other chemicals that could be present. Perhaps someone short-dumped equipment that leaked chemicals, or maybe the site was a former dry cleaner which stored chemicals on site.

What are the steps to evaluating and analyzing the safety of a potential garden spot.? What are the best practices for gardening safely in an urban garden.? You are invited to join a team to complete a step-by-step analysis and determine what sort of testing is required. You will complete the tests and review the results, and make recommendations. Perhaps we can start a food farm, or a mini-orchard, or a pollinator habitat. We do know that being in green spaces reduces stress, helps clean the air and water. We also know that increasing green spaces in neighborhoods helps reduce gun violence. Let's work on figuring out how we can do this without harming our health!

First, as a group we will identify a location within walking distance of school to tackle. Then we will walk around and do an on-line site history using We will do other research as needed, and then collect soil -using proper protocols as detailed by the labs we are sending them to (TBD). We will utilize a resource that I wrote a few years back, when I worked for Penn State Extension as an Urban Garden educator, entitled *Gardening from the Ground Up*. This guide was written after a year-long set of meetings with a group of gardeners, soil scientists and policy makers convened as the Philadelphia Soil Safety Working Group. This pamphlet lists the steps for evaluating, researching a site history, the detailed steps for collecting soil and sending a soil sample to a lab. Students will participate in all of these steps to collect soil samples, send them in for analysis to two soil testing labs, and act as a consultant to the landowner or resident of the property from which the soil was collected. We will also provide samples for heavy metal testing locally. After this group project, pairs of students identify a site of their choosing, and go through this process independently, demonstrating their competence by either doing this with

me, or by submitting a photo essay of the process. They will submit both a copy of the intake form, and their summary of what the results of their testing mean, and what (if any) mitigation strategies or advice they would offer the landowner/resident.

This unit The Power of Environmental Monitoring will overlap with a unit (also written for a TIP seminar) called The Power of Place. The Power of Place explores the geographic context of how and why cities in general - but Philadelphia in specific - have preserved, restored, created certain green spaces, and ignored others - why polluting factories are located in one neighborhood and not others, how lead service lines are still found more often in homes in low-wealth neighborhoods. Many of these issues have been shaped by cultural forces of race, class and gender, and all of the solutions to the biggest problems we face will need to acknowledge and address these cultural forces. I want my students to feel prepared to tackle big issues with the grounding in facts, information, skills and partners. It is also important to me that students understand that many of the issues most relevant to our work in urban agriculture and urban environmentalism are systemic and complex, and that solutions will require data, collaboration, and advocacy - all things that they can start to participate in during their senior year of high school and continue going forward. It is my hope that students will feel motivated to be changemakers, not overwhelmed by the enormity of the problems that we have identified in so much detail during this seminar.

## Teaching Strategies

As mentioned above these units will be mix of direct instruction, project, and problem-based learning strategies. It is essential that all the students in an AFNR CTE class have exposure and experiences with evaluating and measuring and practicing natural resources tools of the trade. As in all classrooms students have a wide range of interests and abilities. To accommodate an array of learners all my units offer multiple ways to engage with the required content, a variety of ways to check for student understanding, multiple options for student projects and demonstrating mastery and competency. Several students do not read fluently, or regularly, and so I always offer a recorded versions of slide deck presentations, offer a number of Ed Puzzle video assignments, and allow for "mote" voice memo recordings or "talk to text" in google docs for submitting work. I also try to include content created by teenagers, and content featuring and/or created by people of color. We engage local experts to visit, mentor, consult, partner and advise. As a white women, working in a school which serves almost exclusively black and brown students, in a field (urban agriculture) which is focused on environmental justice and equity, I am cognizant that the many partners, and other adults that students learn from about this work, should as often as possible be as diverse as possible, to ensure that students see themselves represented in environmental science, health, food systems and natural resources work and feel connected to the work through the ideas they are exposed to, the relationships they make, and the people they see doing this work alongside them.

"Children base their visions of their futures on what they see in their everyday environments. In their classrooms, minority students can envision what's possible for them when the people who are teaching them look like them and have a similar background." (*Why teachers teach at low-performing schools: Representation matters* 2020).

I have many students who take advantage of every opportunity, and a minority who want to do the minimum to pass. Because the same students who are eager to do it all are also the students who have strong attendance, these students are building and participating in many more of the hands-on experiential learning opportunities and consolidating their understanding by demonstrations and multi-week projects. These students can then provide support, encouragement, and direct instruction to students whose attendance is more sporadic. Students need to demonstrate their understanding of a concept, or their ability to do a task properly – and many will do these in our larger group on the timeline set out by the teacher, and others will do them one on one with me if and when they are ready.

I am able to provide the flexibility required to truly offer students the opportunity to work on problems in a project-based way by dedicating one period each day (of the 14 weekly class periods the same students are rostered to me) for independent project work. During this time students have a range of activities and responsibilities. This is time that I can check in with individuals and small groups, and review direct instruction, demonstrations and support research and data visualization and technical aspects of students learning.

It is also essential to this unit that students are able to explore the environment to collect samples inside and out, review real data and results, and learn directly where possible from professionals in the field that do this work. It is also my hope that some of the solutions to the problems will be actions such as building and/or maintaining new green spaces, and working directly on-site with partners. This requires some ability to organize resources, schedule field trips and to be able to invite and host guest experts to the classroom (in person or via zoom). This flexibility has been harder to navigate during the pandemic, but since being outside is safer (at least vis a vis Covid) I am a proponent of outside learning and doing with my students.

For teachers with less time in their schedule this unit can be truncated to dig into a smaller subset of lessons or tasks, and may be less about hands on monitoring and problem solving, and more on the specific and important connections between the environment's health and human health.

## Resources

Duch, B. J., Groh, S. E, & Allen, D. E. (Eds.). (2001). *The power of problem-based learning*. Sterling, VA: Stylus.

*Why teachers teach at low-performing schools: Representation matters*. Why Representation Matters in Low-Performing Schools | American University. (n.d.). Retrieved December 20, 2021, from https://soeonline.american.edu/blog/why-representation-matters-in-low-performing-schools

**Resources for teachers:**

State of the Air

How Your Invisible Exposome Could Be Messing With Your Health

Air Quality & Covid An Unexpected Consequence of COVID

NY Times - Pollution is Killing Black Americans - Philadelphia

Drinking Water Quality – Philadelphia Water Department

Philly's drinking water is contaminated with PFAS, environmental group claims | PhillyVoice

Soil Health Brochure, Penn State Extension Master Gardener

NRCS-USDA Web Soil Survey Mapping Tool

https://www.nature.org/en-us/what-we-do/our-insights/perspectives/the-power-of-nature-in-cities/

Does Nature Need Cities? Pollinators Reveal a Role for Cities in Wildlife Conservation

The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes

Urban ecosystem services and decision making for a green Philadelphia

Opinion | To Combat Gun Violence, Clean Up the Neighborhood

Podcast: High-Schoolers' Winning Podcast Tackles Environmental Racism

CSO - cast

https://www.sciencehistory.org/downstream

http://water.phila.gov/blog/2021-stormwater-pioneers

For more information, and access to resources and data from the Air Quality Bioinformatics Unit, please contact: Jooeun Shim jshim@gse.upenn.edu

## Appendix

Introduction to Environmental Monitoring Lesson Slide Deck:
https://docs.google.com/presentation/d/1MRKe3c5NCqvx9Oi8eZpWjE-jPRs8SP_5rA-EBpP6KDs/edit?usp=sharing

What is an Exposome Lesson Slide Deck:
https://docs.google.com/presentation/d/1r9o50vBSC3YuwjQqPK-NGp9xgxK1oKMAgP0R22o6SDI/edit?usp=sharing

The Power of Citizen Science Slide Deck:
https://docs.google.com/presentation/d/1E_d_9V8xgjXAUVeUs2YPaWQC77RZu51JEPrLyttdvpg/edit?usp=sharing

**Environmental Monitoring Project Assessment Rubric**

| Criteria | Not Quite 1 | Basic = 2 | Solid= 3 |
|---|---|---|---|
| Presentation | missing key components such as intro, conclusion, details | Basic presentation, could be better organized | Presentation is organized, attractive and complete |
| **Research** | information used was not accurate | Looked at only one or two sources | Learned about the topic from a variety of sources |
| **Comprehension** | little is any understanding demonstrated | limited, superficial understanding demonstrated | demonstrations of accurate and thoughtful understanding |
| **Solution/Plan/Idea** | Idea relates, but doesn't address the problem | addresses the problem somewhat | addresses problem |
| **Data/Results** | data table and charts are incomplete and contain inaccuracies | data table and charts are complete, but inaccuracies are evident | Data is visualized accurately and completely |
| **Summary / Conclusion** | Missing a summary | addresses research, but conclusions are flawed | satisfactorily addresses research |
| **Teamwork** | little if any cooperation evident; no synergy exhibited | some collaboration during project | cooperation & collaboration clearly evident |
| Partners | Did not reach out to external partners for ideas or advice | Did internet research about possible partners | Engaged in some way with outside partner |

**Final Air Quality Project Report Outline**

What is the Story We Can Tell About Air in our Neighborhood?

***Overview***

- What is air quality, and how is it measured?
- Why do we need to address air quality?
- What does it have to do with asthma?
- **Where** is the air quality a problem?

- How do we know?
- How big a problem is this?
- What are some ways humans impact air quality?
- What are some ways we can improve our air quality?
- What else do we want to understand or explain to others?
- How do we share what we have learned in a way that impacts change?

***Investigations & Presentations:*** What do we want to find out and then what?

Procedure - How can we collect information about local air quality?

- Learn what tools we have access to to measure air quality and how they work.
- Learn what will we measure, and why it matters.
- Decide where you and your team will collect data.
- Why were those locations chosen?
- Ask - are there things you want to measure that we do not have the tools to measure?

***Data Review & Analysis***

- What are the next steps now that we have collected data?
- What calculations can we do together with our data (e.g., average, range, etc.)

How can you visualize/present your data? (e.g., Story Maps, Bar Graphs, Box Plots)

***Data Comparison***

- How does the data we collected compare to data from other sources? (e.g., from national databases, from local news articles). What did we add to the story? How can we share the work that we did with others?
- Use the articles you read for class, as well as websites on the Resources List, but also look for your own resources. Make sure you list all resources that you use in the References section.

***What Did We Learn and What Do We Want to Do About it?***

- Based on what we discovered, what do you propose we should do?
- Why is this a good solution to the problem of poor air quality and rising asthma rates?
- What are the costs/challenges to implementing it?
- What would your next step be to implement this solution?
    - Is it something you can do on your own?
    - Who might you need to contact for support/help?
- What actions can you personally take to help address air quality issues?

***Who Are Some of the Individuals and Organizations in Philadelphia Working on Air Quality***

- What Youth Organizations & other Schools are working on this issue?
- What connections can we make with these folx?
- What jobs exist in the air quality monitoring and mitigation field?

**References**


GSI Career Exploration Student Report Back: https://forms.gle/kY3dtUmiuCdm2HbV8

Ed Puzzle - AIr Quality

Ed Puzzle - Indoor Air Quality

Ed Puzzle - How Asthma Works

An Ed Puzzle: Introduction to Urban Wastewater Systems

Urban Water Cycle

Urban Water Cycle: Pollution Control


CIP 1.999 Agriculture Food & Natural Resources Skills, Tasks & Competencies Covered

- 501 Discuss the environmental impacts of agricultural activities on soil, water and aerial systems.
- 605 Identify steps in analyzing soils found in different natural resource management areas.
- 606 Understand how to analyze existing soil surveys to develop effective management plans.
- 701 Discuss the government's role in regulating air, soil, and water use & management.
- 703 Identify local, regional and global air and water conservation issues and conservation measures being employed in the region.
- 706 Analyze the ways in which human needs and environmental considerations interrelate.
- 1001 Discuss the environmental impacts of agricultural activities on soil, water and aerial systems with an environmental justice lens; paying attention to racism and the effects of poverty
- 1003 Understand how natural resources are used in agriculture with a focus on environmental justice.
- 4009 Apply research skills in searching for a job utilizing various job search resources (e.g. CareerLinks, O-Net, Professional Organizations).

- 811 Analyze the relationship between water quality and species diversity and distributions.

Key Words: Air quality, water quality, soil health, lead, soil contamination, urban gardening, environmental justice, environmental monitoring, environmental advocacy, youth environmental justice, green stormwater infrastructure