Concentrating on Solutions to Soil Lead Contamination at Home

Eual A. Phillips, Jr.

Abstract

Soil contamination is prevalent in urban cities that have had a history of either high vehicle emissions during times of leaded gasoline consumption or lead-based manufacturing. While there are laws and programs in place to monitor lead contamination of our water systems, there are significantly fewer programs regarding soil contamination. This unit explores the topic of soil lead contamination by allowing students to investigate their home and neighborhood to determine their risk of lead exposure. Students will learn how data is collected from soil via the topic of solution chemistry and will apply scientific principles to explore remedies to soil contamination and preventative methods to lower the risk of exposure in their homes. Ultimately, students will be challenged to take responsibility for their learning by creating educational media to inform others in their neighborhood about potential soil lead exposure. Overall, this unit gives opportunity for students to develop and apply scientific literacy and environmental consciousness as they learn how to calculate the concentration of chemicals in mixtures.

Content Objectives

Problem Statement

Education for Sustainability (EfS) or Education for Sustainable Development (ESD) standards have been developed and considered across the globe for integration into today's classrooms, with the School District of Philadelphia being a recent adopter of those standards. The Philadelphia School District has set a goal for 100% of schools to demonstrate evidence of EfS across school curriculum, administration, and both family and community engagement by 2023. However, most of the sample curriculum provided focuses on developing a sustainability mindset in language arts and social studies. Very little has been directly tailored to advancing the science curriculum toward EfS standards other than the first professional development opportunity offered back in 2016. An additional challenge that has always been a thorn in teachers' sides is the balancing act of breadth versus depth of content. The question becomes this: How can science teachers securely implement school district, next generation science, and education for sustainability standards? In order to begin the process of implementing EfS standards in addition to the requirements directed by the district and the state, the entire philosophy of science teachers must undergo reconstruction.

While writing this curriculum as a fourth-year chemistry teacher, I already find it quite challenging to teach the current curriculum to my sophomore level students. In addition, I disagree with the delivery of much of the content because it is based on how I was taught chemistry during the early 2000s. A lot of it was rote memorization and notetaking to learn facts that I will never use in life. There have been attempts made to adopt the Next Generation Science Standards, but I believe that most teachers are not next generation teachers. In order to teach to NGSS, then you must have insight into the next generation of scientific advancements. I have some insight because I left the professional realm of biomedical engineering to become a teacher. However, what effect does that have on another chemistry teacher who may have never worked full-time as a chemist or research scientist?

Without a proper perspective of the future that lies ahead, it is impossible to teach the next generation of students. By offering the same curriculum to my students today that was presented to me in the early 2000s only makes them as good as my past experience, and the "next generation" label becomes a misnomer. Instead of sending the students forward into a bright future, we have perpetuated sending them back in time to the dark ages. The root word for curriculum means race. Therefore, there is no race to the finish line if you are simply running the treadmill.

Curriculum Goals

In this curriculum unit, I will share my plan on implementing ESD standards into the chemistry curriculum, by examining the local environmental issue of lead toxicity in urban soil. Overall, this unit will attempt to accomplish three goals. First, the unit will provoke you to reconsider the neighborhood resources that are available to you and your students. This this unit will unveil how I work with a university partner to conduct research with my students. In order to teach ESD standards in the science class, students need opportunities to meaningfully engage their communities. Thus, teaching this curriculum unit will grant students the opportunity to consider the chemistry that could be happening literally in their own back yards and how it could potentially affect their lives. Finally, students will learn how to reconstruct acquired knowledge into teachable formats so that they may serve as community activists or educators concerning lead toxicity in urban soil.

The Pedagogy of Education for Sustainable Development

Research has found that chemistry teachers' perceptions of the world's condition are less than comprehensive, outlining that many college level textbooks, such as the *Handbook of Research of Science Education*, *Teaching and Learning the many faces of Chemistry*, and the *Environmental Education* Handbook, do not effectively examine the route of EfS standards (Vilches & Gil-Pérez, 2013). One could argue that the textbook really creates an artificial point of view of how the world works, especially when dealing with a topic that is not within their scope of expertise. I believe that the best educational practice in science requires that the teacher and the students experience science together.

Based on pedagogical models in Finland, the EfS approaches can be sorted into three categories: (1) experiences and knowledge in an environment or place towards sustainable development, (2) skills and knowledge about environmental chemistry and sustainable development, and (3) value education, which is the action required for sustainable development to occur through chemistry.

One of the methods for teaching ESD in chemistry uses a three-phase model that focuses on student empowerment in environmental education. The goal is to teach SSI controversies in the chemistry lessons. Phase 1 of the process focuses on the socio-cultural causes and history of an environmental issue in order to develop a background knowledge for a rounded viewpoint. In Phase 2, the students conduct experiments related to the issue, which creates the opportunity for students to learn the content that is directly related to problem solving. In Phase 3, students are required to examine the socio-cultural and ecological challenges, possible outcomes, and future outlooks, all the while considering economic viewpoints. Examples of higher-order thinking activities and summative assessments include interests' group brochures, role-playing debates, and journalistic news productions. The overall outcome of student response will either lend itself to student empowerment towards a sustainable future or feeling disempowered realizing that society may possibly be doomed.

EfS Models

Other nations have already begun the quest to marry EfS standards to the chemistry curriculum. For example, the international baccalaureate program focuses on inquiry-driven education. Although there are few IB textbooks for students who are in grades 9 and 10, the textbook *Chemistry: MYP by Concept*, written by Hodder, contains several units that applies chemical concepts to sustainability of resources, such as river pollutants and air pollution.

Germany has shifted to implementing EfS standards into their curricula through participatory action research (PAR) (Burmeister & Eilks, 2013). They believe that teacher professional development in applying chemistry to EfS is essential to changing the curriculum, beginning with pre-service teachers. The advantage of equipping teachers during their pre-service season is that personal teaching philosophies are uncovered, exposed, and are subject to modifications, improvements, and adjustments before they emerge as full-time educators. Despite their efforts to train teachers, the framework for implementing chemistry with ESD is still underwhelming.

Since there is little literature concerning ESD in chemistry, the ideas present in this unit will hopefully serve as a pioneer. Without many examples of sustainable development and having a clear understanding of the concept, it is difficult to try to adopt ESD standards. A key objective of this curriculum is to demonstrate how an experienced teacher could potentially develop lessons aligned to ESD. Studies have intently focused on pre-service teachers, but the truth is that in order for ESD to work, it requires the onboarding of seasoned teachers. So hop on board the ESD train with me!

Contextual Background

Lead is ubiquitous. Its historical uses are many including lining pipes, flavoring wine, anti-knock agent in gasoline and adding durability to paint. Its many uses throughout history have led to smelting throughout this time. Smelters were simple furnaces leading to tremendous air emissions and ground deposition. Lead is found in many ores of other metals that also were smelted, adding to the environmental contamination. Over the last century most countries have recognized the need to reduce lead in the environment, in particular due to its deleterious health effects. Young children can have life-long impacts to cognition, behavior and development if exposed to lead. Regulatory agencies and legislative bodies have passed numerous pieces of legislation and designed extensive regulatory procedures to reduce lead exposure. The effort and resources devoted to the clean-up of lead should increase the appreciation of sustainable practices in the prevention of environmental contamination and human exposure.

Sources of Soil Lead

Long after the discontinued use of lead-based paints and leaded gasoline, lead exposure continued to be a problem in old urban communities. Urban youth are still exposed to lead via lead-enriched soils and resuspended lead-containing particulates from the contaminated soils (Gabriel M. Filippelli & Mark A. S. Laidlaw, 2010). The sources of soil lead include degradation of lead-based paints from older homes and lead deposited from vehicles during the era of leaded gasoline usage. In urban cities where there are many impervious surfaces, precipitation promotes surface run-off of insoluble lead-enriched particulates that accumulates in nearby soil if the runoff does not make it to the storm drains and into treatment plants. With Philadelphia being an urban city with a combined sewer system, flooding can definitely create this scenario.

Lead (Pb) naturally occurs in various minerals in the Earth's crust and is considered toxic when it is available in high enough concentrations. Common lead minerals are galena (PbS) and cerussite ($PbCO_3$), while anglesite ($PbSO_4$) and pyromorphite ($Pb_5(PO_4)_3Cl$) are found in small quantities. Lead is found in copper, zinc, and silver ores and is often a co-product of those metals. While lead has been used for over 8,000 years, the surge in human activity due to technological advances has mobilized lead across the globe, making it a widely available toxic metal.

Soil Bioavailability

The key to lowering the bioavailability of soil lead is to understand the insoluble forms of lead-based compounds. By introducing compounds into the soil that readily react with lead, the toxic metal is essentially immobilized, thus it is less reactive.

Although one can measure the concentration of Pb within a medium, only a fraction of Pb ingested is actually absorbed by the organism. Thus, there are two types of assessments that measure Pb absorption. Bioavailability assessments measure the amount of compound that is absorbed in vivo after having fed an organism a fixed amount of the compound. Bioaccessibility assessments measure the amount of Pb extracted from a one medium in vitro into laboratory media, which simulates the extraction processes of gastrointestinal environments (Henry et al., 2015, p. 8952). The two assessments are similar, but bioaccessibility assessments are artificial and are conducted under more controlled laboratory conditions than bioavailability assessments. Scientists are moving in the direction of using the less invasive bioaccessibility assessments; however, this type of assessment requires the validation of in vivo bioavailability assessments before this practice is officially adopted.

Soil Remediation

There are three remediation strategies primarily available for reducing soil Pb exposure. The first is to remove the contaminated soil and replace it with cleaner soil. The second is to leave the contaminated soil, but place barriers on top to reduce exposure. The final method is treating the soil in situ by amending the soil with phosphates or other similar chemicals to reduce the bioavailability of Pb (Henry et al., 2015; Scheckel et al., 2013). While the first method is costly, especially for urban areas, more research is needed to confirm the cost analysis of soil amendment, as the effectiveness of soil amendment is dependent on soil composition, which is subject to variation.

The goal of amending the soil is to immobilize Pb and make it less bioavailable (Henry et al., 2015, p. 8951). Soluble forms of lead include lead(II) carbonate, lead(II) oxide, and lead(II) hydroxide. Less soluble forms include lead(II) chromate, lead(II) sulfate, iron-lead oxides and sulfates, and manganese-lead oxides.

One chemical identified for soil amendment is monobasic calcium phosphate ($Ca(H_2PO_4)_2 \bullet H_2O$ or MCP). A study examined the use of MCP to amend both alkaline and acidic firing range soils (Dermatas, Chrysochoou, Grubb, & Xu, 2008, p. 55). Alkaline soil had Pb concentrations of about 35,000 ppm while basic soil had concentrations of about 5,000 ppm. After 28 days, results showed that alkaline conditions caused the MCP to form brushite, a calcium hydrogen phosphate mineral, while there was limited extraction of Pb from cerussite mineral present in the soil. While there were significant decreases in bioavailable Pb in the acidic soil, metallic Pb still persisted 28 days after the application of MCP to the soil. Even though this research team showed that soil amendments did not produce favorable results, one must consider that the Pb concentrations studied were extremely high.

When it comes to education for sustainability, the historical context of legacy pollution is an important place to begin. Students should understand how ecological damage and the opportunity for human exposure has evolved through practices that have not been sustainable. Lead is a great example for this lesson in sustainability.

Teaching Strategies

Student Audience

The unit is originally intended for my tenth grade students, who attend classes together as an advisory or homeroom. Students have 50-minute class periods three days per week and 50-minute class periods twice weekly. An estimated 85% of the students are enrolled in algebra II, while the remainder have advanced to geometry. The students enrolled in geometry are usually in the same homeroom, which hastens the pace of the class compared to sections without geometry students. Grade 10 students are also committed to the completion of a personal project as a requirement for finishing the International Baccalaureate (IB) Middle Years Program (MYP). Approximately 85% of the student population is African American. One-third of students are from the neighborhood, while the remainder come from around the city of Philadelphia. My classroom is also highly inclusive. Students' abilities and motivations span across a broad spectrum. Since there are no electives in the high school, every student takes the same prescription of courses. Thus, I have a combination of motivated and unmotivated students. To neglect the unmotivated student is to deny them of high-quality instruction, while to neglect the motivated learner is to stunt their academic growth. Regardless of age, this unit can still be adapted for upper grade levels of students taking chemistry or environmental science.

Developing the Concept and Context

In IB MYP, key concepts are words used to paint a broad picture of learning expectations that can be observed within and across disciplines. Of the three fundamental key concepts recommended by IB (change, relationships, and systems), this unit will focus on the key concept of *relationships*.

Related concepts are more discipline-specific and allow for exploration of the key concepts in greater detail to cultivate students' conceptual understanding. The three related concepts selected for this unit's presentation are *quantity*, *measurements*, and *interactions*.

The conceptual phrase is a generic statement that summarizes a concept, is nonspecific, and can be applied across multiple content areas and topics. The conceptual phrase developed for this unit is as follows: ***Relationships*** *between* ***quantitative measurements*** *affect* ***interactions***. This conceptual phrase can be translated to topics, such as ion formation, acids and bases, solution chemistry, and redox reactions. Thus, students benefit from learning conceptual phrases because they potentially build continuity between old and new content.

Inquiry-Based Learning

Inquiry questions are provided for students as a guide to their learning expectations. They are not necessarily exam questions, but they ought to provoke students into learning the content. Below are the several examples of inquiry questions that can be used throughout the unit. Other potential questions for inquiry-based learning will be listed in the classroom activities as needed.

Factual Questions: What the derived units for molarity? What is a solution? What is a double displacement reaction? What are the names and chemical formulas soluble forms of lead? What are the names and chemical formulas for insoluble forms of lead? State the derived unit commonly used to express small concentrations.

Conceptual Questions: How does a solution differ from a colloid? How are a solute and solvent related? Explain how lead can be chemically separated. Explain why oil does not dissolve in water. Describe the challenges of chemically treating soil.

Debatable Questions: Is it worth the effort to remediate our soil? Can you put a price on soil remediation if it can save human lives? Do you believe that humanity has the ability to reverse the damage done to the environment using chemistry?

The global context is what allows me to connect my content to the real world. The IB program identifies six areas of global context. The context of this unit is in the area of scientific and technical innovation, where students will be challenged to understand the world that they live in and examine the impact that scientific and technological advances have on communities, environments, and human activities in order to meet a specific need. Ultimately, students will explore the risks, consequences, and responsibilities of having chemically altered the environment. The inquiry statement combines the conceptual phrase with the global context to clearly point the students in the direction of their learning. Therefore, the inquiry statement of this unit will be: Studying the relationships between quantitative measurements of chemical interactions in the soil can help humanity evaluate environmental risks, consequences, and responsibilities.

Assessment Criteria

The IB program identifies four areas of assessment for performance-based learning in science. This unit will primarily focus on two of those criteria. The first is “knowing and understanding”, in which students are required to explain and apply scientific knowledge and understandings while analyzing and evaluating information to make scientifically supported judgments. This will primarily be accomplished through performing calculations and reading literature concerning concentration of lead. The other is "reflecting on the impacts of science", in which students are required to explain, discuss, and evaluate how science is applied and used to address a specific problem or issue while applying scientific language effectively. This will be accomplished through student research and presenting their research findings.

Learning Activities

Overview of Unit Activities

Below, you will see a suggested timeline of strategically planned lessons and activities to engage students in learning. Activities marked with an asterisk (*) are ones developed specifically for lead safety. You do not need to follow this format exactly. If you find that these activities are best implemented in another area of chemistry content other than what is suggested below, feel free to adapt the activities to your curriculum map. I recommend that this unit is taught after students have demonstrated mastery in the topics of chemical reactions and intermolecular forces.

- 5-10 Days Prior to Unit: Collect Soil Samples for Lead Testing*
- Day 1: Lead-Safe WebQuest*
- Day 2: Introduction to Solutions
- Day 3: Calculating Concentration and Molarity
- Day 4: Solubility
- Day 5: Properties of Solutions
- Day 6+: Lead-Safe Infographic/Presentation*
- Post-Unit: Lead-Safe Education Interview*

Approaches to Learning

In this curriculum unit, students will exercise and develop several key skills or approaches to learning. Students will develop research skills by using web-based sources to acquire information about lead exposure in urban communities. After having collected information, they will develop critical thinking, communication, and social skills while collaborating with a partner to design literature and media that will educate members of the family and/or neighborhood.

Prior to starting this unit, students will engage in activities that help develop their research skills, which includes classwork and field work. The first activity requires that students collect soil samples from their homes 2-3 weeks prior to teaching the unit. More details about the assignment and its place in the curriculum may be found in the "Activity 1" section of this document. Students will continue to develop their research skills at the beginning of the unit in order to establish the context for teaching solution chemistry. As the second classroom activity, students will conduct guided research on lead exposure in homes via a web quest assignment. Afterwards, you are free to teach lessons on solutions and solubility as you see fit.

Once students have demonstrated mastery in tasks such as calculating concentration in parts per million, the students may deserve a break from the mathematics. The third activity gives the students an opportunity to develop their critical thinking and communication skills. Students will reconstruct their knowledge to design an infographic or presentation that summarizes important findings from their online research. Finally, students will have the opportunity to develop their social skills by interviewing and educating their neighborhood peers using their infographic. Ultimately, having had their own soil tested for lead contamination at the beginning of the unit, students will use the scientific results and their infographic to actively engage their communities and prompt neighbors to have the soil near their homes tested as well.

Activity 1: Collect Soil Samples for Lead Testing

Overview

The purpose of this activity is to awaken the students to be environmentally conscious. With the help of the Center of Excellence in Environmental Toxicology (CEET) of the University of Pennsylvania, I was given an opportunity to partner with them in the data collection of soil lead contamination in the City of Philadelphia. I asked my students to collect soil from a location near their homes. If the student does not have access to soil on their property, I suggested that they go to a nearby park where children play to collect soil. The CEET provided paper instructions on how to collect the soil (see Appendix). For the students' benefit, I published a video on YouTube of myself following those instructions (Phillips, 2019).

Preparation

This activity should be assigned at least 2-3 weeks prior to the conclusion of the unit for timely results. There should be enough time for you to review the results of the lead test and return them to your students before they begin the third activity. For example, I would recommend giving students one week to bring in soil samples. Then you must consider a date to deliver the samples to the research lab. Results will be generated after one week or 8-9 days, depending on number of samples provided. I also recommend playing the following video on YouTube if you cannot demonstrate the data collection in front of your students.

You must remember that university faculty may be conducting a variety of research. Unless you find a local research group that is dedicated to soil lead contamination like the CEET, then the soil testing becomes an additional workload for the research group. The

CEET at University of Pennsylvania requires that soil samples are dried for a week before analysis. Therefore, you must plan to receive the test results while you are in the middle of teaching the unit.

When you receive the results of the soil lead tests, the units will be in parts per million. Explain to the students how to interpret the results and have them refer to their webquest assignment. The CEET has provided an infographic explaining recommended precautions depending on the level (see Appendix).

Activity 2: Lead-Safe WebQuest

Overview

In this activity, students will conduct guided research with a list of questions and suggested websites. This assignment is a prerequisite to the Lead-Safe Infographic activity, in which students will use the information from this assignment to design the infographic.

Preparation

If your students readily have access to technology, then this webquest is as simple as creating a Google Doc and listing the questions with the appropriate websites. Without access to technology, I suggest printing copies of the questions so that students can write their answers. In addition, several web site offer PDF files that can be downloaded for print. Therefore, this activity can be adapted to a jigsaw activity by dividing the students into groups to look for specific answers to questions.

Sample of Assignment

Below are the list of questions and suggested websites to be used for the Lead-Safe WebQuest. Suggested websites can be found in the bibliography as cited.

1. State three major ways people can take lead into their bodies (US EPA, 2019).
2. List five problems that can occur in children due to high concentrations of lead in the body (US EPA, 2019).
3. Explain what is meant by the statement “the dose makes the poison” (“The Dose Makes the Poison Concept | Toxicity,” 2019).
4. Children are likely to have high concentrations of lead in the body due to their considerably smaller size when compared to adults. State another reason as to why children tend to have more lead in their bodies than adults (“Lead Poisoning Prevention Program - Community Development Agency (CDA) - Alameda County,” 2012).

5. Name five adverse effects that high concentrations of lead that are observable in adults (US EPA, 2019).
6. Explain why high lead levels and lead poisoning in children is associated with behavioral and learning problems ("Resources — Environmental Health Watch," n.d.).
7. Explain why lead poisoning is more easily prevented than treated.
8. In the past, lead was used as an additive to gasoline in the United States, but lead is still found in homes, particularly built before 1978. State four areas in older homes that contribute to the risk of lead exposure (US EPA, 2010).
9. What is the only method to prove whether or not a child has been exposed to lead? (US EPA, 2010)
10. List five practices that can help protect children from lead exposure in older homes (US EPA, 2010).
11. At what concentrations of Pb is it too dangerous to grow garden crops? ("Soil and Plant Nutrient Testing Laboratory: Soil Lead: Testing, Interpretation, & Recommendations | UMass Center for Agriculture, Food and the Environment," 2016)
12. At what concentrations of Pb should someone contact a local health department or environmental agency? ("Soil and Plant Nutrient Testing Laboratory: Soil Lead: Testing, Interpretation, & Recommendations | UMass Center for Agriculture, Food and the Environment," 2016)
13. What types of chemicals/additives can be added to soil to reduce exposure to soil lead? Where can someone purchase these? (Stehouwer, 2010)

Activity 3: Lead-Safe Infographic

Overview

This activity focuses on giving the students an opportunity to reconstruct their knowledge for the purpose of service learning. Students will use their research from the Lead-Safe WebQuest to design a presentation on creating lead-safe homes with three major headings. The presentation can be in the form of a one-page infographic or three-slide presentation. Students will select two (2) questions from the Lead-Safe WebQuest that will become two headings for their infographic. Question number ten (10) of the webquest (five ways to protect children…) is a mandatory third header for each infographic.

Preparation

If students are working without electronic devices, the assignment can be completed on paper using art supplies. However, if students work in pairs, this can be an implication when it is time for the students to share their presentations at home in the follow-up activity. Since a pair of students will share a physical copy of their infographic, they will need to decide who can take it home and when so that they can complete the interviews. Another option includes allowing students to complete their interview in pairs as well.

If students are equipped to work using Google Slides, you should create a blank template for the student that already contains three blank slides. I would go as far as even to create a box that includes the students' name on the first slide. Ultimately, electronic presentations make the follow-up activity more readily accessible as students can present the infographics from their phones or other digital media devices.

Activity 4: Lead-Safe Education Interview

Overview

This activity is designed to get the student to participate in science education outside of the classroom. Students will interview a neighbor or non-household friend/relative. The interview should not take longer than 15 minutes. As part of the interview process, the student will present their lead-safe infographic or presentation. After conducting the interview, students will ask whether or not the participant would like to have their soil tested for lead contamination. Students must return a written or typed interview even if the participant refuses to have their soil tested.

Preparation

Provide extra snack-sized resealable bags and plastic spoons with instructions on collecting the soil. Provide paper copies of the interview questions. Consider giving students extra credit for receiving a soil sample from the participant who interviewed. Remind students that this is a real science experiment and they are not to provide false or inaccurate data about the soil sample they collected under any circumstances in order to preserve the integrity of the study.

Sample of Assignment

Instructions

You will select either a neighbor or nearby relative who does not live in your household to interview about his/her knowledge of environmental toxicology concerning lead exposure. Note: you may not interview yourself or your parent/guardian. You must explain the requirements of your assignment and ask permission to take notes as you will record the participant's answers. You are responsible for locating this person. Your teacher will not assist you in locating this neighbor or relative. Ask your parent/guardian to assist you.

When prompted towards the end of the list of interview questions, share your presentation about lead-safe homes with the participant and ask if they would like their soil tested for lead contamination. If the participant agrees, collect the soil sample as you did with your personal sample and return it to school with the name of the participant, your name, date, and GPS coordinates (latitude and longitude).

Interview Questions

1. First and Last Name of Person being interviewed:
2. Relationship to the interviewer:
3. Date of the Interview:
4. Do you, or have you, given any thought to toxic chemical exposure of your children or anyone in your home?
5. What household chores do you regularly perform to keep your home environment clean or free of toxic chemicals?
6. What are your primary concerns or worries about chemical exposure in the home?
7. Consider your risk of chemical exposure or pollution in your neighborhood. Do you feel you are at a low- or high risk of chemical exposure? Explain why.
8. What do you already know about lead poisoning?
9. If there were programs that could assist you in determining your risk of chemical exposure in your home, such as lead exposure, would you participate? Why? or Why not?

Closing Script for Students: I've had my soil tested with the help of my chemistry teacher and a local university and I would like to share my results with you. If you would like your soil tested for lead contamination, I can collect it for you. It will only take 5 minutes.

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Appendix

State of Pennsylvania Content Standards

CHEM.A.1.1.3 Utilize significant figures to communicate the uncertainty in a quantitative observation.

CHEM.A.1.2.1 Compare properties of solutions containing ionic or molecular solutes (e.g., dissolving, dissociating).

CHEM.A.1.2.2 Differentiate between homogeneous and heterogeneous mixtures (e.g., how such mixtures can be separated).

CHEM.A.1.2.3 Describe how factors (e.g., temperature, concentration, surface area) can affect solubility.

CHEM.A.1.2.4 Describe various ways that concentration can be expressed and calculated (e.g., molarity, percent by mass, percent by volume).

CHEM.A.1.2.5 Describe how chemical bonding can affect whether a substance dissolves in a given liquid.

Pennsylvania Department of Education Standards Aligned System

3.2.C.A1. Differentiate between pure substances and mixtures; differentiate between heterogeneous and homogeneous mixtures

3.2.C.A4 Predict how combinations of substances can result in physical and/or chemical changes.

3.2.12.A1. Compare and contrast colligative properties of mixtures.

Common Core Standards

CC.3.5.11-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

CC.3.5.11-12.B: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

CC.3.5.11-12.C: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

CC.3.5.11-12.G: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

CC.3.5.11-12.H: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

CC.3.5.11-12.I: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

CC.3.6.11-12.F: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

CC.3.6.11-12.H: Draw evidence from informational texts to support analysis, reflection, and research.

Next Generation Science Standards

HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.].

HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Soil Sampling for Lead Resources

How To: Collect Soil Samples for Lead Testing

WHAT you will need to sample

- Clean plastic spoon for each sample.
- A permanent marker.
- Clean plastic bag with a Ziploc closure for each sample.
- An outdoor sampling location with bare soil.

HOW to sample

- With a permanent marker, write your **name, date**, and **sample location** on each plastic bag. GPS coordinates are preferred over address.
- Choose up to 5 places at least two feet apart with exposed soil.
- Draw an imaginary "X" on the ground. You will take small samples from the middle and each corner of the "X".
- Collect the top ½ inch of soil from each of the 5 places with a clean plastic spoon.
- Put the composite samples (about ¼ cup) in the same plastic bag and seal the bag.
- Repeat sample procedure with a new plastic bag at a different location.
- Deliver samples to your teacher. An appointment will be made with a researcher to test the soil.

Infographic: Interpreting Soil Lead Concentrations