The Flint Michigan Water Crisis

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Introduction

William Penn High School is in a unique position as the only high school in the New Castle County area, serving a large population from Pre-K to High School. The Colonial School District serves a diverse community, reaching areas such as Wilmington and Middletown. Within the last six years, WPHS has revamped its academic framework, shift from the traditional four model to a more specific structure that mirrors that of a college. Within WPHS, there are three colleges, Business, Humanities, and Science, Technology, Engineering, and Mathematics (STEM). The establishment of these colleges affords each student the ability to self-select program that provides college and career readiness. Students within our population are opting for a new trajectory, specifically career readiness and with that, our programs provide opportunities for certification in legal studies, EMT, EKG, Phlebotomy, Air Force Jr. ROTC, Manufacturing (Delaware Technical Community College) online courses and most recently the opportunity for students to earn college credits during his or her senior year. The new administration for the Colonial School District deemed it important to provide alternative routes for those not focused on a four-year college trajectory. In addition, with neighboring vocational schools providing specific trade opportunities, it was imperative to attract students to WPHS and prepare students for impending changes in the job market.

In addition to establishing specific colleges and opportunities for students to receive certification in the aforementioned courses, other programs in agriculture, culinary, engineering, medical laboratory (partnership with Christiana Care and UDEL), exercise science, computer science, and robotics. Colonial School District serves approximately 9,900 students each school year and has remained consistent over the past 15 years. WPHS currently serves 2200 students 48.9% African American, 21% Latino, 25.7% Caucasian and the remaining population Asian, American Indian, and Hawaiian. With the construct of our colleges, there is an evident shift to the alternative career readiness route specific to students of color and of low socio-economic status.

As a Department Chair and lead Chemistry teacher, one of my charge is to improve enrollment in our STEM program, increase rigor and to explore different STEM opportunities for incoming 9^{th} grade students. With the shift from a traditional science instructional approach to the Next Generation Science Standards, there is a concerted effect to incorporate a more inter-disciplinary approach to lesson development, showing more relationship to real world phenomena-based exploration. Teaching Honors Chemistry, affords me the opportunity to introduce students to new topics that are

transferrable to different disciplines with an emphasis on the meta-cognitive aspect, why is this important to my community and as a student.

With 40% of student population categorized as low income and 20% special education, differentiation of our lessons is paramount. To complement this approach, the Colonial School District has invested significant resources in technology providing one-to-one technology, and the use of an online platform Schoology. Utilizing these resources underscores a push towards blended lessons, incorporating simulations, videos, scaffolded online activities, and survey and assessment tools. Today, there is disconnect between what is taught in class as in relates to students and their perceived value and importance of the lesson to their community and environment.

Rationale

The infrastructure within the United States is aging. The news media is reporting a pipe rupture or water main break more frequently. The aging system that supplies drinking water and extracts waste are traditionally made out of iron or lead. They were not projected to perform at the current increased demand. With changes in the water, additives, pressure points, vibration, road construction, and the addition of anti-corrosive additives; all factors point to infrastructure failure and potential contaminants that result from chemicals reacting within the water supply being consumed by the public. In Flint, Michigan the decision to change water sources created an inevitable disastrous chemical reaction from an increase in pH, seepage of lead in the water system, and resulting in potential long-term impact on human health and the environment.

Identifying the appropriate lessons and the online resources is paramount in making connection and relevance, along with identifying the appropriate readings. This unit specific to the Flint Michigan water crisis is reflective of what is happen in other states and other countries. Specific to this unit, the NGSS standard 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, the resulting effects of the municipalities decision to switch the main water source from Lake Huron to the Flint River. An event such as this as noted is not uncommon and will not become public knowledge unless there is a public outcry to investigate observed changes via smell or reported illnesses. Another area of concern are these occurrences observed more frequently within inner city developments, what actions are taken to address the issue regarding public health and environmental concerns.

This unit integrates science concepts from environmental science, chemistry, sociology, public health and politics. This unit requires students to engage in extensive research and reading, presenting data from evidence through an a la carte list of presentation formats, and finally argumentation from evidence. Students engage in hands on experiments to predict changes in a system once equilibrium is disrupted with

different metals and acids at varying molar concentrations. Students have an opportunity to develop and use models, analyze and interpret data by collecting data specific to pH level changes.

Students research to assess the long-term impact of exposure to harmful chemicals, specifically lead, and the resulting impact on brain chemistry linked to post traumatic stress disorder, Legionnaires disease. In the case of the Flint, Michigan disaster, numerous cases were reported of illnesses observed after the crisis; however, no one clearly knows the long term impact and who is responsible to monitor those exposed to these harmful chemicals. Will the public feel uneasy with drinking public water in the future, and how will this compound mental health and PTSD cases?

Through experimentation, students observe the level of reactivity and increased acidity to four selected metals. Students monitor the changes in pH, observe the volatility of the reaction, and observe other changes such as temperature or gas formation. Students assess the impact of increased pH on the human body along with environmental issues that will result from continued exposure. Concepts such as the Le Chatelier's principle, specific to chemical equilibria and Kinetics specific to the projected time it will take a harmful chemical to meet an acceptable permissible level for consumption will allow students to observe the subtle effects of the above stated variables.

The final aspect of this unit addresses the political concerns, such as, who is believable, credible, trustworthy, and takes ownership of a crisis, such as the Flint, Michigan crisis. In response, Flint officials continued to insist that the city water was safe to drink and there was no relationship between health problems and water quality. As a point of discussion, students will examine whether public officials are responsible for the long-term impact on public and environmental conditions and how their continued denial of the severity of disasters affects the public's trust. Students research how decisions are made specific to a region; how and when infrastructural repairs are made and how decisions are made on where landfills reside. Within this final component, students develop a survey to determine a community's level of preparedness in the event of disaster. The survey focuses on catastrophic infrastructural failure resulting from chemicals long and short term.

Content Objectives

- Create a model demonstrating the effects on varying molar concentrations on different metals.
- Analyze and interpret data specific to pH levels and its effect on humans and the environment specifically farmlands and rivers streams.

- Explain how increase in water toxicity contributes to debilitating diseases and PSTD both long and short term along with the financial strain on both the state and the public.
- Demonstrate how inaccurate reporting creates distrust between the public and elected officials.

Background

America's Infrastructure Issue

Environmental disasters, also called environmental emergencies, are disasters caused to the natural environment by human activity.[1] Human activities can be deliberate or unintentional, such as engineering failures or industrial accidents. Other calamities may be a combination of naturally occurring events triggering or exasperating engineering or industrial accidents. Some disasters are triggered by storms and/or earthquakes resulting in loss of life, both human and animal, and also environmental losses. These disasters create disruptions of the ecosystem and loss of biodiversity.[2] Recent disasters include the nuclear accidents at Three Mile Island in 1979 resulting from a meltdown releasing small amounts of radioactive gases. In 1986, the Chernobyl explosion and the Fukushima Daiichi disaster in 2011, created radioactive smoke causing 60 reported deaths and large-scale evacuation and relocation from Belarus, Ukraine, and Russia. In Guadalajara in 1992, a sewer explosion was caused by poor design and placement of zinc-coated pipes too close to an underground steel pipeline. Humidity in the city created a chemical reaction between zinc and steel causing corrosion and leakage of gasoline into the city water supply and sewer system. Though residents did complain of gasoline odor, no action was taken. Explosions in the sewer system destroyed miles of streets with multiple deaths and injuries. In Romania, a dam failed from heavy snowfall releasing 300,000 cubic feet of cyanide. The contaminated water spilled into farmlands, contaminating drinking water supply, killing fish and wildlife. Another incident occurred in this area five weeks later releasing heavy metals as zinc, copper and lead into the Tisza.[3]

Industrial toxins have also created disasters. The Seveso disaster of 1976 released large amounts of dioxin from a chemical manufacturing plant. Dioxin is a toxic substance that can contaminate soil as well as work its way up the food chain. It is reported that 3,300 animals were killed immediately after this disaster. A report in 2011 found an increase incidence of cancer among women of Seveso 30 years after the disaster.[4] Additional industrial accidents include Bhopal in 1984, Love Canal in 1978 and Sandoz spill in 1986. As recent as 1989, major oils spills were reports including Exxon Valdez and Deepwater Horizon in 2010. Coastlines of four states were severely affected by tall balls washed up on the shore, crippling tourism and fishing industry.

The varying types of disasters, their relationships to natural weather patterns and storms; and the dependence of modern society on construction and manufacturing processes make it unlikely that environmental disasters can ever be completely prevented.[5] With the unlikelihood of completely preventing all disasters, humans have the ability to learn from these disasters and to prepare for the aftermath accordingly.[6] One emerging trend following disasters are the unusual and unexpected challenges on mental health and physical well-being on humans and the community.[7] [8] Another emerging finding is the disparity with disaster responses in areas where those affected were of low socio-economic status (SES), mostly poor and African American.

The students at WPHS may identify disasters as hurricanes, earthquakes, fire, tornados and flooding. Unless they emigrated from other countries familiar to cyclones, super volcanic eruptions, tsunamis, landslides, typhoons, famine, and pandemic diseases, students would be unfamiliar with the aforementioned types of disasters. One common theme familiar to students is global warming, climate change, and their effect on prolonged and increased severity from natural disasters. Scientists may link climate change and disasters, to the increase and or intensity of some natural hazards. To simplify for students, the climate system can be considered as a heat engine, distributing radiation energy from the sun.[9] The energy differences are based on temperature gradients that drives circulation.[10] Students associate these variations based on observed extended heat waves, unusually warm winters, and reduction in rainfall. Students also associate climate change to extreme flooding resulting from rising sea levels. In the Southbridge area of Wilmington, Delaware, public perceptions on the root cause of flooding, pollution and contamination varies based on age, length of residency, education and perception.[11] To underscore the likelihood of a disaster occurring in Wilmington, the Flint, Michigan disaster is referenced as a model to reflect an impending disaster facing Wilmington, specific to low line gradient areas such as Southbridge. Students through this lesson will research impacts on the environment, pollution and contamination, infrastructure incurring damages (oil/gas storage facilities), seepage of contaminants in water and sewer systems, impact on health, disaster preparedness, social changes, communities most affected (race/ethnicity), disaster response (agencies), media reports (false or inaccurate) and the psychosocial and mental impact on the community.

The Aging Pipe System

The provision of safe and sustainable drinking water is one of the hallmarks of a successful society.[12] A community with safe drinking water is susceptible to public health risks, and the full economic potential will not be recognized. There is opportunity for recontamination and microbial growth during distribution and plumbing posing the greatest risks to public drinking water.[13] It is reported that an estimated 500,000 water main breaks occur each year in the United States with the American Society of Civil Engineers giving the U.S. water system a “D,” rating, indicating poor.[14] In close proximity to Wilmington, Delaware is the city of Philadelphia. Water main breaks occur

frequently, creating havoc of businesses, transportation, disaster management costs, community inconvenience, and mental health issues resulting from the concern or lack of trust. Treating water serves to remove human pathogens, suspended particles, organics, disinfection by-products and finally compliance with regulations.[15] In 1974, the United States Congress passes the Safe Water Drinking Act to minimize the incidence of water borne pathogens. Though there are systems in place to monitor water quality, the aging water distribution system is aging, and as such, the distribution system can fail unexpectedly.[16] Of particular interest to students are the causes to distribution deterioration that may not come to mind such as firefighting, and sports events that depressurizes the water system, subsequently drawing up contaminated water. In addition, the chlorine-based disinfectants can be overwhelmed during the treatment process allowing the reintroduction of pathogens that remain infectious. Evidence supports corroded, unlined metallic pipe absorb disinfectant residuals. An area of interest to encourage students to research, are the decisions made on what areas should be repaired first (water distribution system), is it based on taxes, the presence of prominent businesses, race, or income status.[17]

Flint, Michigan, is the seventh largest metropolitan area in state of Michigan, and with a population of nearly 100,000 people, it was ravaged with high crime, financial distress and most recently an escalation in public health crisis. As reported nationally, the most pressing issue occurring in Flint was the high levels of lead that leached out from pipes and entered the city's water supply system. The issues resulted from a decision made by the state-appointed emergency manager to switch the water supply from Detroit's system, which comes from Lake Huron, to the Flint River as a cost savings measure. The water from Lake Huron was treated with anti-corrosives, but none to the Flint system.[18] The untreated water created a chain reaction compounded by an aging distribution system that favored the growth of bacteria, including *Legionella pneumophila*. To provide an economical backdrop of Flint, many towns in Flint were once bustling with automotive plants; however, as of the 1980's those plants were closed with an estimated 40% of families below the poverty line and 57% of the population African American.[19] Residents reportedly complain about water color, taste, and odor. Officials reportedly minimized the issue, reporting there was no imminent threat to the water system.[20]

Economies of Scale

Most old water systems in the U.S. have some lead in the pipes; however, in most established cities, softer water sources or treatment of the water occurs before it goes through the system with phosphates for preventative corrosion control. Lower pH of the river water allows the lead scale and lead ions to become more soluble. The issue of lead in the water distribution system also occurred in Washington in the early 2000s resulting in the Lead and Copper rule. General Motors noticed the issue two months after the switch in water distribution; increased rusting in every item produced. Testing by GM showed elevated levels of chlorides allowing the water to more easily oxidize metals.[21]

GM officials reported the issue to city officials; however, they failed to act, prompting GM to switch back to the Detroit water system. Science took a back seat to financial and political concerns. This cautionary tale will serve as a discussion point for students to discuss the immediacy of the disaster response team, and city officials. If the location of this disaster was different would there have been a swifter and prompter response? What would be the response of DEMA officials in Delaware if a category 5 hurricane affected Southbridge with known contaminants from chemical plants looming as potential disaster to the water and sewer system?

Lead Pipes

The American Chemical Society reports that cities adjust their water's chemistry to control water pipe corrosion.[22] One way cites do this is by the addition of phosphates to the water. The compound helps maintain a protective mineral crust in the pipes, which prevents corrosion. Environmental engineers note that without the phosphate, the protective crust dissolves, exposing pipes, allowing the lead to leach in to the water.[23] When iron pipes corrode, the exposed iron can react with, and break down, the chlorine added to the water as a disinfectant.[242526] Switching to water supplied by Detroit did not improve the quality of the Flint River. With the passage of the Clean Water Act in 1972, the Flint River showed some improvement upstream, but downstream there were significant toxins.[27] The toxins included raw sewage from Flint's wastewater plant containing fecal coliform bacteria, and phenol from GM plants. Fertilizers in rural areas also polluted the river. Road salt raised the rivers chloride levels making the water more corrosive. [28]

Lead is a lustrous bluish-white metal when freshly cut. When exposed to air, it tarnishes and turns a gray color. This serves as a protective coating. Lead is soft, highly malleable, ductile, and a poor conductor of electricity (compared to other metals). It is a moderately active metal. It slowly dissolves in water and cold acids. It is rarely found free in nature and generally found in ores such as galena, PbS (lead sulfide); anglesite, $PbSO_4$ (lead (II) sulfate); and cerussite, $PbCO_3$ (lead (II) carbonate). Lead makes up only 0.0013% of the Earth's crust, but is not generally considered rare, since it is easily mined and refined. Elemental lead was most commonly obtained historically by roasting galena in hot air. Today most elemental lead is obtained by recycling. Lead is produced around the world, with Australia, China, the United States, Peru, Canada, Mexico and Sweden being the largest producers.[29]

Corrosion is a natural process that occurs when metals react with oxygen and form metal oxides.[30] All water contains some dissolved oxygen and is therefore somewhat corrosive. The rate of corrosion depends on the water's pH, electrical conductivity, oxygen concentration, and temperature. In addition to corrosion, metals dissolve when the water is extremely low in dissolved salts and in the presence of certain water-borne ions. This process causes the plumbing material to gradually dissolve. Though corrosion

and dissolution are fundamentally different, the result is similar, and they are generally discussed as corrosion.

Modification to Current Piping System

One way to correct or prevent plumbing system corrosion is to install corrosion-resistant components. Most often, this involves replacing copper pipe or substandard plastic pipe with approved plastic pipe. PEX plumbing has gained wide acceptance in recent years. Unlike PVC, many PEX manufacturers claim it can tolerate high heat and freeze solid with no damage. Approved plastic pipe is stamped with NSF (National Sanitation Foundation) and Drinking Water on the side. Local plumbing and building codes vary; consult local regulations before replacing or installing plumbing materials.[31]

Chemistry Behind the Seepage of Lead

The corrosion process is an oxidation/reduction reaction that converts metals to metal ions. The most familiar example of corrosion is the rusting of iron. The green coating called patina that forms on bronze statues is another type of corrosion. The green color is caused by the formation of copper ions. Corrosion is a complex reaction, but it can be understood if it is considered an electrochemical process. An electrochemical cell consists of two cells called half-cells. Each half-cell contains a metal electrode and an electrolyte. The half-cell where oxidation occurs is called the anode, and the one in which reduction occurs is called the cathode. The electrons naturally flow from the anode to the cathode, creating an electrical current.[32]

The following equations describe the reactions discussed in the diagram above.

At the anode:

$$Fe\ (s) \longrightarrow Fe^{2+}\ (aq) + 2\ e^-$$

At the cathode:

$$O_2\ (g) + 2\ H_2O\ (l) + 4\ e^- \longrightarrow 4\ OH^-\ (aq)$$

In the water droplet above, the iron (II) ions and the hydroxide ions combine to form a precipitate:

$$Fe^{2+}\ (aq) + 2\ OH^-\ (aq) \longrightarrow Fe(OH)_2\ (s)$$

The precipitate quickly oxidizes to form rust (Fe_2O_3):

$$4\ Fe(OH)_2\ (s) + O_2(g) \longrightarrow 2\ Fe_2O_3 \bullet 2\ H_2O\ (s) + 2\ H_2O\ (l)$$

The corrosion of pipes used to distribute drinking water causes problems, such as: contributing toxic metals to the drinking water; staining laundry, sinks and tubs; and creating a poor taste. The metal water pipes are made of a variety of metals including iron, copper, galvanized steel and lead. Many factors affect the rate of corrosion in these water pipes including the pH of the water, concentration of oxygen dissolved, the chemical composition of the water, the temperature of the water, and the velocity and pressure of the water. Water that is slightly basic, with a pH of around 8, is less corrosive, while slightly acidic water, with a pH less than 6.5, will be very corrosive. Water exposed to air dissolves oxygen. Oxygen is an oxidizing agent that causes the metal pipes to be oxidized, resulting in corrosion which adds metal ions to the water. The chemical composition of the water may have varying effects on the corrosion of the plumbing.[33]

Effects of pH

The degree of acidity of a substance is determined by measuring its pH. The pH range commonly goes from 0 to 14 and a neutral substance has a pH of 7. Substances with a pH of less than 7 are acidic and greater than 7 are basic. A small number of water molecules dissociate into hydrogen ions (H^+) and hydroxide ions (OH^-). In pure water the number of H^+ and OH^- ions are equal, and the pH is 7. Hydronium concentration is a measurement of hydrogen ions, H^+, and is believed to stand for the "power of hydrogen". Another key principle that demonstrates the seepage of lead resulting from the increase in pH is called the Le Châtelier's Principle. Le Châtelier's principle is also known as the equilibrium principle.[34] In chemistry, a dynamic equilibrium occurs when the tendency of the reactants to form products is balanced by the tendency of the products to form reactants. This occurs when the rate of the forward reaction is equal to the rate of the reverse reaction. The composition of a system at equilibrium can change if certain conditions change. Any change (also called a stress) in a chemical reaction at equilibrium causes the reaction to proceed in the direction that reduces the effect of the change. Stresses, changes in concentration, pressure/volume and temperature, all cause a reaction to proceed in the direction that reduces the impact of the change. The lead levels within the Flint water systems grew to dangerous levels due to local government not anticipating the extent of the corrosion that would occur between the water and the lead pipes that transferred that water to civilians.[35] Corrosion is affected by the equilibrium of electrons between cathodes and anodes. In the case of Flint, as electrons were balanced in the system of the water pipes, lead was being corroded off into the water itself. This resulted in exorbitant concentrations of lead within the water system, which can also lead to the growth of pathogenic microbes within the water, making that water dangerous to consume.[36]

Toxic Trauma

During the period of revelation from General Motors regarding contamination, local officials took no action. General Motors recognizes the severity of the issue, and the

potential impact on businesses, acted accordingly and changed water source.[37] For the rest of the homes and businesses in Flint, nothing was done and residents continued unbeknownst to them, drinking, bathing and cooking with contaminated water. There were noticeable rashes prompting Flint Michigan residents to discontinue using tap water and purchasing bottled water. Outside experts along with a local pediatrician gained traction with gaining the attention of public officials. The question students will address is the opportunity cost. Was the intent on saving $270 million dollars worth the long term health concerns? Mona Hanna-Attisha, MD., a local pediatrician studied blood levels in Flint children from 2013 to 2015 before and after the water change.[38] In her findings, children in the affected area reported four times the amount of lead in their blood system. Lead exposure in young children can lead to decrements in intelligence, development, behavior and other neurological functions. It also diminishes creativity, the ability to weigh consequences, make good decisions, impairs language, shortens attention span and predisposes to hyperactive and aggressive behavior.[39] Higher levels of lead were identified in male patients of non-Hispanic, Black background. Mostly the poor, specifically the African American population, are affected by this avoidable disaster. Several reports noted that race was one of underlying decisions that led to the disaster in addition to the delay or lack of response prompting some activists in stating that this incident represents environmental racism; a clear violation of environmental justice. Dr. Bullard, Dean of Schools at Texas Southern University, noted that it takes longer for the response and it takes longer for the recovery in communities of color.[40]

A similar disaster occurred in southern Colorado and New Mexico resulting from waste leaching high levels of lead, arsenic and cadmium. This halted agricultural and recreational use of the river by the Navajo Nation. This has created severe health issues, with no adequate reimbursements resulting from hazardous waste disposal, illegal dumping and mining wastes. This highlights how too often poor and minority communities are often exposed to poisonous chemicals leading to environmental injustice.

Soon after the switch in water source in Flint, residents began voicing their concerns that the water was discolored, had a bad smell and taste and was causing health problems.[41] Officials in both the city and state initially dismissed the complaints as insignificant. Accordingly, once the water was switched back, some of the health problems continued. Residents' reactions created distrust of government because their concerns were discounted and how long it took officials to act. Residents felt isolated, angered, disillusioned from the actions of officials. Comparisons were made between Flint and Hurricane Katrina, specific to the ethnicity of those affected, the health costs and the disproportionate impact on low-income residents. Research was conducted to assess mental health concerns or issues reported following the Flint disaster.[42]

Researchers assessed the self-reported socioeconomic and health impacts as well as coping mechanism by adults living in areas affected by the lead exposure in Flint,

Michigan.[43] The data reported 75% incurred additional expenses resulting from additional monthly expenses, 40% of parents reported changes in their children's health and 99% reported the use of both positive and negative coping mechanisms. The report noted, high-risk residents reporting multiple social, economic, and health related consequences stemming from the Flint crisis. The results also indicated increased expenses in purchasing water bottles (lack of trust), sick children, inability to work, stomach/digestive issues, and rashes. What is interesting about the results of research is the reported impact of all the residents those directly and indirectly affected by the crisis. An increase in stress-level had the most devastating impact on low-income residents. They exhibited noticeable behavior changes and there was an observed increase in depression amongst residents. Additional results from the research noted that though depression was identified as an additional mental health effect of the water problems, it was cited less frequently than anxiety or stress. Other observed trends include increased substance abuse, triggered by other variables such as reduction in property values, job loss, restaurants no longer lucrative, and the shortage of summer job opportunities.

Based on research, there is an increase in stress created by the potential and permanent physical health effects of lead exposure, the findings of high lead levels in children and the lack of knowledge of where to find lead testing for children.[44] To address this issue Genesee County panelists recommended intervention to help restore the fiscal health and support for the provision of basic public services. In addition to increase levels of stress, depression, anxiety, research concluded there is an increase in residents experiencing post-traumatic stress disorder (PSTD).[45] The American Psychiatric Association defines (as cited posttraumatic stress disorder (PTSD) is defined as a mental illness that can result from experiences of traumatic events. The study showed residents who were exposed to water with high levels of lead experienced greater PTSD symptomatology. Recommendations in all the above stated research suggest allocating resources to conduct further testing of children affected by the crisis to monitor long-term health impact not just physiologically but mental health included.[46]

No level of lead is safe, and fills no essential function in the body. Injuries caused by lead poisoning tend to be permanent, and the effects can last years or a lifetime.[47] Chelation therapy can remove lead from the body, but the effects remain. The degree of exposure to lead depends on the concentration of lead, the route of exposure (air, water or food), and the current medical condition and age of the person. Fetuses, infants, and young children are particularly at risk to lead poisoning since their bodies are growing quickly, which facilitates the bioaccumulation of lead. Copper contamination causes gastrointestinal problems in the short term and progressively damages the liver and kidneys. Lead contamination can cause physical and mental development problems in children. In adults, it can lead to high blood pressure and kidney problems.[48]

When lead enters the body it initially goes into the blood. It is then distributed throughout the body. Most of the lead is then stored in the soft tissue, bones, and teeth.

Only about 1% remains in the blood. The lead stored in the bones and teeth remains there indefinitely unless it is released back into the blood during a time of stress. When lead is present in the body, especially when present in high concentrations, it tends to compete with magnesium ions, Mg^{2+}, calcium ions, Ca^{2+}, and iron ions, Fe^{2+}. When lead ions, which are also divalent, replace these ions in enzymes, they render the enzymes ineffective. This potentially affects every organ of the body. Lead ions and calcium ions react in similar ways under similar conditions. As a result, lead is absorbed into the bones, replacing calcium. This is a problem for young children who are building bones because as lead is deposited instead of calcium, growth is stunted.

Reliability of Disseminated Information by Elected Officials

Three aspects of media depictions of Hurricane Katrina were analyzed and the relationship between race and coverage of the crisis, media language use surrounding two key phrases as well as descriptions of looting versus finding food.[49] Loot loops and Ralli depicted two news service photographs taken in front of a grocery store. One image has a black male carrying food items waist deep in water and the other a white couple carry food items as well in similar conditions. [50]The caption reference the black male referenced looting while the other caption read two-resident waist deep in water after finding bread and soda. One writers alleges they say the black male taking the items but nothing corroborate the other story. Is race considered a factor when news media report incidences in times of disaster? In another case, a report was submitted noting the recipients of aid delivered to a rest stop exhibited deplorable behaviors. Upon fact checking, the manager at the rest stop categorically denied the incident occurred. The Katrina incident flooded the internet will allegations that depicted the victims as looters inciting violence, suggesting that aid be delivered to white only residents. In the Flint Michigan Water crisis, officials categorically denied the emergence or presence of any pollutants in the water system. The same occurred in Washington DC, in Colorado and Mexico. Most recently in Puerto Rico mainstream media noted, that no one cared about Puerto Rico with President Trump lambasting and blaming the island for its desperate situation on Twitter.[51] As noted previously, and specifically Flint Michigan, disasters creates disruptions mentally, emotionally, financially, economically with long term financial costs to restore normalcy and costs associated with reported cases of stress, depression, anxiety and PTSD. In times of disaster to whom should residents consult for coping mechanisms. Are established coping mechanisms more readily available in more affluent areas and if so what resources must be in place to create these coping mechanisms? If the news media does not convey reports fair and equitable, what outlets can be trusted to ensure that resources are mobilized in times of disaster, a meeting location and the means to trek to these locations?

Teaching Strategies

Collaborative Groups

Working together with peers is a life skill that students need to practice and to accomplish tasks. Collaborative learning allows students to build higher level thinking skills, builds self-esteem, fosters different dialogues from each students perspective, it creates an environment for students to engage problem solving techniques (NGSS) and when used effectively can reflect real world social issues. Individual and group evaluations are essential to monitor the group's work and their progress in working as a team.

Laboratory reports are performed, prepared, and presented by groups of four. In addition to the data collected by each group, three additional sets of data are included in the final report. Each group will discuss their findings by identifying common trends, discrepancies, compare, contrast, and validate their claim from data using classroom results and peer-reviewed journals. Students may opt to present using a tri-fold, PowerPoint, or Prezi.

Think Pair Share

Think-Pair-Share is a strategy for students to respond to questions. It allows for collaborative learning. Students think critically and generate conclusions about a prompt or question. They then pair up with an assigned partner (or a peer of their choice) and share the conclusions they developed. The Think-Pair- Share strategy will be implemented to allow the students to collaborate and share their ideas on the author's intentions and use of persuasive techniques. We will use this technique when students share their thoughts on the discussion forum on Schoology.

With this activity, students will discuss amongst themselves beliefs and biases concerning the media, perceptions with their community, comparisons with areas noting similar disaster issues and finalize the types of questions fitting in language and concern for their community.

Student Activity

Students will engage in a study in effects of different acid concentrations and how they react with different metals. Students will assess the both qualitative and quantitative observations. Students will measure the pH before and after to assess the varying pH changes.

Experiment 1

Students will be given three metals a nail, copper wire, zinc, aluminum, lead shots and nickel. Students will use varying concentrations of Hydrochloric Acid and will asked to

describe what they observe quantitatively and why. Students will be asked to provide their answers using the table below.

	Volatility	Production of a gas	Temperature change	Color change	pH (LabQuest)
Metal					
Metal					
Metal					
Metal					
Metal					

Students will repeat this experiment three more times using a 1M HCl, 2.0M HCl, 3.5M HCl solutions. Using the activity series and effect increase pH has on reactivity, students will justify the observed changes. This experiment will serve to demonstrate the effects on increased pH and perhaps why certain metals are not used within our water distribution system.

Students will conduct research to highlight the correlation with increase pH and levels of lead to the specific health issues. Students will be asked to engage in research to identify the most common reported toxins/contaminants that located below the surface in the Southbridge area of Wilmington in addition to where they currently reside. Students will identify the specific contaminants, health effects of prolonged exposure, what is being done to remove these contaminants, what could trigger or agitate these contaminants (natural versus human disasters). If there were reported incidents of contaminants, what are the key health impact, disaster response strategies and specifically how these health concerns were addressed it at all. Using data from observed pH changes students will identify specific diseases resulting from increased exposure in lead. Students will research the effects of prolonged exposure, identify systems used to track patients still living in the affected area or relocated and the effects of toxic trauma as it relates to mental health, depression and PTSD.

Experiment 2- Le Chatelier's Principle

This experiment mirrors a laboratory activity Flinn Scientific (purchased). This laboratory activity is inquiry based, incorporating the NGSS framework. The purpose of this experiment is to calculate the equilibrium constant for the reaction of iron(III) ions with thiocyanate ions. The reaction is tested under different conditions to determine if the equilibrium constant always has the same numerical value. There are two parts to the experiment.

In Part A, a series of reference solutions and test solutions are prepared. The reference solutions are prepared by mixing a large excess of Fe^{3+} ions with known amounts of

SCN^- ions. According to Le-Châtelier's Principle, the large excess of iron(III) ions should effectively convert all of the thio- cyanate ions to the blood-red $FeSCN^{2+}$ complex ions. The concentration of $FeSCN^{2+}$ complex ions in the reference solutions is essentially equal to the initial concentration of SCN^- ions. The test solutions are prepared by mixing a constant amount of Fe^{3+} ions with different amounts of SCN^- ions. These solutions contain unknown concentrations of $FeSCN^{2+}$ ions at equilibrium.

In Part B, the absorbances of both the reference solutions and the test solutions are measured by colorimetry. A calibration curve is constructed from the absorption values of the reference solutions. The unknown concentrations of $FeSCN^{2+}$ in the test solutions are calculated by comparing their absorbance readings to the absorbance values of the calibration curve.

Required supplies

Iron(III) nitrate, Fe(NO3)3, 0.200 M, 30 mL† Iron(III) nitrate, Fe(NO3)3, 0.0020 M, 25 mL† Potassium thiocyanate, KSCN, 0.0020 M, 15 mL Potassium thiocyanate, KSCN, 0.0002 M, 20 mL Water, distilled or deionized, 0.200 M 30ml Silver Nitrate, $AgNO_3$, Potassium Oxalate, $K_2C_2O_4$ 0.200 M 30.0ml. Colorimeter sensor or spectrophotometer Computer interface system (LabQuest), 15* Computer or calculator for data collection Students will complete a series of pre-lab questions to confirm their understanding regarding equilibrium. Students will then be asked to calculate the concentrations of two mixtures at different dilutions. The reactants include an Fe3+ solution and a SCN- solution. Both solutions are colorless, however when they are mixed, a deep reddish-brown solution is formed. The intensity of the color is dependent on the concentration of the reactants. As the reaction proceed (equilibrium reactions are dynamic), students are asked predict the point at which the reaction has achieved equilibrium. As the reaction proceeds, the deep brown color slowly changes to a light pale brown color indicating that the reaction has reached equilibrium. Students will use the spectrophotometer to calculate absorbance to determine the concentration at which the reaction reaches equilibrium.

As an extension to the laboratory to highlight how shifts/stressors affect the outcome of a reaction to underscore what occurred during the Flint disaster. Students will obtain seven petri dishes. One petri dish will contain the iron solution and another, the thiocyanate solution. Students will retrieve four samples from the above experiment that have been deemed to reach equilibrium. Students will demonstrate the reaction between Fe^{3+} and SCN- in petri dish A. Students will add excess Fe^{3+} to petri dish FeSCN to observe what shift occurs. Silver Nitrate will be added to E1, Potassium Oxalate to E2 and $Fe(NO_3)_3$ Iron Nitrate to E3. Students should observe specific changes, predict why

the changes occurred, and correlate these changes to what happened when lead seeped out as a contaminant. The key question, what shift occurred?

Students will research cases similar to Flint Michigan that have occurred in their community or close to their community specific to Southern Wilmington Delaware. Students will research how the exposure was reported, coping mechanisms, checks and balance used to monitor the water system. As an extension, students should research the equitability of remediation is implemented based on SES, ethnicity and financial viability. The effects of identified disasters should also be examined specific to age, gender, community infrastructure and the systems in implemented by state, local and community members to address disasters.

Media Assignment

As recent as the Puerto Rico disaster resulting from Hurricane Maria, 10 trailers full of food, water and baby supplies donated for victims of the hurricane were left rot a state elections office in Puerto Rico. It is hard to comprehend how donations meant to create some normalcy and to provide relief from hunger goes wasted after a disaster. Donations now become the disaster after the disaster requiring relief workers to dispose of these items. Donations not stored promptly become susceptible to rodents, and in some cases, the items shipped exceed the expiration date and can longer be distributed as relief.

As a final activity, students will be tasked with developing a strategy on how to communicate through any news channel the current need of the Southbridge Wilmington area in light of the pending hurricane. The collections system should at least emphasize specific needs, strategies to collect, store and disseminate donations, how to minimize food waste. The model they develop should account for population size, age specific and strategy to determine how much supply is needed and the duration. Coordination should include medical supplies as well. Students can contact nearby health facilities to determine what strategies are used to determine supply needs in times of disaster

Students will be tasked with developing a model to address explore strategies that the . public can create to support community survivability. Students will be tasked with designing a survey to ascertain the level of trust vs distrust of information regarding disaster disseminated to the public in the event of a major catastrophe. As a final task students will design a relief system. to account and report waste of relief supplies. Students should research failed relief efforts from prior disasters to develop a viable relief model. Develops models should consider environmental and social concerns.

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Appendix 1

Next Generation Science Standards

HS-PS1-6 Refine the design of a chemical system by specifying a change in condition that would produce increased amounts of products at equilibrium

Common Core Standards

CCSS.ELA-LITERACY.RST.11-12.3
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.

CCSS.ELA-LITERACY.RST.11-12.9
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.

Students will engage in research to understand phenomena using data from experimentation in observed pH changes, and color changes to determine equilibrium. Students will report findings using the NGSS framework using claim, evidence and reasoning (CER), highlight patterns and trends and science and engineering practices. Students may opt to use different modalities to communicate their findings including but not limited to PowerPoint (PPT) Presentation, and gallery presentations (Tri-fold).

Notes

[1] (Frey 2013)
[2] (Frey 2013)
[3] (Frey 2013)
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[5] (Frey 2013)
[6] (Frey 2013)
[7] (Frey 2013)
[8] (Campbell 2016)
[9] (Etkin and Higuchi 2012
[10] (Etkin and Higuchi 2012
[11] Perez 2016
[12] Allen 2018
[13] Allen 2018
[14] Allen 2018
[15] Allen 2018
[16] Allen 2018
[17] Allen 2018
[18] Nelson 2016
[19] Nelson 2016
[20] Nelson 2016
[21] Augenstein 2016
[22] American Chemical Society 2016
[23] American Chemical Society 2016
[24] Rising Scholar 2017
[25] DeWitt 2017
[26] ACS 2016
[27] Allen 2018
[28] Hanna-Attisha 2016
[29] American Chemical Society 2016
[30] (Mark L. McFarland 2008)
[31] Mark L. McFarland 2008
[32] American Chemical Society 2016
[33] American Chemical Society 2016
[34] American Chemical Society 2016
[35] Olesky 2016, 1-4
[36] Olesky 2016, 1-4
[37] Augenstein 2016
[38] Campbell 2016)
[39] Campbell 2016)
[40] Campbell 2016
[41] Cuthberston, et al. 2016
[42] Cuthberston, et al. 2016
[43] Heard-Garris, et al. 2017
[44] Cuthberston, et al. 2016

[45] Kruger 2017
[46] Kruger 2017
[47] American Chemical Society 2016
[48] Mark L. McFarland 2008
[49] Sommers 2006
[50] Sommers 2006
[51] Anushka Shah 2017