

**ABSTRACT**

The purpose of this research is to determine a ratio of food waste to primary sludge to maximize the amount of methane gas produced by anaerobic digestion. As the climate changes worldwide, methods are needed to reduce the amount of methane gas being produced by various outlets, specifically food waste in landfills. If the methane gas produced by anaerobic digestion of food waste can be captured and stored, it can be used in place of non-sustainable practices for capturing natural gas. The methods used in determining the amount of methane present is found by measuring gas production with gas chromatography. The data obtained in this experiment will provide a ratio to use anaerobic digestion on a larger scale in order to produce the maximum methane gas and operate sustainably. This research will be used in the classroom to educate students on waste management in the United States and challenge the students to create sustainable waste practices.

1. **INTRODUCTION**

According to the United States Environmental Protection Agency (US EPA), about 95% of the food we throw away ends up in a landfill (US EPA, 2015). Once in landfills, the food waste begins to decompose producing methane gas. Landfills are the third largest producers of methane gas behind the petroleum and natural gas industry and agriculture (US EPA, 2015).

The average household in the United States wastes about $2,275 in groceries a year and about 24% of that waste is made up of fruits and vegetables and other organic compostable materials (US EPA, 2015). Food waste is currently managed by several different methods depending on what is available in that part of the country. Some of the methods include composting, food waste disposals, direct anaerobic digestion, mixed materials recovery facilities, and landfill sites. Several studies have suggested that anaerobic digestion emits the least amount of greenhouse gases into the atmosphere, specifically methane gas, and is considered the most sustainable (Parry, 2013). There are several places in Central Florida, including many of the theme parks in Orlando, that provide their food wastes to local waste treatment facilities for in anaerobic digestion to create biogas energy (Sorensen, 2014).

According to the American Biogas Council, “Anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen.” One of the main products of these reactions is biogas which can be used to generate heat and electricity. It can also be processed into natural gas which can be sold back to the grid or to the public. The other product of this process is the digestate which can be directly added to farmland as a soil amendment.

Parry (2013) reported that anaerobic digestion had the least amount of CO2 equivalent emissions because of carbon capture of methane gas; however, anaerobic digestion is the second most expensive process based on current practices.

There are other benefits to anaerobic digestion. These include the economical benefits of converting biogas from food waste into electricity and reducing landfill space. Food waste has three times the methane production potential as municipal waste water treatment plant sludge (US EPA, 2015).

1. **LITERATURE REVIEW**

Because of the increasing demand for renewable energy, there has been an increased interest in anaerobic digestion of solid organic waste for energy production. It is a widely applied technology and has used various inoculates and biowaste to produce this energy. Because this is a fairly new method i.e., 1991 there were only 7 papers published on the topic as compared to 70 papers by 2007, there is not a standard method being used for assessing gas production nor has a consistent substrate-inoculum composition or ratio been determined (Angelidaki et al., 2009). Serrano et al. (2014) used strawberry food waste from a company that made jams and jellies along with fish waste parts from a meat canning facility to optimize the anaerobic co-digestion process. For inoculum they used methanogenically active granular biomass obtained from a full scale anaerobic reactor used to treat waste water from a brewery. Gavala et al. (1996) used wastewaters from agriculture facilities to generate biogas. Liu (2007) studied the anaerobic co-digestion of municipal waste and restaurant grease.

Despite all of these experiments and the large amount of data that have been generated, comparisons of these studies are very difficult. Some of these studies have focused specifically on the substrate to inoculum ratio, while others have focused on very specific substrates such as food waste. (Angelidaki et al., 2009).

To assess the anaerobic digestion process, Angelidaki et al. (2009) suggests in their protocol that the substrate should be characterized as thoroughly as possible through the measurements of total solids (TS), volatile solids (VS), and chemical oxygen demand (COD). They also mention that the content of lignin, cellulose and hemicellulose should be determined. Lignin is a known inhibitor of anaerobic digestion. Serrano et al. (2006) noted that the amount of lignin was potentially high from the strawberry waste so they implemented a filtering processes before beginning their experiment.

Hansen et al. (2003) adapted and modified existing procedures for the Biochemical Methane Potential (BMP) test that was originally set up by Angelidaki and Ahring (2003) to assess biogas production forom waste separated from household wastes. They used a triplicate batch experiment because this biological test method used inoculum from full scale biogas plants with varying quality and the household organic waste is relatively heterogeneous. Also as part of their experiment they used 2-L glass bottles as reactors to ensure sufficient headspace for potential gas production. The inoculum was comprised primarily of manure with some industrial organic waste and organic household waste.

1. **GOALS AND OBJECTIVES**

The main goals of this experiment are to optimize the ratio of food waste to primary sludge for maximum methane generation and to study the stability of the anaerobic digestion process when food waste and primary sludge are used as substrates.

**4. RESEARCH STUDY DETAILS**

**4.1 Experimental Design**

The experiment performed was based on the BMP Serum Bottle Test. The experiment used three main materials: Inoculum (I), Primary Sludge (PS), and Food Waste (FW). The inoculum and primary sludge were obtained from the Fairfield wastewater treatment plant. The food waste was obtained from the Center Court Dining Hall at the University of Cincinnati. The experiment was performed with the same of FW to PS in Table 1. In each experiment there were six time points and each time point had triplicate bottles. The amount of material that was placed in each bottle can be found in Table 2. All of the bottles were set up in an anaerobic chamber that was prepared overnight. The anaerobic chamber was set to be 95% Nitrogen and 5% Hydrogen. The serum bottles that were used were 100 mL in volume. The food waste and primary sludge were loaded into the bottles with a wide bore 10 mL pipette. The substrate to inoculum ratio was set to 1: 4 on a volumetric basis. (Hansen et al. 2004). The buffer was added using a 10 mL pipette. After the bottles were filled they were closed off using an aluminum crimp seal with butyl rubber septum. For measuring gas production as well as gas composition, a syringe was put into the bottle through the cap. After those measurements were complete, the bottle caps were removed and the content analyzed for total and volatile solids, pH, chemical oxygen demand, and ammonia.

 **Table 1: Experimental Design (Ratio of FW to PS by Volume)**

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment 1 | 1:3 | 1:1 | 1:9 |
| Experiment 2 (NaHCO3) | 1:3 | 1:1 | 1:9 |
| Controls | FW only | PS only | I only |

 **Table 2. Amount of Materials Added to Serum Bottles (mL)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Experiment | Ratio | Inoculum | Food Waste | Primary Sludge | Water | NaHCO3 |
| 1 | 1:1 | 40 | 2.5 | 7.5 | 40 | 0 |
| 1 | 1:3 | 40 | 2.5 | 22.5 | 25 | 0 |
| 1 | 3:1 | 40 | 7.5 | 7.5 | 35 | 0 |
| 1 | FW-C | 40 | 10 | 0 | 40 | 0 |
| 1 | I-C | 40 | 0 | 0 | 50 | 0 |
| 1 | PS-C | 40 | 0 | 10 | 40 | 0 |
| 2 | 1:1 | 40 | 2.5 | 7.5 | 31 | 9 |
| 2 | 1:3 | 40 | 2.5 | 22.5 | 16 | 9 |
| 2 | 3:1 | 40 | 7.5 | 7.5 | 26 | 9 |
| 2 | FW-C | 40 | 10 | 0 | 31 | 9 |
| 2 | I-C | 40 | 0 | 0 | 41 | 9 |
| 2 | PS-C | 40 | 0 | 10 | 31 | 9 |

**4.2 Test Methods**

Gas production was measured daily during the weekdays. Gas composition was determined before destructive sampling. Parameters such as pH, total and volatile solids, COD, and NH3 were measured at specific time points by destructively sampling the serum bottles. Solids, total COD and pH were measured in the mixed liquor. Aqueous phase of the mixed liquor was extracted for analyses like sNH3 and COD, by centrifuging the mixed liquor at 8500 rpm for five minutes. For Total and Volatile Suspended Solids, the SOP that was used was based on Method 2540D Total Suspended Solids Dried at 103-105 °C and Method 2540E - Fixed and Volatile Solids Ignited at 500°C (Standard Methods, 1992). The Chemical Oxygen Demand SOP that was used follows the Method 8000 Colorimetric determination of chemical oxygen for water and wastewater as described in the Water Analysis Handbook (Hach, 1992). Particulate COD was then calculated from the difference between total and soluble COD. The analysis of ammonia was based on the Method 4500 D ammonia selective electrode method (Standard methods, 1992). The pH was tested with a pH Orion Dual Star pH meter from Thermo Scientific. Gas composition was analyzed using a Gas Chromatograph (HP series II 6890) with thermal conductivity detector. Helium was used as carrier gas.

**5. RESEARCH RESULTS**

**5.1 Biogas Production**

Biogas production for all three ratios increased over time and then showed a plateau at day 14. As seen in Figure 5.11, Ratio A had the highest amount of biogas production whereas Ratios B and C were fairly similar until day eight where Ratio B started to increase steadily. In Figure 5.11, it is shown that Ratio A had a variance from 70:30 carbon dioxide to methane to 60:40 carbon dioxide to methane. Day six had the most amount of methane for Ratio A at 40%. In Figure 5.13 the ratio of methane to carbon dioxide for Ratio B is presented. The level of methane is relatively low throughout the experiment. When looking at Figure 5.13 a jump in methane can be seen from day six to day seven by about ten percent. Figure 5.14 shows the ratio of methane to carbon dioxide in Ratio C. Ratio C is the most consistent of the three ratios with the methane production not exceeding ten percent. Figure 5.11 demonstrates that the bacteria in Ratio A were operating the most efficiently and producing the most gas. Figure 5.12, 5.13, and 5.14 show the amounts of methane produced. These graphs only show the methane and carbon dioxide concentrations although oxygen and nitrogen were measured as well. These graphs show that Ratio A was the most effective at producing methane. Ratio A reached 40% methane on the 6th day which is the highest amount of methane in the experiment.



**Figure 5.11 Biogas Production over 17 days**



**Figure 5.12 Ratio A: CH4 and CO2 Production**



**Figure 5.13 Ratio B: CH4 and CO2 Production**



**Figure 5.14 Ratio C: CH4 and CO2 Production**

**5.2 pH and Ammonia**

pH is an important factor to consider when looking at bio-methane potential. If the pH <7 then the methanogens are not working at their full potential causing an acidic build up. If the pH >8, then the ammonia may be inhibiting the production of methane. Figure 5.22 shows the ammonia content in the samples. In Figure 5.21, it can be seen that Ratio A had the most constant pH which was closest to 7. Since this is the optimum range for the pH, it further leads to the conclusion that Ratio A was the most efficient ratio. Ratio B had the second best methane production as well as the second best pH range. Ratio C had the worst methane production as well as the most acidic pH. These results show that there is a correlation between pH and methane production in that the closer the pH is to 7, the more methane will be generated.



**Figure 5.21 pH of Ratio A, Ratio B, and Ratio C.**



**Figure 5.22 Ammonia of Ratio A, Ratio B, and Ratio C.**

**5.3 Total and Volatile Suspended Solids**

Figure 5.31 shows the Total Solids for the three ratios. It is apparent that there is a decrease in total solids as time progresses which indicates that the microbes are hydrolyzing the solids in the sample. Figure 5.32 shows the Volatile Solids are generally the same until day 7 – day 13 where there is a drop in concentration. This indicates that around day seven, many of the microbes died off since volatile solids is a surrogate for biomass content. This is also supported by looking at Figure 5.11 and seeing that total gas production starts to plateau around that time. This is seen most in Ratio C in Figure 5.32 because there is a 15 g/L drop and in Figure 5.11 that time frame is when Ratio C starts to plateau.

**Figure 5.31 Total Solids**

**Figure 5.32 Volatile Solids**

**5.4 Chemical Oxygen Demand**

Chemical Oxygen Demand is a measure of the organic matter than can be used as food by the microbes. It is important to know because it informs of what organic matter cannot be degraded by the microbes and be converted into methane. Soluble Chemical Oxygen Demand can be seen in Figure 5.41 whereas Particulate Chemical Oxygen Demand can be seen in Figure 5.42.



**Figure 5.41 Soluble Chemical Oxygen Demand**



**Figure 5.42 Particulate Chemical Oxygen Demand**

**6. RESEARCH CONCLUSIONS**

The amount of food being wasted is a growing concern across the world. Food waste is problematic not only for waste of a resource but also because it emits methane when it degrades which is a greenhouse gas. Anaerobic Digestion takes the potent greenhouse gas methane and uses it for energy. In this study, the Biochemical Methane Potential test was conducted in serum bottles to choose an optimum ratio between food waste and primary sludge for producing maximum biogas under stable operations.

In this experiment, Ratio A (1:3 Food Waste to Primary Sludge) produced the most Biogas with the highest rate of methane. Ratio C was the least effective with less than 10% methane being produced which was probably due to the low pH of Ratio C. Ratio B was the 1:1 ratio and had a max methane production of 30%.

This study relates significantly to current food waste disposal processes. There have been various studies about combining food wastes with other waste to reach maximum methane production. Waste water treatment plants would be ideal sites to digest the food waste along with the primary sludge. Anaerobic Digestion has numerous advantages like the biogas generated from the co-digestion process can be used to power the treatment operation and food waste can be diverted from landfills. Optimizing the working ratio between food waste and primary sludge could help the treatment plants to operate the co-digestion process better.

**7. RECOMMENDATIONS FOR FUTURE RESEARCH**

As discussed in the introduction, many experiments have been done in this area and, very few, if any have held consistent results. Future experiments should work with different ratios of food waste to primary sludge based on total volume and volatile solids to maximize methane potential. Furthermore, a different inoculum or a different amount of inoculum could be used. Characterization of the food waste should be performed as different fruits and vegetable content could produce different results. Also, based on the pH of this experiment, it is recommended that a buffer be used to maintain an optimal pH of 7.

**8. CLASSROOM IMPLEMENTATION PLAN**

**8.1 Hoffman Unit Plan**

The title of the unit is Waste Management, Food Waste, and Recovery. This unit will be taught in an Environmental Science class for about 4 weeks. The lessons are geared towards 10th through 12th grade students. Waste management is a growing concern worldwide with landfills becoming full. Another growing concern that is lesser known, but everyone plays a part of, is the excess food that is wasted and not consumed. This food is contributing to the landfill problem and as it decomposes produces methane, a greenhouse gas.

The challenge that the students will face is to design a compost container to reduce the amount of food waste that ends up in a landfill. The process of composting will then provide a sustainable source of natural fertilizer for school gardens. The students will create these containers in groups of three or four.

This unit was selected for my classroom as it relates to the research completed in the summer of 2015. This unit was also selected because it was not previously covered in this Environmental Science class and is considered a growing, relevant, environmental issue.

The Engineering Design Process (EDP) is a teaching method that engages students to design a product or process to help solve real world problems while integrating communication throughout the process. This unit is set up to support all aspects of the EDP. For the gathering information stage, students will learn about current waste management practices and visit a local recycling center. Then students will then be asked to keep a diary of the things that they throw away to see how much they contribute to solid waste. They will also be analyzing their diaries and comparing them to their classmates to find common items and to determine if there is an alternative method of disposal from a landfill.

The second piece to this unit is tied specifically to food waste. Students will watch a documentary entitle *Just Eat It: A Food Waste Story*. They will fill out an evaluation sheet about the impacts of food waste and how it is related to methane production. Students will then be asked how they could fix this problem and will be directed towards composting. Students will then design a compost container using food waste from the school cafeteria and their own homes. They will conduct a web quest on the EPA’s website discovering the benefits of composting and how this type of decomposition is beneficial how we can measure the progress of a compost container and maintain constant decomposition. When the compost bins are complete, the students will share their design with their classmates and their community.

This unit will be taught to two high school environmental science classes containing 34 students each. Incoming student achievement levels range from very high to very low. This unit and the idea of challenge based learning will bring these students together so they can all take a part in the engineering design process and increase their problem solving skills.

**8.2 Richmond Unit Plan**

The title of my unit is “Applying Chemistry to Waste Management”. It will be taught in my Biochemistry class to juniors and seniors. The unit is expected to last eight class periods, with each class period being 45 minutes. In America, landfills are becoming overwhelmed with our waste and society is pushing towards new ways to reuse, reduce and recycle our trash. In 2013 alone, 167 million tons of trash were placed in landfills in America whereas 87 million tons of trash were recycled or composted. Most sorting facilities for trash and recyclables use physical and chemical properties to sort objects. The challenge they will be assigned is to design a process to sort six different types of common trash by using physical properties. This should lead to essential questions such as: How do we sort trash? What trash can be recycled? How much of what I put in the recycling bin is recycled? Where does my trash go when I put it in the dumpster? How much trash do I produce? How can I reduce my environmental impact?

This unit was chosen because it shows a real life application of physical and chemical properties. This is an important concept in chemistry which will be covered over the entirety of the year. This will allow for student knowledge on the concept to be tested later in the year. The initial hook for the lesson will be Baltimore Mr. Trash. Mr. Trash is a self-powered large apparatus that sits in the Baltimore Bay and gathers trash out of the water. This improves water quality and helps keep fish and other aquatic life from eating trash. Some cities are starting to implement similar systems due to the popularity and impact of Mr. Trash. While this is a great initiative, once the trash is collected it goes to a landfill. The students should see that taking trash out of a river and moving it to land isn’t the most efficient way to help our planet. Then the students will do a web quest for several days which will teach them about physical properties, chemical properties, physical changes, chemical properties, density, weight, and mass. Then several examples will be given in class where students must determine if something is a physical or chemical change or property. Then, students will examine how much trash they generate per day and what types of trash they most commonly generate. They will examine what types of trash are reusable and recyclable and talk about ways they can lessen their environmental impact. For the challenge, the students must create a process to sort 6 materials without hand sorting using their chemical and physical properties. They have 3 days to create and revise their process. The teams will consist of 3 members: A Speaker (the only member of the group who can ask the teacher questions), A Researcher (Who can look up the physical and chemical properties of the different materials), and A Recorder (Who will record the groups thought process and the processes that they come up with). At the end of the challenge, the groups will present their design in front of the class and share their engineering design process. During the challenge the groups will be documenting their design process and aligning it with the engineering design process.

This unit covers multiple school biochemistry standards as well as a few of the Next Generation Science Standards. Each of the units will formatively be assessed by asking questions to gauge student understanding. The summative assessment for the unit will be the presentation of the process as well as the post test that will be given before and after the unit. This will be taught in 3 classes which will have class sizes ranging from 15-25. This unit will have a significant impact on student’s future learning. It will allow for them to learn collaboration skills and problem solving skills as well as the biochemistry content. It should allow for students to see how their classroom learning will relate to the real world as well as build confidence in their problem solving skills.

**9. ACKNOWLEDGEMENTS**

This research would not have been possible without funding by the National Science Foundation, Grant ID #EEC-1404766. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

The authors would like to thank the faculty mentors Dr. Drew McAvoy and Dr. Pablo Campo-Moreno, and the graduate research assistants Mr. Narasimman Lakshminarasimman Meanakshisekar, and Ms. Pooja Chari from the University of Cincinnati’s Environmental Engineering Program. The authors would also like to thank Mrs. Deborah Liberi and David Macmorine, resource teachers for the RET Program.

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**11. APPENDIX I: HOFFMAN UNIT TEMPLATE**

**11.1 Unit Template**

|  |  |  |
| --- | --- | --- |
| **Name: Emily Hoffman** | **Contact Info:** **mlehoffie@gmail.com** | **Date: 6/30/15** |

|  |
| --- |
| **Unit Number and Title: Unit 1 – Waste Management and Composting** |

|  |  |
| --- | --- |
| **Grade Level:** | 10-12 |

|  |  |
| --- | --- |
| **Subject Area:** | Environmental Science |

|  |  |
| --- | --- |
| **Total Estimated Duration of Entire Unit:** | 2 weeks |

**Part 1: Designing the Unit**

|  |
| --- |
| 1. **Unit Academic Standards (**Identify which standards:NGSS, ONLS and/or CCSS.Cut and paste from NGSS, ONLS and/or CCSS and be sure to include letter and/or number identifiers.**):**
 |

NGSS

 HS-ESS3-4 – Evaluate or refine a technological solution that reduces impacts of human activties on natural systems

 ESS3-A Natural Resources

 ESS3-C Human Impacts on Earth Systems

 ESS3-D Global Climate Change

 ETS1-B Developing Possible Solutions

|  |
| --- |
| 1. **Unit Summary**
 |

The Big Idea (including global relevance):

Waste management is a big issue in this country and worldwide. Landfills are quickly becoming full with excess food waste which is decomposing and producing large amounts of methane gas. This methane is contributing to the greenhouse effect and global warming.

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge):

How can we eliminate waste from landfills?

How can we eliminate food waste from landfills?

How can we monitor/control the amount of food waste generated by people?

What can we do to apply the three R’s to food waste?

|  |
| --- |
| 1. **Unit Context – Check all that apply.**
 |

Justification for Selection of Content:

[ ]  Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.

[x]  Misconceptions regarding this content are prevalent.

[x]  Content is suited well for teaching via CBL and EDP pedagogies.

[ ]  The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)

[ ]  Other reason(s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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The Hook: Students will watch the 30 minute documentary Garbage World, or watch Just Eat It.

The Challenge and Constraints:

 [x]  Product **or** [ ]  Process (Check one)

|  |  |
| --- | --- |
| Description of Challenge (Either Product or Process is clearly explained below):  | List the Constraints Applied |
| **The students will construct a small batch compost container using food waste from school cafeteria.** **The compost will then be tested on moisture, pH, Odor, and, Macroinvertebrates for effectiveness of design.** **Students will then redesign as the compost process proceeds** | * **Must be no larger than a 7 gallon bucket**
* **Must use waste from school cafeteria**
* **Must use the materials given in class**
* **Test parameters every day for two weeks.**
 |

Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

**How can we collect the recyclable trash and reuse it?**

**As a school, how can we lower the amount of waste we produce?**

**How can we change the perception of wasted food and recyclable items?**

**How can we implement a recycle program at school?**

**How can we manage our food waste sustainably?**

|  |
| --- |
| **4. EDP: Use the diagram below to help you complete this section.** |

 ****

How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

Students will construct a compost container and then test the contents of their container to determine how well it is working. They will then make adjustments (additions or subtractions) to the contents to maximize the production of the container.

Students will have to gather information on what small batch compost containers look like and how they are constructed. Students will then have to decide on a design as a group of 4. Students will then have to monitor the progress and collect data, with that data they will have to modify their contents. After a few weeks they will communicate what they have found.

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

Students will create a poster on PowerPoint to display their design and convey their results to their peers and the community.

What academic content is being taught through this Challenge?

Lesson 1.

HS-ESS3-1 Construct and explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influence human activity

HS-ESS3-3 Create a computational simulation to illustrate the relationships among the management of natural resources and sustainability of human populations.

HS-ESS3-A Natural Resources

HS-ESS3-C Human Impacts on Earth Systems

Lesson 2.

HS-ESS3-3 Create a simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-6 Relationship among earth systems and how relationships are modified by human activity

HS-ESS3-A Natural Resources

HS-ESS3-C Human Impacts on Earth Systems

HS-ETS1-B Developing Possible Solutions

Lesson 3.

HS-LS2.A Interdependent Relationships

HS-LS2.C Ecosystem Dynamics

Lesson 4.

HS.LS2-3 Construct Explanation of Cycling of Matter

HS-LS1.C Organization and matter and energy flow

HS-LS2.B Cycles of Matter and Energy Flow in an Ecosystem

HS-LS2-7 Reducing impacts of human activities

HS-LS4-6 Mitigate adverse impacts of human activity on biodiversity

HS-LS-2.A Interdependent Relationships

HS-LS-2.C Ecosystem Dynamics

ETS1.B Developing Solutions

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

|  |  |
| --- | --- |
| What EDP Processes are ideal for conducting an Assessment? (List ones that apply.) | List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative. |
| \_\_\_\_Gathering Information\_\_\_\_\_\_\_ \_\_Gathering Information\_\_\_\_\_ \_\_Evaluate Solutions\_\_\_\_\_ \_\_Communicate Results\_\_\_\_\_\_\_\_\_  | \_\_Field Trip Evaluation Sheet\_\_\_\_\_\_\_\_ [x]  formative [ ]  summative\_Movie Questions \_\_\_\_­­\_\_\_\_\_\_\_\_\_\_\_\_\_ [x]  formative [ ]  summative\_Lab Sheets for Activities\_\_\_\_\_\_\_\_\_\_\_ [x]  formative [ ]  summativePresentation of design and results\_\_\_\_ [ ]  formative [x]  summative |

Check below which characteristic(s) of this Challenge will be incorporated in its implantation using EDP. (Check all that apply.)

[x]  Has clear constraints that limit the solutions

[ ]  Will produce than one possible solution that works

[x]  Includes the ability to refine or optimize solutions

[x]  Assesses science or math content

[x]  Includes Math applications

[x]  Involves use of graphs

[x]  Requires analysis of data

[x]  Includes student led communication of findings

|  |
| --- |
| **5. ACS (Real world applications; career connections; societal impact):** |

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

|  |  |  |
| --- | --- | --- |
| **Abstract or Loosely Applies to the Real World**  | **|--------------------------------------|--------------------X------------------|** | **Strongly Applies to the Real World** |

Provide a brief rationale for where you placed the X**:­­­­­­­­­­­­­­ Composting is a technique used by many people in suburban and urban areas. This process will help maximize their compost piles and allow students to check parameters to make sure it is working correctly\_\_**

What activities in this Unit apply to real world context? Use of a compost bin, the problem of creating too much trash and food waste\_\_\_\_\_

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

|  |  |  |
| --- | --- | --- |
| **Shows Little or No Societal Impact** | **|-------------------------------------|-----------------X----------------------|** | **Strongly Shows Societal Impact** |

Provide a brief rationale for where you placed the X**: The entire topic of what to do with food waste is a major issue cities are dealing with as landfills become full. ­­**

What activities in this Unit apply to societal impact? \_Watching the Movie to generate thinking on what to do about food waste, Designing a useful compost container \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.)

Waste Water Treatment

Waste Management

Solid Waste Management

Environmental Waste Manager

Field Trip: Waste Water treatment OR Rumke Recycling center

|  |
| --- |
| **6. Misconceptions:**1. **Landfills solve waste problems**
2. **Recycling solves waste problems**
3. **Everyone recycles**
4. **Waste management ends in a landfill**
5. **Everything grown in the field ends up in the market to sell**
6. **The dates on the food labels are exact**
 |

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| **7. Unit Lessons and Activities: (**Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #’s and Activity #’s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.)

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| --- |
| Lessons 1 with Activities 1 and 2 deal with current waste management issues. Students will visit a recycling center or waste management area and are then introduced to the issue of food waste through watching a documentary. Watching the documentary serves as the hook for the EDP process and begins the thought process of how to solve this major issue of the amount of food waste produced |
| Lesson 2 with Activities 3 & 4Activities 3 and 4 contain an informational lab and the challenge. In the lab, students will gain a component of information that will allow them to assess the progress of their design in the challenge portion. In activity 4, students are presented with the challenge of designing a compost container to deal with food waste at school.  |
| Time | Lesson/Activity | Name | EDP/CBL steps |
| Day 1-2 | Lesson 1 Activity 1 | Where does our waste go? | Identifying the ProblemGathering Information |
| Day 3-4 | Lesson 1 Activity 2 | Just Eat it: Food Waste | The HookGathering Information |
| Day 5 | Lesson 2 Activity 3 | Macroinvertebrates and Decomposition | Gathering Information |
| Day 6-20 | Lesson 2 Activity 4 | Design a Compost container and monitor the decomposition progress | The ChallengeDesigning, Evaluate Solutions, Refining,  |

 |

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| **8. Additional Resources:****Food Waste Movie Link**<https://www.youtube.com/watch?v=C8650YKglHA>  |

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| **9. Pre-Unit and Post-Unit Assessment Instruments:**  |

Students will take a survey with a scale of 1-5 about their feelings on specific statements regarding trash and food wastes. Students will then be given a post assessment with the same questions. Included in those questions will be statements of misconceptions about how waste is currently handled. There will also be questions about the design process of the compost container and why it was designed a particular way.

|  |  |
| --- | --- |
| **10. Poster (Link here.)** | **11. Video (Link here.)** |

**If you are a science teacher, check the boxes below that apply:**

| **Next Generation Science Standards (NGSS)**  |
| --- |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| [x]  Asking questions (for science) and defining problems (for engineering) | [x]  Patterns |
| [ ]  Developing and using models | [x]  Cause and effect |
| [ ]  Planning and carrying out investigations | [x]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [x]  Systems and system models |
| [x]  Using mathematics and computational thinking | [x]  Energy and matter: Flows, cycles, and conservation |
| [x]  Constructing explanations (for science) and designing solutions (for engineering) | [x]  Structure and function.  |
| [ ]  Engaging in argument from evidence | [x]  Stability and change.  |
| [x]  Obtaining, evaluating, and communicating information  |  |

**If you are a science teacher, check the boxes below that apply:**

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| [x]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [x]  Interpreting and Communicating Science Concepts **(C)** |
| [x]  Recalling Accurate Science **(R)** |

**If you are a math teacher, check the boxes below that apply:**

| **Common Core State Standards -- Mathematics (CCSS)** |
| --- |
| **Standards for Mathematical Practice (Check all that apply)** |
| [ ]  Make sense of problems and persevere in solving them | [ ]  Useappropriate tools strategically |
| [ ]  Reason abstractly and quantitatively | [ ]  Attendto precision |
| [ ]  Construct viable arguments and critique the reasoning of others | [ ]  Look for and make use of structure |
| [ ]  Model with mathematics | [ ]  Look for and express regularity in repeated reasoning |

**Part 2: Post Implementation- Reflection on the Unit**

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| **Results: Evidence of Growth in Student Learning - A**fter teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.**Please include**:* Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.)
* An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.)
* Other forms of assessment that demonstrate evidence of learning.
* Anecdotal information from student feedback.
 |

**11.2 Activity 1**

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| --- | --- | --- |
| **Name: Emily Hoffman** | **Contact Info:** **mlehoffie@gmail.com** | **Date: 7/7/2015** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Lesson Title : Waste Management** | **Unit #: 1** | **Lesson #: 1** | **Activity #: 1** |
| **Activity Title: Where does your waste go?** |

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| **Estimated Lesson Duration:** | **Five Days** |
| **Estimated Activity Duration:** | **One-Two Class Periods** |

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| **Setting:** | **Classroom and Waste treatment facility** |

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| **Activity Objectives:****The students will be able to**1. **Explain why waste production is a problem**
2. **Compare the types of waste we generate**
3. **Compare the different ways waste is managed**
4. **Describe how recyclables are separated once they reach a facility**
 |

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| **Activity Guiding Questions:**1. **What are the different types of trash we generate?**
2. **What can be done with each of the different types of trash?**
3. **What can we do to reduce the amount of waste produced?**
 |

| **Next Generation Science Standards (NGSS)**  |
| --- |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| [x]  Asking questions (for science) and defining problems (for engineering) | [ ]  Patterns |
| [ ]  Developing and using models | [ ]  Cause and effect |
| [ ]  Planning and carrying out investigations | [x]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [x]  Systems and system models |
| [ ]  Using mathematics and computational thinking | [ ]  Energy and matter: Flows, cycles, and conservation |
| [ ]  Constructing explanations (for science) and designing solutions (for engineering) | [x]  Structure and function.  |
| [ ]  Engaging in argument from evidence | [ ]  Stability and change.  |
| [x]  Obtaining, evaluating, and communicating information  |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| [x]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [x]  Interpreting and Communicating Science Concepts **(C)** |
| [ ]  Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** |
| --- |
| **Standards for Mathematical Practice (Check all that apply)** |
| [ ]  Make sense of problems and persevere in solving them | [ ]  Useappropriate tools strategically |
| [ ]  Reason abstractly and quantitatively | [ ]  Attendto precision |
| [ ]  Construct viable arguments and critique the reasoning of others | [ ]  Look for and make use of structure |
| [ ]  Model with mathematics | [ ]  Look for and express regularity in repeated reasoning |

|  |
| --- |
| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS****HS-ESS3-1 Construct and explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influence human acvitity****HS-ESS3-3 Create a computational simulation to illustrate the relationships among the management of natural resources and sustainability of human populations.****HS-ESS3-A Natural Resources****HS-ESS3-C Human Impacts on Earth Systems** |

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| --- |
| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation: Arrange a field trip to a Waste Treatment Facility or Recycling Center. Most places require one month in advance.**  |

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| **Activity Procedures:**1. **Show PowerPoint with student guided notes for waste management.**
2. **Arrange a field trip to a local recycling or waste treatment facility**
3. **Pass out questions for field trip analysis before attending so students know what to look for or what to ask.**
4. **Allow students time to work on field trip assessment form either for homework or the next day in class.**
 |

**Formative Assessments:**

Student field trip form

Trash Survey

**11.3 Activity 2**

|  |  |  |
| --- | --- | --- |
| **Name: Emily Hoffman** | **Contact Info:** **mlehoffie@gmail.com** | **Date: 7/8/2015** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Lesson Title : Food Waste** | **Unit #:1** | **Lesson #:1** | **Activity #:2** |
| **Activity Title: Just Eat it: A food waste story** |

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| --- | --- |
| **Estimated Lesson Duration:** | **Four Class Periods** |
| **Estimated Activity Duration:** | **Two-Three 70 minute Class Periods** |

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| **Setting:** | **Classroom with video capabilities** |

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| **Activity Objectives:*** **Identify current issues with the build-up of waste in our community and nation**
* **Reflect on own trash production**
* **Differentiate between different types of waste**
* **Explain why so much food waste is generated**
 |

|  |
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| **Activity Guiding Questions:**1. **What are the current issues we have in our community with the amount of trash we produce?**
2. **What is something we could do to cut down on the amount of trash we produce?**
3. **What can we do to cut down on the amount of food waste we produce?**
 |

| **Next Generation Science Standards (NGSS)**  |
| --- |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| [x]  Asking questions (for science) and defining problems (for engineering) | [x]  Patterns |
| [ ]  Developing and using models | [x]  Cause and effect |
| [ ]  Planning and carrying out investigations | [ ]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [ ]  Systems and system models |
| [x]  Using mathematics and computational thinking | [ ]  Energy and matter: Flows, cycles, and conservation |
| [ ]  Constructing explanations (for science) and designing solutions (for engineering) | [ ]  Structure and function.  |
| [ ]  Engaging in argument from evidence | [x]  Stability and change.  |
| [ ]  Obtaining, evaluating, and communicating information  |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| [ ]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [ ]  Interpreting and Communicating Science Concepts **(C)** |
| [x]  Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** |
| --- |
| **Standards for Mathematical Practice (Check all that apply)** |
| [ ]  Make sense of problems and persevere in solving them | [ ]  Useappropriate tools strategically |
| [ ]  Reason abstractly and quantitatively | [ ]  Attendto precision |
| [ ]  Construct viable arguments and critique the reasoning of others | [ ]  Look for and make use of structure |
| [ ]  Model with mathematics | [ ]  Look for and express regularity in repeated reasoning |

|  |
| --- |
| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS****HS-ESS3-3 Create a simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.****HS-ESS3-6 Relationship among earth systems and how relationships are modified by human activity****HS-ESS3-A Natural Resources****HS-ESS3-C Human Impacts on Earth Systems****HS-ETS1-B Developing Possible Solutions** |

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| **Materials**: Whiteboard, Markers, Food Waste Diary, Pre Assessment Survey, Just Eat It Video Sheet, Youtube Video Link <https://www.youtube.com/watch?v=C8650YKg> lHA |

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| **Teacher Advance Preparation:**1. **Use the link above or obtain a copy of the DVD Just Eat it: A food waste story.**
2. **Make Copies of the Pre/Post Self Assessment Survey**
3. **Make copies of Student Video Sheet**
4. **Make copies of Student Trash Diary**
5. **Make copies of Trash Diary Analysis Sheet**
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| **Activity Procedures:****Student Self Evaluation****This can be done as a homework assignment over a day or a week**1. **Ask students how much “stuff” they throw away?**
2. **Make a list on the board of some common things that end up in the garbage.**
3. **Create a T chart on the board with the items that students listed (like the one below). Have students place check marks in boxes of alternative locations for their trash.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Landfill** | **Compost** | **Recycle** | **Other (special items like batteries, electronics)** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

1. **Pass out Student Trash Diary Sheet and have students complete over a set amount of days (up to teacher).**
2. **The next day have students compare their diaries and answer Trash Analysis Sheet.**
3. **Show the movie Just Eat It: A food waste story.**
4. **Have students answer the movie question sheet and use their Trash Diary to compare to what they saw in the movie.**
5. **Have students generate essential questions for how we can solve this problem.**
6. **Generate an essential question guiding them to building or designing a compost container.**
 |

**Formative Assessments:**

* The student chart
* The discussion and class chart

 **11.4 Activity 3**

|  |  |  |
| --- | --- | --- |
| **Name: Emily Hoffman** | **Contact Info:** **mlehoffie@gmail.com** | **Date: 7/17/2015** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Lesson Title : Dealing with Food Waste** | **Unit #:1** | **Lesson #:2** | **Activity #:2** |
| **Activity Title: Macroinvertebrates in Compost** |

|  |  |
| --- | --- |
| **Estimated Lesson Duration:** | **4 Weeks** |
| **Estimated Activity Duration:** | **One day** |

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| **Setting:** | **A classroom will be fine if there is water available, but this would best be done outside.**  |

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| --- |
| **Activity Objectives:** **The students will be able to:**1. **Identify various macroinvertebrates based on physical characteristics**
2. **Analyze the health of the compost pile based on the colonization of various organisms**
3. **Determine the stage of composting based on the ecological succession that is taking place in the compost ecosystem**
 |

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| **Activity Guiding Questions:**1. **What are macroinvertebrates?**
2. **What kinds of organisms live in a compost pile**
3. **What is the benefit of these organisms to the compost and to humans?**
4. **What is ecological succession?**
 |

| **Next Generation Science Standards (NGSS)**  |
| --- |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| [x]  Asking questions (for science) and defining problems (for engineering) | [x]  Patterns |
| [ ]  Developing and using models | [x]  Cause and effect |
| [ ]  Planning and carrying out investigations | [ ]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [x]  Systems and system models |
| [ ]  Using mathematics and computational thinking | [x]  Energy and matter: Flows, cycles, and conservation |
| [x]  Constructing explanations (for science) and designing solutions (for engineering) | [ ]  Structure and function.  |
| [x]  Engaging in argument from evidence | [x]  Stability and change.  |
| [ ]  Obtaining, evaluating, and communicating information  |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| [ ]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [x]  Interpreting and Communicating Science Concepts **(C)** |
| [x]  Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** |
| --- |
| **Standards for Mathematical Practice (Check all that apply)** |
| [ ]  Make sense of problems and persevere in solving them | [ ]  Useappropriate tools strategically |
| [ ]  Reason abstractly and quantitatively | [ ]  Attendto precision |
| [ ]  Construct viable arguments and critique the reasoning of others | [ ]  Look for and make use of structure |
| [ ]  Model with mathematics | [ ]  Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS****HS-LS2.A Interdependent Relationships****HS-LS2.C Ecosystem Dynamics** |

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| --- |
| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:*** **Teacher should have a large amount of mature compost to pass out to class.**
* **Need to obtain cookie sheets or containers to hold compost**
* **Students will need gloves, spray bottles, spoons, large wooden popsicle sticks**
* **Students will need copies of the student hands outs**
 |

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| **Activity Procedures:**1. **Pass out student sheet on ecological succession and allow students time to fill in the chart and revisit/learn for the first time about trophic levels and ecological succession**
2. **Pass out student data sheet and allow them time to read over the information and carefully look at the pictures to be able to identify the organisms they are finding.**
3. **Divide the class into groups of 2,3, or 4 depending on how your class works together. This is best done in groups of two or three.**
4. **Provide each group with a tray, protective gloves, spoons and sticks, and a scoop of compost.**
5. **Allow students to sift through the compost using a spoon or wooden stick as to not injure any of the organisms.**
6. **Have students fill out the lab sheet**
7. **Allow students to either present their ideas or show their results to the class**
8. **Use the teacher sheet for discussion points and analysis questions.**
 |

**11.5 Activity 4**

|  |  |  |
| --- | --- | --- |
| **Name: Emily Hoffman** | **Contact Info: mlehoffie@gmail.com** | **Date: 7/20/15** |
| **Lesson Title : What to do with Food Waste** | **Unit #:1** | **Lesson #:2** | **Activity #:2** |
| **Activity Title: The Challenge: Design a Composter** |
| **Estimated Lesson Duration:** | **4 weeks** |
| **Estimated Activity Duration:** | **15-20 class periods due to monitoring the progress of the compost** |
| **Setting:** | **Classroom** |
| **Activity Objectives:****The student will be able to:** 1. **Determine the parameters that optimize compost production**
2. **Design a small batch compost container**
3. **Analyze data collected from compost**
4. **Evaluate your process**
5. **Make a recommendation about composting to community**
 |

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| **Activity Guiding Questions:**1. **What is the best mixture of food waste to have in the compost?**
2. **What is the best ratio of “brown” to “green” material for the compost?**
3. **How does moisture effect the rate of decomposition?**
4. **Does the addition of worms add to the rate of decomposition?**
5. **How does temperature play a role in decomposition?**
 |

| **Next Generation Science Standards (NGSS)**  |
| --- |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| [ ]  Asking questions (for science) and defining problems (for engineering) | [x]  Patterns |
| [ ]  Developing and using models | [x]  Cause and effect |
| [x]  Planning and carrying out investigations | [x]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [x]  Systems and system models |
| [x]  Using mathematics and computational thinking | [x]  Energy and matter: Flows, cycles, and conservation |
| [ ]  Constructing explanations (for science) and designing solutions (for engineering) | [ ]  Structure and function.  |
| [ ]  Engaging in argument from evidence | [ ]  Stability and change.  |
| [x]  Obtaining, evaluating, and communicating information  |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| [x]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [x]  Interpreting and Communicating Science Concepts **(C)** |
| [x]  Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** |
| --- |
| **Standards for Mathematical Practice (Check all that apply)** |
| [ ]  Make sense of problems and persevere in solving them | [ ]  Useappropriate tools strategically |
| [ ]  Reason abstractly and quantitatively | [ ]  Attendto precision |
| [ ]  Construct viable arguments and critique the reasoning of others | [ ]  Look for and make use of structure |
| [ ]  Model with mathematics | [ ]  Look for and express regularity in repeated reasoning |

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| --- |
| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS****HS.LS2-3 Construct Explanation of Cycling of Matter****HS-LS1.C Organization and matter and energy flow****HS-LS2.B Cycles of Matter and Energy Flow in an Ecosystem****HS-LS2-7 Reducing impacts of human activities****HS-LS4-6 Mitigate adverse impacts of human activity on biodiversity****HS-LS-2.A Interdependent Relationships****HS-LS-2.C Ecosystem Dynamics****ETS1.B Developing Solutions** |

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| --- |
| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| --- |
| **Teacher Advance Preparation:** * **Copies of lab sheet hand outs**
* **Copies of the informational sheet hand outs**
* **Supplies for composter (can be wood box, plastic containers, 5 gallon buckets, old garbage cans, chicken wire,**
 |

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| --- |
| **Activity Procedures:**1. **Allow students one class period to complete the EPA webquest on composting**
2. **Begin discussion on composting. Discuss parameters students found in their webquest**
3. **Put list of possible materials on the board and have students sketch several designs keeping the constraints and parameters in mind.**
4. **Have students discuss in groups and choose the best design.**
5. **Construct the compost container**
6. **Add food waste and brown components and take initial measurements as seen on the lab sheet.**
7. **Add one scoop of “compost starter” (compost from current mature pile containing micro/macro organisms.**
8. **Continue to take measurements throughout the course of 2-4 weeks to monitor the progress of the compost and allow the students to make adjustments.**
9. **After said amount of time have students present results to the class and make recommendations**
 |

**Formative Assessments:**

* Webquest student response sheet
* Student Progress sheet
* Student Lab sheets

**Summative Assessments:** Student presentions

**12. APPENDIX II: RICHMOND UNIT TEMPLATE**

**12.1 Unit Template**

|  |  |  |
| --- | --- | --- |
| **Name: Jillian Richmond** | **Contact Info: Jillianrrichmond@gmail.com** | **Date: 7/27/2015** |

|  |
| --- |
| **Unit Number and Title: Unit 1- Sorting Trash by Physical Properties** |

|  |  |
| --- | --- |
| **Grade Level:** | 11-12 |
| **Subject Area:** | Biochemistry |

|  |  |
| --- | --- |
| **Total Estimated Duration of Entire Unit:** | 8 class periods ( 45 minutes ) |

**Part 1: Designing the Unit**

|  |
| --- |
| 1. **Unit Academic Standards (**Identify which standards:NGSS, ONLS and/or CCSS.Cut and paste from NGSS, ONLS and/or CCSS and be sure to include letter and/or number identifiers.**) :**

School Standards* 1.A.2 - Distinguish between chemical and physical properties and between chemical and physical changes.
* 1.A.3 - Classify specific examples as either chemical or physical properties. Classify specific examples as either chemical or physical changes.
* 1.A.6 - Classify selected elements as metals, nonmetals, or metalloids based on observations of chemical and physical properties.

Next Generation Science Standards* When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-PS2-c),(HS-PS3-b),(HS-LS2-j),(HS-ESS2-b),(HS-ESS3-f),(HS-ESS3-h)
* Testing should lead to improvements in the design through an iterative procedure. (HS-PS2-c),(HS-PS3-b),(HS-PS4-d) (HS-ESS3-f)
* The aim of engineering design is not simply to find a solution to a problem but to design the best solution under the given constraints and criteria. (HS-PS2-a),(HS-PS3-b),(HS-LS2-l),(HS-ESS2-c),(HS-ESS3-b),(HS-ESS3-f)
 |

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| 1. **Unit Summary**
 |

The Big Idea (including global relevance):

In America, Landfills are becoming overwhelmed with our waste and society is pushing towards new ways to reuse, reduce and recycle our trash. In 2013 alone 167 million tons of trash were placed in landfills in America whereas 87 million tons of trash were recycled or composted. Most sorting facilities for trash and recyclables use physical and chemical properties to sort objects.

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge):

1. When I throw away or recycle something, where does it go?
2. How are Trash/Recyclables sorted?
3. How are my recyclables used?
4. Does everything I put in the recycling bin get recycled?

|  |
| --- |
| 1. **Unit Context – Check all that apply.**
 |

Justification for Selection of Content:

☐ Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.

X☐ Misconceptions regarding this content are prevalent.

X☐ Content is suited well for teaching via CBL and EDP pedagogies.

☐ The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)

☐ Other reason(s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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The Hook:

Mr. Trash in Baltimore is a self-powered large apparatus that sits in the Baltimore Bay and gathers trash out of the water. This improves water quality and helps keep fish and other aquatic life from eating trash. Some cities are starting to implement similar systems due to the popularity and impact of Mr. Trash. Although this is a great, once the trash is collected it goes to a landfill. The students should see that taking trash out of a river and moving it to land isn’t the most efficient way to help our planet.

 ☐ Product **or** X Process (Check one)

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| Description of Challenge (Either Product or Process is clearly explained below): The students must create a process to sort 6 materials without hand sorting using their chemical and physical properties. They have 3 days to create and revise their process. The teams will consist of 3 members: A Speaker (the only member of the group who can ask the teacher questions), A Researcher (Who can look up the physical and chemical properties of the different materials), and A Recorder (Who will record the groups thought process and the processes that they come up with).  | List the Constraints Applied3 days time3 members per groupCan only use items found in the home or schoolThe students will only be able to use things that they have access to: Water, Magnets, Fire, etc. They must be able to sort the following items: Aluminum, Foam, Paper, Cardboard, Plastic #1, Plastic #2 |

Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

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| **4. EDP: Use the diagram below to help you complete this section.** |



How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

During the presentation day, students will get a chance to demonstrate their processes granted that they don't take too much time. The students will closely follow the EDP process when working with their group and will be given copies of what the process looks like to help guide them. This process in the real world would be something that a chemical engineer would actually design and possibly implement.

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

The students will do a 6 slide PowerPoint and a demonstration of their Process if that is feasible.

What academic content is being taught through this Challenge? Physical and Chemical Properties, Physical and Chemical Changes, Density, Mass, Volume

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

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| What EDP Processes are ideal for conducting an Assessment? (List ones that apply.) | List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative. |
| \_\_\_All of the Processes\_\_\_\_\_\_\_ \_\_\_\_PowerPoint\_\_\_\_ \_\_\_Ability to identify properties in the design process: Worksheet\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  | \_\_\_\_\_\_\_\_\_\_\_Checklist \_\_\_\_\_\_\_\_\_\_\_ X formative ☐ summative\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ X☐ formative ☐ summative\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ X☐ formative ☐ summative\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ☐ formative ☐ summative |

Check below which characteristic(s) of this Challenge will be incorporated in its implantation using EDP. (Check all that apply.)

X☐ Has clear constraints that limit the solutions

☐ Will produce than one possible solution that works

X☐ Includes the ability to refine or optimize solutions

X☐ Assesses science or math content

☐ Includes Math applications

☐ Involves use of graphs

☐ Requires analysis of data

X☐ Includes student led communication of findings

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| **5. ACS (Real world applications; career connections; societal impact):** |

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

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| --- | --- | --- |
| **Abstract or Loosely Applies to the Real World**  | **|--------------------------------------|-----------------------------------X----|** | **Strongly Applies to the Real World** |

Provide a brief rationale for where you placed the X**: Although it is not likely that the students will be creating this process in the real world, It is something that is done by engineers daily and may be used late in their life**

What activities in this Unit apply to real world context? **The Challenge, The Hook, and Activity 3-Home Study**

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

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| **Shows Little or No Societal Impact** | **|-------------------------------------|----------------------------------X------|** | **Strongly Shows Societal Impact** |

Provide a brief rationale for where you placed the X**: It is very important that students know where trash goes when they throw it away and how it could be reused, reduced, or recycled.**

What activities in this Unit apply to societal impact? **The Challenge, The Hook, Activity 3- Home Study**

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.)

**Mention of how an engineer would design this process in the real world.**

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| **6. Misconceptions: The differences between Chemical and Physical properties and changes, Density vs. Mass.** |

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| **7. Unit Lessons and Activities: (**Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #’s and Activity #’s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.) |

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| Lesson 1: Involves the students getting hooked into the unit and learning content. The students will learn about Mr. Trash and how trash is disposed of. Students will learn about physical and chemical properties and changes as well as the differences between mass, density and volume |
| Lesson 2: Involves students looking at their own waste and creating a process to sort waste. The students will study how much trash they waste as well as what can be reduced, reused and recycled. Students will also be challenged to create a process to sort trash. |
| Day | Lesson/Activity NumberName | Description | Step of CBL or EDP |
| Day 1  | 1.1 Hook | The students will watch videos on Mr. Trash and pollution in the Ohio River. The class will discuss ways they can use chemistry to help Mr. Trash to be more ecofriendly. This discussion will lead to students generating essential questions. | Identify and Define |
| Day 2-3  | 1.2 Web quest | Students will use their laptops to learn about physical and chemical properties and changes while following a web quest. The class will review what was learned in the web quest by looking at problems involving physical and chemical properties and changes. | Gather Information |
| Day 1/Day 4 | 2.3 Home study  | Students will calculate the amount of trash they generate over a 2 day period. They will look at a composter and put food waste into the composter to see one mechanism of trash use. They then will get into pairs of two to think pair share about their study. Then the class will come back together and see what types of trash they most often wasted. | Gather Information  |
| Day 5-8 | 2.4 Challenge  | On Day 5, students will find out what the challenge is “Create a process to sort 6 different types of trash by using physical and chemical properties”. They will be placed in groups of 3 and given roles. They then will work on their design, following the EDP process for days 6-7. The students must identify which property is used in the process. On Day 8, students will present their process to the class.  | Identify Alternatives, Select Solutions, Implement Solution, Evaluate Solution, Communicate Solution |

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| **8. Additional Resources:** Aluminum, Foam, Paper, Cardboard, Plastic #1, Plastic #2, Various Classroom materials, Computers, PowerPoint, Worksheet 3, Worksheet 2.  |

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| **9. Pre-Unit and Post-Unit Assessment Instruments:** **The students will take a Pre/Post test on physical and chemical properties before and after the unit**  |

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| **10. Poster (Link here.)** | **11. Video (Link here.)** |

**If you are a science teacher, check the boxes below that apply:**

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| **Next Generation Science Standards (NGSS)**  |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| X☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| X☐ Developing and using models | X☐ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | X☐ Systems and system models |
| ☐ Using mathematics and computational thinking | X☐ Energy and matter: Flows, cycles, and conservation |
| X☐ Constructing explanations (for science) and designing solutions (for engineering) | X☐ Structure and function.  |
| X☐ Engaging in argument from evidence | ☐ Stability and change.  |
| X☐ Obtaining, evaluating, and communicating information  |  |

**If you are a science teacher, check the boxes below that apply:**

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| X☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| X☐ Demonstrating Science Knowledge **(D)** |
| X☐ Interpreting and Communicating Science Concepts **(C)** |
| X☐ Recalling Accurate Science **(R)** |

**If you are a math teacher, check the boxes below that apply:**

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| **Common Core State Standards -- Mathematics (CCSS)** |
| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

**Part 2: Post Implementation- Reflection on the Unit**

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| **Results: Evidence of Growth in Student Learning - A**fter teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.**Please include**:* Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.)
* An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.)
* Other forms of assessment that demonstrate evidence of learning.
* Anecdotal information from student feedback.
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| **Reflection:** Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Instruction sheet. Describe how the actual Engineering Design Process was actually used in the implementation of the Unit. |

**12.2 Activity 1**

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| **Name: Jillian Richmond** | **Contact Info: Jillianrrichmond@gmail.com** | **Date: 7-10-2015** |

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| **Lesson Title : Physical and Chemical Properties** | **Unit #:****1** | **Lesson #:****1** | **Activity #:****1** |
| **Activity Title: Mr. Trash- Hook** |
| **Estimated Lesson Duration:** | **45 - 1 class** |
| **Estimated Activity Duration:** | **40 minutes** |
| **Setting:** | **Classroom** |

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| **Activity Objectives:** **The students will be able to:**1. **Explain how Mr. Trash works and what its purpose it**
2. **State 2 alternatives to throwing away recyclables**
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| **Activity Guiding Questions: Where do trash/recyclables go once I throw them away?****Why do we sort trash? What is the purpose?** |

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| **Next Generation Science Standards (NGSS)**  |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| X☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | X☐ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | X☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function.  |
| ☐ Engaging in argument from evidence | ☐ Stability and change.  |
| X☐ Obtaining, evaluating, and communicating information  |  |

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| X☐ Demonstrating Science Knowledge **(D)** |
| X☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

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| **Common Core State Standards -- Mathematics (CCSS)** |
| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts (HS-PS2-c),(HS-PS3-b),(HS-LS2-j),(HS-ESS2-b),(HS-ESS3-f),(HS-ESS3-h) |

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:** **Teacher should have a sheet of questions to ask students between videos, all videos should be pulled up on the computer. Teacher should have worksheets for activity 3 to pass out to students at the end along with exit slips.**  |

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| **Activity Procedures:**Question of the day: *Where could your trash end up when you throw it on the ground? In a garbage can? In a Recycling bin?***Talk about Baltimore- the harbor and all of the trash- Show 2 videos of Mr. Trash**[**https://www.youtube.com/watch?v=RkQbcrzyAeE**](https://www.youtube.com/watch?v=RkQbcrzyAeE)[**https://www.youtube.com/watch?v=jmwxiYGp4OA**](https://www.youtube.com/watch?v=jmwxiYGp4OA)Ask students:*What is Mr.Trash?**How does Mr.Trash get his power?**Why do we need Mr.Trash?**Where does the Trash go once it's picked up?**Could we use something like this in Cincinnati?***Show video on the Ohio River Clean up**[**https://www.youtube.com/watch?v=v8SwCRQyxU0**](https://www.youtube.com/watch?v=v8SwCRQyxU0)*How much trash is picked out of the ohio river annually vs. picked out of the baltimore harbor daily?***Show video on the Garbage patch gyre**[**https://www.youtube.com/watch?v=4dNhMfemjKk**](https://www.youtube.com/watch?v=4dNhMfemjKk)*Why does the gyre have so much plastic?* *Were you surprised by this video? Why or why not?***Show video on the recycling** [**https://www.youtube.com/watch?v=TvN9W3XxFfc**](https://www.youtube.com/watch?v=TvN9W3XxFfc)*How much of the plastic that you put in your recycling bin gets recycled?**What are the alternatives to just using plastic you can sort?**What could America do to improve their recycling program?***Assignment of Activity 3- Home study on how much trash students use (1 day of data collection)** Teacher will ask students to get into pairs or groups of 3 to ask essential questions and to write them down. Guiding questions for the students should be “How can we use chemistry to help fix the Mr. Trash process of sending trash to a landfill” The teacher will tell the students that they will create a challenge out of these questions/ideas the students come up with.  |

**Formative Assessments:** There are two types of formative assessments in this unit. First there is the class discussion which tells the teacher how well the students understand concepts. Second, there is the generation of essential questions which can tell the teacher the level of understanding the students are at.

**12.3 Activity 2**

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| **Name: Jillian Richmond** | **Contact Info: Jillianrrichmond@gmail.com** | **Date: 7/10/2015** |

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| **Lesson Title : Sorting Trash** | **Unit #:****1** | **Lesson #:****1** | **Activity #:****2** |
| **Activity Title: Physical and Chemical Webquest** |

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| **Estimated Lesson Duration:** |  **2- 45 minutes Periods** |
| **Estimated Activity Duration:** |  **75 minutes**  |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:****Students will be able to:****Summarize Chemical properties, physical properties, chemical changes, physical changes, density, volume, and mass****Apply knowledge of physical and chemical properties to real world examples** |

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| **Activity Guiding Questions:****What is a physical property?****What is a chemical property?****What is a physical change?****What is a chemical change?****What is the difference between volume, mass, and density?** |

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| **Next Generation Science Standards (NGSS)**  |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| X☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | ☐ Cause and effect |
| X☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | X☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| X☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function.  |
| X☐ Engaging in argument from evidence | ☐ Stability and change.  |
| ☐ Obtaining, evaluating, and communicating information  |  |

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| X☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| X☐ Recalling Accurate Science **(R)** |

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| **Common Core State Standards -- Mathematics (CCSS)** |
| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):**School Standards* 1.A.2 - Distinguish between chemical and physical properties and between chemical and physical changes.
* 1.A.3 - Classify specific examples as either chemical or physical properties. Classify specific examples as either chemical or physical changes.
* 1.A.6 - Classify selected elements as metals, nonmetals, or metalloids based on observations of chemical and physical properties.
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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation: Teacher should have the Webquest printed out or available to students online. Teacher should have food waste and compost sitting out for students to view.** |

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| **Activity Procedures:** **Teacher will have the compost sitting out and will ask students if they have ever seen one before.** **Teacher will tell students it is a compost used for breaking down food to turn it into usable soil. Teacher will ask students what a compost has to do with Biochemistry?** **Teacher will deposit food into the compost and tell students they will revisit it in a week to see what has happened to the waste.****Students will complete the first half of the webquest.** **At the end of the lesson the teacher will review with students the ideas of physical changes, chemical changes, chemical properties, density, mass, volume, and physical properties. Teacher will have a powerpoint of various chemical and physical changes and properties and will go over them as a class.**  |

**Formative Assessments:** The students will have formative assessments in two ways. First, the students will have answers on their actual web quest. Secondly, the students will have to answer in class questions about what constitutes as a chemical and physical property.

**12.4 Activity 3**

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| **Name: Jillian Richmond** | **Contact Info: Jillianrrichmond@gmail.com** | **Date: 7/10/2015** |

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| --- | --- | --- | --- |
| **Lesson Title : Sorting Trash** | **Unit #:****1** | **Lesson #:****2** | **Activity #:****1** |
| **Activity Title: Trash Home Study** |
| **Estimated Lesson Duration:** | **1 period- 45 minutes** |
| **Estimated Activity Duration:** | **1 period- 45 minutes** |
| **Setting:** | **Classroom**  |

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| **Activity Objectives:** **Students will:****Analyze data from their home study and compare their trash and compost usage with other students** **Recognize trends within the classroom by collectively looking at and analyzing data from the students**  |
| **Activity Guiding Questions:****How much trash do I generate vs the average American?****How much of my trash is reusable/recyclable?** |

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| **Next Generation Science Standards (NGSS)**  |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| X☐ Asking questions (for science) and defining problems (for engineering) | X☐ Patterns |
| ☐ Developing and using models | ☐ Cause and effect |
| X☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| X☐ Analyzing and interpreting data | X☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function.  |
| ☐ Engaging in argument from evidence | ☐ Stability and change.  |
| X☐ Obtaining, evaluating, and communicating information  |  |

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| X☐ Demonstrating Science Knowledge **(D)** |
| X☐ Interpreting and Communicating Science Concepts **(C)** |
| X☐ Recalling Accurate Science **(R)** |

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| **Common Core State Standards -- Mathematics (CCSS)** |
| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):****NGSS:*** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-PS2-c),(HS-PS3-b),(HS-LS2-j),(HS-ESS2-b),(HS-ESS3-f),(HS-ESS3-h)
* Testing should lead to improvements in the design through an iterative procedure. (HS-PS2-c),(HS-PS3-b),(HS-PS4-d) (HS-ESS3-f)
 |

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation: Teacher should have the Answer sheet copied before hand and should have group questions planned out.** |

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| **Activity Procedures:****Students will individually answer the worksheet response questions.** **Students will get into groups of 2 or 3 and do a Think Pair Share on their personal food usage. The students will be guided by the worksheet response questions.** **The classroom will come back together as the individual groups share what they learned during their TPS: What surprised you? What was your most common trash?** **As a classroom, Make a class chart of the top 5 most used materials and estimate the amount of trash the class generates. After this, have a classroom discussion on what could be done with the most commonly generated trash types.**  |

**Formative Assessments:** The students will be formatively assessed in their answer sheet to their study. They also will be formatively assessed with the discussion that happens after the think pair share activity.

**12.5 Activity 4**

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| --- | --- | --- |
| **Name: Jillian Richmond** | **Contact Info: Jillianrrichmond@gmail.com** | **Date: 7/10/2015** |
| **Lesson Title : Sorting Trash** | **Unit #:****1** | **Lesson #:****2** | **Activity #:****2** |
| **Activity Title: The Challenge** |
| **Estimated Lesson Duration:** | **4 days- 45 minutes** |
| **Estimated Activity Duration:** | **120 minutes** |
| **Setting:** | **Classroom**  |
| **Activity Objectives:****Students will:****Create a process to sort trash by research and collaboration****Compare their process with others and modify** **Present the process to the class and judge others processes** |

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| **Activity Guiding Questions:****What are the chemical and physical properties of different materials?****How can I use the physical properties to sort trash without human interaction?****What materials at my house and in my classroom could be used to sort materials?** |

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| **Next Generation Science Standards (NGSS)**  |
| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| X☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| X☐ Developing and using models | X☐ Cause and effect |
| X☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | X☐ Systems and system models |
| X☐ Using mathematics and computational thinking | X☐ Energy and matter: Flows, cycles, and conservation |
| X☐ Constructing explanations (for science) and designing solutions (for engineering) | X☐ Structure and function.  |
| X☐ Engaging in argument from evidence | X☐ Stability and change.  |
| X☐ Obtaining, evaluating, and communicating information  |  |

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| X☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| X☐ Demonstrating Science Knowledge **(D)** |
| X☐ Interpreting and Communicating Science Concepts **(C)** |
| X☐ Recalling Accurate Science **(R)** |

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| --- |
| **Common Core State Standards -- Mathematics (CCSS)** |
| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| --- |
| **Unit Academic Standards (NGSS, ONLS and/or CCSS):*** 1.A.2 - Distinguish between chemical and physical properties and between chemical and physical changes.
* 1.A.3 - Classify specific examples as either chemical or physical properties. Classify specific examples as either chemical or physical changes.
* 1.A.6 - Classify selected elements as metals, nonmetals, or metalloids based on observations of chemical and physical properties.

Next Generation Science Standards* When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-PS2-c),(HS-PS3-b),(HS-LS2-j),(HS-ESS2-b),(HS-ESS3-f),(HS-ESS3-h)
* Testing should lead to improvements in the design through an iterative procedure. (HS-PS2-c),(HS-PS3-b),(HS-PS4-d) (HS-ESS3-f)
* The aim of engineering design is not simply to find a solution to a problem but to design the best solution under the given constraints and criteria. (HS-PS2-a),(HS-PS3-b),(HS-LS2-l),(HS-ESS2-c),(HS-ESS3-b),(HS-ESS3-f)
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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:****Teacher should have the Engineering Process sheet printed for groups. They should have the materials being tested available. They should have the groups of 3 chosen beforehand.**  |
| **Activity Procedures:** **-The teacher will introduce the activity by saying that they thought about all of the possible questions that the students came up with and decided to do this one.** **-They will go through the powerpoint with the students explaining the challenge, the time allotted, the constraints, the roles, the EDP process, and answer any questions.****- They will then break up the class into the groups and have them assign their roles.** **-The students will then work on the project for the next 3 days.****-On the fourth day the students will present their process to the class as well as rating each others effectiveness.**  |

**Formative Assessments:** 1.2.4.e and 1.2.4.f are both formative assessments

**13. APPENDIX III: STANDARD OPERATING PROCEDURES**

**13.1 SOP 2: Total and Volatile Suspended Solids**

The present SPO is based on the 2540D Total Suspended Solids Dried at 103-105 °C and 2540E Fixed and Volatile Solids Ignited at 500 °C (Standard Methods, 1992).

 Apparatus

• Glass fiber filters 0.45 µm pore size.

• Filtration apparatus: Gooch crucible, 25-mL to 40-mL capacity with Gooch crucible adapter.

• Suction flask.

• Muffle furnace for operation at 500 ± 50 °C.

• Desiccator, provide with desiccant containing a color indicator of moisture concentration or an instrumental indicator.

• Drying oven for operation at 103-105 °C.

• Analytical balance, capable of weighing to 0.1 mg.

• Wide-bore pipets. Procedure

a. Preparation of evaporating dish. Insert disk with wrinkled side up in the Gooch crucible and wash the disk with three successive 20-mL portions of reagent-grade water. If volatile solids are to be measured ignite clean evaporating dish at 500 ± 50 °C for, at least, 15 min in a muffle furnace. Cool in desiccator to balance temperature and weigh. Repeat cycle of igniting, cooling, desiccating, and weighing until a constant weigh weight is obtained or until weigh change is less than 4% or the previous weighing or 0.5 mg, whichever is less. Store in desiccator until needed.

b. Sample analysis. Assemble filtering apparatus and filter and begin suction. Wet filter with small volume of reagent-grade water to seat it. Mix sample and pipet a measured volume onto the seated glass-fiber filter. Wash with three successive 10 mL- volumes of reagent water, allowing complete drainage between washings, and continuing suction about 3 min after filtration is complete. Carefully remove the crucible from the adapter. Dry for at least one hour at 103 to 105 °C, cool in desiccator to balance temperature and weigh. Repeat cycle of igniting, cooling, desiccating, and weighing until a constant weigh weight is obtained or until weigh change is less than 4% or the previous weighing or 0.5 mg, whichever is less. Duplicate determinations should agree within 5% of their average. If volatile solids are to be determined, treat follow step

c. WA 2-71, QAPP Amendment for Use of an Innovative Membrane Bioreactor for Sustainable Wastewater Reuse Category IV Research Project Date: October 6, 2012 Revision No. 0 Page 33 of 47 c. Ignite residue form step b in a muffle furnace at a temperature of 500 ± 50 °C overnight. Transfer the crucibles to a desiccator for cooling in a dry atmosphere. Weigh the crucible as soon as it has cooled to balance temperature. Repeat cycle of igniting, cooling, desiccating, and weighing until a constant weigh weight is obtained or until weigh change is less than 4% or the previous weighing or 0.5 mg, whichever is less. Duplicate determinations should agree within 5% of their average.

 d. Calculations where: A = weigh of filter + crucible + dry residue, mg. B = weigh of filter + crucible, mg. where: A = weigh of filter + crucible + dry residue before ignition, mg. B = weigh of filter + crucible + dry residue after ignition, mg.

Reference Standard Methods for the Examination of Water and Wastewater (1992) 18th Edition American Public Health Association, American Water Works Association and Water Environment Federation, Washington DC, USA.

**13. 2 SOP 3: Chemical Oxygen Demand**

This SOP follow the method 8000 Colorimetric determination of chemical oxygen for water and wastewater as described in the Water Analysis Handbook by Hach Company.

Materials and Reagents

• COD reactor 120/140 Vac.

• COD vial adapter, DR/2000.

• Pipet 0.1-1 mL.

• Safety shield.

 • Spectrophotometer (DR 2000, Hach).

• Test tube rack.

• COD digestion regents vials 0-150 mg/L.

• COD digestion regents vials 0-1,500 mg/L.

• COD digestion regents vials 0-15,000 mg/L.

 Procedure

1. Turn in the COD reactor. Preheat to 150 °C. Place the plastic shield on the reactor.

2. Remove the cap of the COD digestion reagent vial of the desire range desire range.

3. Hold the vial at a 45-degree angle. Pipet 2 mL (0.2 mL for the 0-15,000 mg/L range).

4. Replace the vial cap tightly.

5. Hold the vial by the cap and over a sink. Invert gently several times to mix the contents. Place the vial in the preheated COD reactor.

6. Prepare a blank by repeating steps 2 to 5, substituting 2 mL (0.2 mL for the 0-15,000 mg/L range) DI water for sample. Use a clean pipet. One blank must be run with each set of samples as well as an accuracy check.

7. Heat the vials for 2 hours.

8. Turn the reactor off. Wait about 20 min for the vials to cool to 120 °C or less.

9. Invert each vial several times while still warm. Place the vials into a rack. Wait until the vials have cooled to room temperature. a. If a pure green color appears in the reacted sample, the reagent capacity may have been exceeded. Measure the COD and if necessary, repeat the test with dilute sample.

10. Enter stored program number in the Spectrophotometer (DR 2000, Hach) for chemical oxygen demand.

a. Press: 430 READ/ENTER for 0-150 mg/L COD.

b. Press: 435 READ/ENTER for 0-1,500 and 0-15,000 mg/L COD.

11. Rotate the wave length dial until the small display shows a. 420 nm for 0-150 mg/L COD. b. 620 nm for 0-1,500 and 0-15000 mg/L COD.

12. Press READ/ENTER the display will show a. mg/L COD L for 0-150 mg/L COD. b. mg/L COD H for 0-1,500 and 0-15,000 mg/L COD.

13. Place COD vial adapter into the cell holder with a marker to the right.

14. Clean the outside of the blank with a towel.

15. Place the blank into the adapter with the Hach logo facing the front of the instrument. Place the cover on the adapter.

16. Press ZERO. The display will show WAIT then 0 mg/L.

17. Clean the outside of the sample with a towel.

18. Place the sample vial into the adapter with the Hach logo facing the front of the instrument. Place the cover on the adapter.

19. Press READ/ENTER The display will show WAIT then the result in mg/L COD will be displayed.

a. 0-15,000 mg/L note. When HR+ COD vials are used, multiply the displayed value by 10. Accuracy check

• Check the accuracy of the 0 to 150 mg/L range with 100 mg/L standard. Prepare by dissolving 85 mg of dried (120 °C, overnight) potassium acid phthalate (KHP) in 1 liter of DI water. Use 2 mL as the sample volume. The expected result will be 100 mg/L COD. Or dilute 10 mL of 1000-mg/L COD standard solution to 100 mL to produce a 100-mg/L standard ± 20%.

• Check the accuracy of the 0 to 1,500mg/L range with using either a 300 or 1000 mg/L COD standard solution. Use 2 mL of one of these solutions as the sample volume; the expected result will be 300 or 1000 mg/L COD ± 20%, respectively. Or prepare by dissolving 425 mg of dried (120 °C, overnight) KHP in 1 liter of DI water; the final concentration will be 500 mg/L COD ± 20%.

• Check the accuracy of the 0 to 15,000 mg/L range with using 10,000 mg/L COD standard solution. Use 0.2 mL of one of these solutions as the sample volume; the expected result will be 10,000 mg/L COD ± 20%. Prepare this solution by dissolving 8.500 g of dried (120 °C, overnight) KHP in 1 liter of DI water. Run the accuracy check and the blank with every batch.

• In this method, the objective of the blank is to establish the background absorbance of the COD reagents at the required wavelength. For this reason, only distilled water should be use as matrix en the preparation of COD blanks.

Reference Water analysis Handbook (1992) 2nd Edition Hach Company, Lovelan, CO, USA

**13.3 SOP 6: Analysis of Ammonia by NH3 Ion-specific electrode probe**

The present SOP is based on the 4500 ammonia selective electrode method (Standard Methods, 1992).

 Apparatus

 • Electrometer. A pH mete with expanded millivolt scale capable of 0.1 mV resolution between -700 mV and +700 mV. O a specific ion meter.

• Ammonia selective electrode.

• Magnetic stirrer with TFE-coated stirring bars.

Reagents

• Ammonia-free water.

• Sodium hydroxide 10 N. Dissolve 400 g NaOH in 800 mL water. Cool and dilute to 1000 mL with water. Use plastic vessels in the preparation of this solution.

• Stock ammonium chloride solution. Dissolve 3.819 g anhydrous NH4Cl in water and dilute to 1000 mL; 1 mL = 1 mg N = 1.22 mg NH3.

Procedure

a. Prepare a series of standard solutions covering the concentrations of 1000, 100, 10, 1, and 0.1 mg NH3-N/L by making decimals dilutions of stock NH4Cl solution with water.

b. Electrode calibration. Place 25 mL of each standard in a 50-mL beaker. Immerse electrode in standard of lowest concentration and mix with a magnetic stirrer. Do not stir so rapidly that air bubbles are sucked into the solution because they will become trapped on the electrode membrane. Maintain the same stirring rate throughout calibration and testing procedures. Add a sufficient volume of 10 N NaOH (3-4 drops) to raise pH above 11. Keep electrode in solution until stable millivolt reading is obtained. Repeat procedure with remaining standards, proceeding from lowest to highest concentrations.

c. Generate the calibration curve in the ion meter following the manufacturer’s instructions.

d. Measurement of samples. Dilute if necessary to bring ammonia concentration to within calibration curve range. Place 25 mL in a 50-mL beaker and follow procedure in step b. Quality control See Table 1 for quality control criteria.

Reference Standard Methods for the Examination of Water and Wastewater (1992) 18th Edition American Public Health Association, American Water Works Association and Water Environment Federation, Washington DC, US