**The Chemistry of Composting**

Target Grade Level(s): 10-12

Subject(s): Chemistry Prerequisites: 1 semester of Chemistry, Previously or currently taking Algebra 2

Author(s): Harrison Chau (Boeing), John Madden (Boeing), Jake McKinzie (Kentlake High School), Allison Snetselaar (Eastlake High School)

**Problem Statement:**

The Earth’s human population and the support systems of that population (farming, transportation, industry) are growing at an enormous rate. Today, the average human produces about 4.4 pounds of garbage per day. With this growth comes great consumption of Earth’s limited organic natural resources. Composting waste materials is a necessity if we want to limit waste build up. How can our knowledge of chemistry and composting help families, organizations, or businesses to recycle their organic waste quickly and efficiently for future use? The final product is to produce a proposal for the given waste producer based on lab results from the project. Each team will present their data, mathematical calculations, and research about their suggested change.

**Unit Overview and Table of Contents**

Prior to this unit students should have basic knowledge of:

(\*topics with an asterisk need to be mastered by lesson 7, and must be taught during the composting stage or prior to the compost stage)

* Chemistry
  + *Measurements using the mole.* Students should understand the concept of a mole and the context for when this unit is used.
  + *Measurements using the metric system*. Students should be able to use the metric system to measure samples (mass and volume).
  + *Dimensional analysis.* Students should be able to convert from one unit to another using dimensional analysis. Specifically, converting between the mole and mass and within the metric system (kilograms to grams).
  + *Molecular mass and chemical formulas.* Students should be able name ionic compounds and common molecular compounds. They should be able to write chemical formulas from a given name, and name chemicals when given the chemical formula. Using either the name or formula, students should also be able to calculate the molar mass with the use of a given periodic table and calculator.
  + *Organic vs Inorganic.* Students should understand the terminology of organic and inorganic compounds.
  + *\*Stoichiometry.* Determining mass/moles of reactant need to produce a mass/mole of product and vis-versa.
  + *\*pH values.* Students should have an understanding of the pH scale, and be able to identify a substance/solution as acidic, basic, or neutral.
* Mathematics
  + *Graphing.* Students should be able to interpret a graph, read axis labels, identify trends, and draw conclusions.
  + All students in our classes are/have currently or previously taken Algebra 2.
* Research
  + Students should be comfortable using the internet or print resources to conduct research. When given a prompt, students should be able to find basic research by posing an appropriate question on a topic and comprehend information.
* Writing
  + Students should be able to communicate their ideas in a proposal and a formal report. This skill can be accommodated or scaffolded.

*Pre-lesson teacher note: Lessons 1-8 should take a minimum of six weeks*

|  |  |  |
| --- | --- | --- |
| **Lesson** | **Description** | **Time** |
| 1 | Introduction - Can we make garbage valuable?   * Discusses types and amounts of garbage produced annually * How can we use chemistry to reuse organic garbage? | 45 minutes |
| 2 | Revisit stoichiometry with aerobic respiration | 45 mins |
| 3 | Carbon / Nitrogen ratio: good, bad, and meaning   * How does this relate to the process of composting? | 30 mins |
| 4 | Basic knowledge composting data tables: questions, answers, & explanations   * How to interpret information from researched composting sources | 30 mins |
| 5 | Compost Math (teaching, practice, assessment)   * Concepts of proportion and chemistry ratios to be used | 90-135 mins |
| 6 | Prep for lab steps (composting). Students bring in materials and create a compost. | A minimum of 6 weeks |
| 7 | Analysis of compost results   * Review data collected using graphing and dimensional analysis | 30 mins |
| 8 | Proposal introduction / Use data to suggest changes to industry   * Students examine all of the compostable materials made by their waste producer of choice | 45-90 mins |
| 9 | Final Presentation   * Students resent best fit result to begin composting application for the waste producer of choice | 45-90 mins |

**Standards (NGSS, CCSS, CTE):**

* ***Next Generation Science Standards***

NGSS- HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-ES3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems**.**

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

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

* ***Common Core State Standards***

**Reason quantitatively and use units to solve problems**

[CCSS.Math.Content.HSN.Q.A.1](http://www.corestandards.org/Math/Content/HSN/Q/A/1/)- Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

[CCSS.Math.Content.HSN.Q.A.2](http://www.corestandards.org/Math/Content/HSN/Q/A/2/)- Define appropriate quantities for the purpose of descriptive modeling.

[CCSS.Math.Content.HSN.Q.A.3](http://www.corestandards.org/Math/Content/HSN/Q/A/3/)- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

**Analyze proportional relationships and use them to solve real-world and mathematical problems.**

[CCSS.Math.Content.7.RP.A.3](http://www.corestandards.org/Math/Content/7/RP/A/3/)- Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

* ***21st Century Skills - Career and Technical Education Standards***

**Communication and Collaboration: Collaborate with Others**

3.B.1 - Demonstrate ability to work effectively and respectfully with diverse teams

3.B.2 - Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal

3.B.3 - Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

**Information Literacy: Use and Manage Information**

4.B.1 - Use information accurately and creatively for the issue or problem at hand

**Flexibility and Adaptability: Adapt to Change**

7.A.1 - Adapt to varied roles, jobs responsibilities, schedules and contexts

**Soft Skills (21st Century Learning Skills):**

* Communicate Clearly: articulates thoughts and ideas effectively using oral, written, and nonverbal communication skills
* Implementing Innovations: act on creative ideas to make a tangible and useful contributions to the field in which the innovations will occur
* Flexibility and Adaptability: willingness to change, incorporate feedback effectively, understand, negotiate and balance diverse views and beliefs to reach workable solutions
* Responsibility: act responsibly with the interests of the larger community in mind
* Collaborate with others: demonstrate ability to work effectively and respectfully with diverse teams
* Problem Solving: solve different kinds of non-familiar problems in both conventional and innovative ways

**Locally and/or Personally Relevant for Students:**

* High School Level (cafeteria, etc)
  + This is where students spend 8 hours of their day, and personally contribute waste to.
* Boeing / industry (company level, factory level, airplane level)
  + The scale at what Boeing puts out into the world being the largest manufacturing company in the Seattle area.
* Alaska Airlines
  + Local business that creates compostable waste, that may have been used by students.
* Find a place around your school (i.e. favorite restaurant, sports stadium, park, etc)
  + This is a place relevant to students

**Connections to career and educational pathways:**

* Environmental Engineering
* Chemist
* Waste Management
* Agriculture, soil management, botanist
* Water quality management
* Land reclamation / rehabilitation / EPA
* University, community college, technical school

**LESSON 1: Introduction- Can we make garbage valuable?**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* Students will be able to describe one impact their waste has on the environment.
* Students will be able to define and describe the process of composting.

**Lesson standards (NGSS, CCSS, CTE):**

NGSS-HS-ES3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems**.**

**Soft skills:**

Critical thinking- after learning about a real-world problem, students think about how this applies to them, and start brainstorming possible solutions and the impact this could have.

**Locally and/or personally relevant for students:**

The amount of garbage produced in the community and world-wide is discussed during this lesson. Solutions to reducing this waste are introduced, and students start to connect this solutions to their lives. Teacher leads a discussion to bring out students current experience/knowledge with composting, recycling, and waste management.

**Connections to career and educational pathways:**

Role of waste management within a city is brought up. The new initiatives businesses and organizations are taking is brought up to encourage students to think about how they would respond to meet the needs.

**Materials:**

* PowerPoint #1 or the format the teacher is most comfortable with
* Pre-assessment

**Lesson preparation:**

The teacher should be familiar with the content, and may want to take some to edit the content for their specific group of students. The pre-assessment should be copied or uploaded to a class website. The teacher should review the pre-assessment to determine if all questions are appropriate for their group of students, or if more questions need to be added.

**Time required:** 20-30 minutes

**Grouping of students for instruction:**

Whole class, with the option to break into group for discussion or possible extension research

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Show video linked on PowerPoint- shows a US woman collecting all of her garbage throughout the week. | Watch video.  Could have students generate a list of questions they come up with during the video. |
| Uses PowerPoint to post a graphic that demonstrates the volume of garbage produced in the US. | Analyze data. With teacher prompts, students look for their state in the data. |
| Uses PowerPoint to pose three questions:   1. Where does that garbage go? 2. What gas is produced? 3. What can WE do to reduce the amount of garbage in our community? | Have students either brainstorm what they think solutions can be and/or analyze the list produced by the EPA.  What similarities do they notice in all of the three lists? COMPOST |
| Show slide from Boeing environmental report. Explain that companies, such as Boeing, are already making significant changes to reduce the amount of waste they produce. | Students listen |
| Show slide that overviews our PBL unit.  Provide a brief overview of the structure of the unit and what students will be doing. | Students listen |
| Elicit previous knowledge.  Pass out pre-assessment OR guide students to online assessment. | Students complete a survey/pre-test to share their current level of knowledge with composting, chemical reactions and percent composition calculations. |

**Accommodations:** Print out a copy of the powerpoint and/or pre-assessment.

**Extensions:** Rather than simply sharing facts about waste in the U.S. and the three questions that result after looking at data, students could either:

1. Research on their own or in groups to find data on waste in the U.S.
2. Participate in a question-generating activity to develop their own questions related to the amount of garbage produced in the US as well as possible solutions. Try the Q-Focus protocol as outlined in the book “Make Just One Change” by Dan Rothstein and Luz Santana.

Because this unit is a lot of smaller lesson spaced out over a long period of time, a “learning log” was created for students to help track the take-aways from each lesson. It is a Word document that was posted to the class website and students download. Each day, students enter two things they learned, one application they make to composting, and one question/wondering they have. They can submit this to the dropbox each day so that the teacher can ensure they are picking up the big ideas, and kids have a list of the things they learned that they can apply in their final project.

This document can be saved in many ways. A class website and a dropbox can be used, but OneDrive shared folder, OneNote Student Notebook, or DropBox would all work great. You could also print a copy for students to handwrite and hold on to or periodically turn in.

**Assessment:** Pre-assessment. Data generated here will be used to guide the teacher as to how much background on composting is necessary to share, how much scaffolding will be necessary to ensure all students master the calculations, and to help create successful groups so each child to appropriately challenged and supported.

**References/Resources:** Graphics cited in PowerPoint

EPA’s suggestions for reducing waste: <https://www.epa.gov/recycle/reducing-waste-what-you-can-do>

Boeing’s 2015 Environmental Report: <http://www.boeing.com/resources/boeingdotcom/principles/environment/pdf/2015_environment_report.pdf>

**LESSON 2: Aerobic vs. Anaerobic Respiration**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can compare and contrast aerobic and anaerobic respiration
* I can describe the impact of anaerobic and aerobic respiration on a compost.

**Lesson standards (NGSS, CCSS, CTE):**

NGSS- HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-ES3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems**.**

**Soft skills:**

Communication (oral, speaking, capability, written, presenting, listening)

**Locally and/or personally relevant for students:**

The amount of garbage produced in the community and world-wide is discussed during this lesson. Solutions to reducing this waste are introduced, and students start to connect this solutions to their lives. Teacher leads a discussion to bring out students current experience/knowledge with composting, recycling, and waste management.

**Connections to career and educational pathways:**

Role of waste management within a city is brought up. The new initiatives businesses and organizations are taking is brought up to encourage students to think about how they would respond to meet the needs.

**Materials:**

* PPT #2
* Aerobic vs. Anaerobic Respiration Handout (Venn Diagram)
* Formative Assessment for Lesson 2

**Lesson preparation:** Copy handouts OR create a digital format (save to OneDrive, OneNote, or class website)

**Time required:** Approximately 45 minutes (1 class period)

**Grouping of students for instruction:** Whole class and small group (3-4 students)

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Remind students of the context: Last class we discussed the incredible amount of waste produced by Americans each day, as well as some of the EPAs recommendations to decrease the amount of waste that is entering our landfills. We also discovered that gas is produced in a landfill, and know that as things decompose chemical reactions are taking place. | Students listen to you recap  OR  Teacher prompts students to share out some of the things we learned last class. |
| State learning targets:  Today our goal is to better understand two types of chemical reactions that can take place to decompose waste. We’ll then apply that to our future compost pile. |  |
| Composting is a process in which bacteria break down waste into a product that resembles nutrient rich soil. It is a way to turn our waste into food for the bacteria, and a great place for new places to grow. | Use your knowledge of students to determine their role in this brief discussion. Based on pre-assessment, you could have students share out their definitions. Or, you may need to record a definition to post in the classroom so all students will see a correct definition throughout the unit. |
| Pass out “Aerobic vs. Anaerobic Respiration” handout OR guide students to download a digital copy of this handout (using a shared drive, OneNote Student Notebook, or class website).  Clearly state expectations for group research time. | Pick up OR download handout.  Work in a teams, using online resources, to complete the Venn Diagram comparing and contrasting aerobic and anaerobic respiration. |
| Guide students to share out Venn Diagrams.  As a class, answer the last three questions: Which is ideal? signs that aerobic or anaerobic is taking place? Things we can do to ensure aerobic respiration is able to take place in our compost?  Students should conclude:   * Aerobic respiration is ideal. * We’ll know aerobic respiration is taking place if the compost is heating up and by the smell. * To ensure the bacteria in the compost are able to aerobically respire, we should turn the pile regularly to make sure they always have oxygen, cut/break waste into small pieces so air can get in, and smell the compost regularly. | Share out work during discussion. |
| Pass out exit ticket OR direct students to access exit ticket online. See extension for another adaptation of the assessment. | Students complete formative assessment. |

**Accommodations:**

* Language support: Write chemical equations in both chemical and word format to help students become more familiar with the vocabulary. To ensure all students know what a compost is, use your pre-assessment data to alter the amount of instruction/explanation you provide. You may want to show a brief video on an overview of composting.

Use images and diagrams to emphasize the difference the presence of oxygen has.

* Alternative format: The Venn Diagram can be completed by typing or hand written.
* If you have a knowledgeable student with a lot of experience composting, you could prep them to lead the conversation on steps we can take to ensure the bacteria in the compost pile has access to oxygen.

**Alternative Format:**  Information can be shared as a lecture rather than students looking up content.

**Extensions:** Use “Plickers” cards to assess student knowledge at the end of the period. [www.plickers.com](http://www.plickers.com) Teacher needs a smartphone or tablet to collect data, students need paper cards with QR codes (printed from website), results projected at front of classroom with presentation computer and projector (or teacher’s tablet that is connected to projector)

**Assessment:** Informal assessment by the teacher during work time. 3-5 question exit ticket will help determine mastery of two learning targets. .

**References/Resources:**

* Composting Background Information document
* List of Odor Causing Compounds from Composting

**LESSON 3: Carbon/Nitrogen Ratio- Good, Bad, and Meaning**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can explain why the carbon:nitrogen ratio is the driving force behind the chemical reactions involved in composting
* Given a chart, I can identify what happens when the carbon:nitrogen ratio is not ideal based on smell

**Lesson standards (NGSS, CCSS, CTE):**

NGSS- HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

NGSS-HS-ES3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems**.**

[CCSS.Math.Content.HSN.Q.A.1](http://www.corestandards.org/Math/Content/HSN/Q/A/1/)- Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

[CCSS.Math.Content.7.RP.A.3](http://www.corestandards.org/Math/Content/7/RP/A/3/)- Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

**Soft skills:** Communication (oral, speaking, writing, listening) and problem solving

**Locally and/or personally relevant for students:** This lesson we are talking about the carbon : nitrogen ratios in the waste that students produce. We will look at a list of things they throw out regularly, and better understand what composes these foods they eat everyday.

**Connections to career and educational pathways:** Knowledge would help people in these places of employment- King County Waste Management separation professionals, Composting companies such as Cedar Grove Compost, gardening supply stores like Carpinitos.

Chemical engineers and research and development scientists need to calculate ratios and look at the composition of materials, especially new products.

**Materials:**

* Typical Odor Causing Compounds from Composting
* Carbon:Nitrogen ratios for common compostable materials

**Lesson preparation:** Print Composting Resource page (with two tables) or post to class website, OneDrive, OneNote, or DropBox

**Time required:** Approximately 30 minutes

**Grouping of students for instruction:** Independent practice, partner practice, lab groups (3-4 students)

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Answer any relevant questions/comments students wrote on the learning log last class. |  |
| Prompt students to open/find a printed copy of the “Composting Resource Page” (contains two charts, “Typical Odor Causing Compounds from Composting” and “Carbon:Nitrogen ratios for common compostable materials”.  Instruct students to read the charts, then discuss with their teams three things they notice. | Download/pick up charts.  Read, interpret.  Discuss at least three things they notice with teams. |
| Post charts on board so they can be discussed as a class.  Ask each group to share out one things they noticed. *Tip: after groups have discussed, students who are normally quiet should have an answer to share out. This would be a great opportunity to call on a quiet student and help them build confidence sharing in front of the whole class.* | Students share out. |
| Share out big take aways if they haven’t been hit on yet. Draw connection between the two tables. Ask students to start thinking about things they can bring into compost.  At this time you could have groups sign up for a week to be in charge of bringing in materials to add to the compost. |  |
| Prompt students open the Compost Learning Log and complete an entry for today. | Open saved document, type two things they learned, one application they can make to compost, and one question/wondering they still have. |

**Accommodations:**

* Access to printed chart of carbon:nitrogen ratios
* Meaningful groupings to assist specific student

**Extensions:**

**Assessment:** Practice problems leading toward actual application of data to beginning compost additions.

**References/Resources:**

**LESSON 4: Composting Data Tables- Questions, Answers, and Explanations**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can properly record my observations, log actions, and analyze results
* I can create a graph of recorded observations to analyze data

**Lesson standards (NGSS, CCSS, CTE):**

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

**Soft skills:** Table making and analysis for extracting useful information

**Locally and/or personally relevant for students:** Chart and data reading comprehension, enhancing ability to understand news and day to day data.

**Connections to career and educational pathways:** Data analytics/information sciences specialist for various companies/industries such as Google, Microsoft, Amazon, Boeing, and others

**Materials:**

* Data entries from weekly additions and checks on compost mix
* Sample log of information for practice.

**Lesson preparation:** Explanation of chart, what is entered, entry method, and what needs to be understood about information present

**Time required:** Approximately 45 minutes

**Grouping of students for instruction:** Whole class,lab groups (3-4 students),

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| ADD using sample compost log | Note-taking skill focus |
| Sample compost log with analysis questions | Ability to analyze/use material in the table |
|  | Any questions of process or technique |

**Accommodations:** Group support, individual explanations

**Extensions:**

**Assessment:** Using sample log, request information from log about trends and patterns of the compost.

**References/Resources:**

**LESSON 5: Compost Math**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can justify the use of moles for the ratios and math involved in composting (application of stoichiometry)
* Given known values, I can calculate a carbon:nitrogen ratio

**Lesson standards (NGSS, CCSS, CTE):**

[CCSS.Math.Content.HSN.Q.A.1](http://www.corestandards.org/Math/Content/HSN/Q/A/1/) - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

**Soft skills:** As previous

**Locally and/or personally relevant for students:** As previous

**Connections to career and educational pathways:** As previous

**Materials:**

* List of C:N ratios for compostable materials
* Examples of calculations

**Lesson preparation:** Knowledge of stoichiometry and application of mole ratios to find amount values

**Time required:** Approximately 90-135 minutes, plus additional time based on student mastery for practice

**Grouping of students for instruction:**

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Demonstrate proper mathematical conversions for turning C:N ratios into moles per kilogram of material used | Record and analyze examples. |
| Set up students to find carbon moles per kilogram of all materials on possible composting list. | Work on finding values. Determine where comprehension is flawed or lacking. |
|  | Construct and ask questions to improve/correct determined values on list. |

**Accommodations:**  Structure set-up for conversions, template for students to fill in values using periodic table, group support

**Extensions:**  Have students complete more problem sets to reinforce knowledge base

**Assessment:** Information assessment of student performance during practice problems.

Formal assessment (test/quiz).

**References/Resources:** Periodic table, charts of carbon:nitrogen ratios

**LESSON 6: Prep for Composting**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can safely and accurately conduct our class procedure for planning, adding material, and appropriately maintaining our class compost.

**Lesson standards (NGSS, CCSS, CTE):**

NGSS-HS-ES3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems**.**

**Soft skills:** Planning, accomplishing plans, application of chemistry knowledge to proper individual lab group participation in overall class lab experiment.

**Locally and/or personally relevant for students:** Application to home and possible work use of composting materials.

**Connections to career and educational pathways:** As in previous lessons

**Materials:**

* Properly analyzed amounts of chosen materials set up during lesson 5.
* Recording materials for each group including thermometers, data tables, etc.

**Lesson preparation:** First material addition, with math included, done as a class with materials picked and provided by teacher. all parts done together, as well as one week of materials checks to set table patterns and process for individual checks and additions of compost to mix.

**Time required:** Minimum of 7 weeks, first by teacher, with each following week having an addition of 6-10 kilograms of material picked by each lab group.

**Grouping of students for instruction:** By pre-set lab groups used for labs prior to this. These groups should be well versed in working together and have set norms they are comfortable working in.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Direction and then collection of preliminary math for each lab groups compost addition. | Follow guidelines and apply to group work |
|  | Groups add on monday, check on weds and friday, and the following monday before next group adds. lab due for grading on the next monday, one week after their last check, two weeks after they added to the overall compost. |

**Accommodations:**  Group support, teacher support with choosing materials

**Extensions:**  Readings covering other methods of composting

**Assessment:** Individual grading of each group’s analysis of their contributions affect on the overall compost condition/results.

**References/Resources:**

**LESSON 7: Analyzing Class Compost Results**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can use the overall data collected by each lab group to plot trends and changes in the compost based on material added.
* I can use this overall template of data as an application to usage in industry composting plans.

**Lesson standards (NGSS, CCSS, CTE):**

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

[CCSS.MATH.CONTENT.8.F.B.4](http://www.corestandards.org/Math/Content/8/F/B/4/)**-**evaluating graph information for useage.

**Soft skills:** data table analysis and trend data, compilation of data

**Locally and/or personally relevant for students:** waste management material analysis for any business

**Connections to career and educational pathways:** Knowledge would help people in these places of employment- King County Waste Management separation professionals, Composting companies such as Cedar Grove Compost, gardening supply stores like Carpinitos.

Chemical engineers and research and development scientists need to calculate ratios and look at the composition of materials, especially new products.

**Materials:**

* Completed chart using data collected over composting lab in class
* Pre-analysis of materials used by various businesses, industries. Compostable versus recyclable versus garbage. possible material replacement list to make more materials compostable.

**Lesson preparation:** Introduction/application of conceptual ideas using what has come to this point

**Time required:** 45 to 120 minutes

**Grouping of students for instruction:** Via lab groups

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “understanding” portion of the PBL. The purpose of this lesson is to engage students and increase interest in the science and math content over the next few lessons.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Introduction of culmination of all lab group’s contributions as an overall assignment | Ability to see what they will use from the compost data table to answer compilation questions such as patterns of temperature, textures and appearances. analysis of data to conclude effectiveness of process as done. |

**Accommodations:** As per previous lessons

**Extensions:**  Readings/lectures on other composting techniques, other materials that can be gathered via composting, such as methane and heat.

**Assessment:** Transfer of information from table to consumable data suitable for publication and peer analysis.

**References/Resources:**

**LESSON 8: Proposal Introduction**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can use what I have learned to improve composting techniques for usage in business.
* I can also analyze if this improvement is cost effective and simplistic enough to be manageable at any level of business from a small cafe to a large industrial complex.

**Lesson standards (NGSS, CCSS, CTE):**

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

**Soft skills:**

Critical thinking- after learning about a real-world problem, students think about how this applies to them, and start brainstorming possible solutions and the impact this could have.

**Locally and/or personally relevant for students:**

The amount of garbage produced in the community and world-wide is discussed during this lesson. Solutions to reducing this waste are introduced, and students start to connect this solutions to their lives. Teacher leads a discussion to bring out students current experience/knowledge with composting, recycling, and waste management.

**Connections to career and educational pathways:**

Role of waste management within a city is brought up. The new initiatives businesses and organizations are taking is brought up to encourage students to think about how they would respond to meet the needs.

**Materials:**

* PowerPoint #1 or other method of presenting problem
* Document sharing project details to students (this can be in PPT, on class website, or printed)
* Cost-Benefit Analysis

**Lesson preparation:**

The teacher should be familiar with the content, and may want to take some to edit the content for their specific group of students.

**Time required:** depends on application, complexity, and extension application. anywhere from 90 to 270 minutes

**Grouping of students for instruction:**

Whole class, with students broken into lab groups for discussion, planning, or possible extension research to determine a solution for the problem.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the start to the “explore” portion of the PBL.

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Uses PowerPoint to restates problem statement.  Uses PowerPoint to list out the 1-2 companies/organizations student groups could focus on. The teacher should select organizations that they know their students find relevant and interesting. Our strong suggestions are in bold, and other options are listed below:   1. School cafeteria 2. Starbucks 3. Alaskan Airlines 4. Boeing Corporation & Manufacturing 5. Student household (\*great for younger students) 6. Local restaurant (McDonald’s, TacoBell, other places students frequent) 7. Sports Stadium (Century Link, ShowWare Center, etc) 8. Apartment complex 9. WA state ferry system 10. Cruise Ships   Provide an overview of their task:  Your job is to develop a plan to turn as much garbage into compostable material as possible, and ultimately produce an ideal compost that is able to turn over into usable soil quickly.  Each team will present their proposal to the class, representing their organization.  Each presentation will include:   * Their idea to turn garbage into compost * Rational with cost analysis and accessibility (estimation based on resources we shared with them). * What is the ease of converting the system? From a business standpoint, how difficult will it be and what has to be done to make this change. | Listening to presentation, thinking about their interests.  Selecting a group (can be choice or assigned by teacher). For best results, use the groups that did the addition steps for the actual compost production lab leading up to this project. |
| Provide students with clear instructions and a time deadline.  “Your job is to develop a list of items this organization sends to the landfill. Think about all aspects of this business, and try to brainstorm as comprehensive of a list as possible. You may want to organize your list into different categories- this will help you ensure you are identifying all waste items, and may help to distribute responsibilities among the team.  As students work, monitor progress, giving feedback to teams about on-task behavior, organization of ideas, and creativity.  Help students keep the time deadline. Could set timer on screen. Suggested time: 15-30 minutes. This depends on age, experience level, and the format you are asking them to display their ideas on. | Work in teams to create a list of all items this organization throws in the garbage.  Students can record this list in any format…. poster, large white board, paper, online document that can be shared and/or submitted. |
| Teacher redirects students to given instructions on next stage.  “This company has recruited you to propose a change that produces less garbage sent to the landfill that is both environmentally friendly and economically reasonable. Your team will select 1 item to change from waste to compostable/recyclable.”  Give students a set amount of time to select 1 item they will compost or change the type or material so it is compostable or recyclable. This can also be done by assigning waste items to a team, and they have to figure out how to change or reduce that waste. This is the teacher’s choice if they want students to choose their topic or assign it- either way students are the ones generating the solutions.  Set goal time for this stage. Suggested time: 30 minutes  Ways to provide more structure to this research portion:  -provide a set of websites that have good suggestions/ideas for compostable materials.  -Have students take out their compost notes which includes a list of compostable materials and ideal ratios.  -Have students do a structured brainstorm so all team members can share ideas before one is decided.  The teacher should make a decision based on the experience, age, and skill level of their students. | Listen to instructions.  Team members begin brainstorming and planning for proposal based on problems selected. They will need to agree on 1 solution to 1 waste item. Students should look most closely at how change will affect their business, ease of change over, ease of application of new materials and practices.  Once team members come up with an idea, they will need to do some research. |
| Regroup class. Share “Cost-Benefit Analysis” PowerPoint/document. | Students listen, ask questions. |
| Have students move on to the next step of the project- finalizing their solution to reduce waste, and justifying why this choice will benefit both the company and the environment.  *Repeat this portion of the lesson for as many class periods as necessary. Will likley take more than one class period for students to create a solution.* | Complete cost-benefit analysis (generating estimates) of chosen ideas. |
| With 6-8 minutes left in class:  Have groups stop their work and conclude ideas for the day. Pass out “Memo” exit ticket. This can be digitally as an email, digitally to the dropped on a class website, or on paper. Students write a note to their supervisor (the teacher) sharing what they accomplished and what their team’s next step is. The purpose of this is to hold students individually accountable, help get a gauge of where each team is at the end of the day, and for students to practice writing in the format of an email to a supervisor.  \*This lesson will likely span more than one period. This exit ticket is a great way for the teacher to assess the amount of additional time needed, which teams to check in with next, and which individual students need support with teamwork. | Students wrap of conversations, come to a stopping point in their group work, and clean up materials.  Students individually write a memo to their supervisor (teacher). |

**Accommodations:** At this point, further application of all accommodations which have been used to this point should suffice.

**Extensions:** This can also be done by direct contact and analysis with a local business. a possible list could be compiled by teacher or students. this could also be done by households.

Students could do more specific calculations of cost.

Could partner with a statistics or other mathematics class to have the students in math for the actually values.

**Assessment:** Final product will be presented to class. class will question process and grade proposal.

**LESSON 9: Proposal Presentations**

**Problem statement:** Based on US citizen consumption, how can our knowledge of composting help families, organizations, or businesses to recycle their organic waste for future use? The final product is to produce a proposal for the given waste producer. Each team will present their data, mathematical calculations, and research about their suggested change.

**Learning objectives:**

* I can present my proposal to a group, providing justification for my claim.

**Lesson standards (NGSS, CCSS, CTE):**

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

**Soft skills:**

Critical thinking- after learning about a real-world problem, students think about how this applies to them, and start brainstorming possible solutions and the impact this could have.

**Locally and/or personally relevant for students:**

The amount of garbage produced in the community and world-wide is discussed during this lesson. Solutions to reducing this waste are introduced, and students start to connect this solutions to their lives. Teacher leads a discussion to bring out students current experience/knowledge with composting, recycling, and waste management.

**Connections to career and educational pathways:**

Role of waste management within a city is brought up. The new initiatives businesses and organizations are taking is brought up to encourage students to think about how they would respond to meet the needs.

**Materials:** Student presentations

**Lesson preparation:**

**Time required:** Depends on class size

**Grouping of students for instruction:**

Whole class, with students broken into lab groups for discussion, planning, or possible extension research to determine a solution for the problem.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

This is the end to the “resolve” portion of the PBL. The purpose of this lesson is the culmination of the PBL

**Details of lesson**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Remind students of expectations. | In teams, share out proposal, providing justification. Students provide evidence in some form (PPT, poster, other evidence). Presentations are estimated to be about 2-5 minutes. |
| After presentation, open up for questions. | Students not presenting ask follow up questions about the presentation. |

**Accommodations:** Continue providing accommodations from previous lessons

Alter presentation format based on student need

**Extensions:**  Could be paired with Lesson 8, or separated into two lessons.

**Assessment:** Final product will be presented to class. class will question process and grade proposal.