Waste: What do we do with it?

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Introduction

Most people don't take the time to think about what happens when they throw away a bin of old holiday decorations, leftovers (and the container they were stored in) that were starting to smell, or even old clothes that get stained or ruined. Things just get tossed into the garbage and then are assumed to be taken care of in an efficient and eco-friendly manner by someone else. Unfortunately, that is not the case. There is no one solution or procedure that works across the board. Waste management is an ongoing process that needs to continue to change as we, as a society, change and learn more about the environmental impacts our actions have. This unit delves into the good, the bad, and the ugly of where we've been, where we are, and where we could go with our waste management.

I teach at West Park Place Elementary School (WPP). West Park is part of the Christina School District and is in Newark, DE. WPP is less than a mile from University of Delaware (UD), which provides our school with many distinctive opportunities, such as walking field trips to places on campus and a diverse student body. We often get students from other countries who move here only for a few months as their parents are part of an international program through UD. Because there are enrolled students from over 100 countries, WPP provides children with experience learning and appreciation of many different cultures. By the time students get to me in third grade, they are accustomed to having new students join their class throughout the school year who speak very little to no English. This is our "normal" and it is a unique experience compared to most elementary schools. West Park serves slightly under 400 students in kindergarten to fifth grade. This makes us a relatively small school with only two to three classes per grade level. Approximately forty-five percent of students get free/reduced lunch.

After graduating from Bloomsburg University in 2017, I got a job at West Park as a third-grade teacher. I am lucky enough to be in my third year at West Park and third year in third grade. I teach all subject areas including reading, writing, math, science, and social studies.

Rationale

One of my favorite things about being a teacher is witnessing curiosity and desire to learn in my students. When children encounter situations they don't understand, they often fill in the gaps with whatever their mind can come up with. Once students get to third grade, they can start understanding that they can seek out the answers to questions they have about the world. Their minds start filling things in with educated guesses, rather than whatever first comes to mind. It is a crucial time for students to take control of their learning and practice seeking to understand the *whys* and *hows* of the world we live in.

What happens to our waste? Do we get any say? What are the environmental impacts of dumping mounds of waste into a landfill? What about the carbon footprint of transporting cargo ships full of waste to other countries to get incinerated? Those are the questions that we should be asking each time we toss an empty chip bag into the nearest trash can. I want my students' curiosity to grow in regard to the environmental footprint they are leaving on our planet. In this unit, I'm hoping that not only will they learn to ask these types of questions, but will also learn to find the answers.

The choices people have made for years are directly influencing the status of life on earth. I believe that the one of the biggest impacts I can have toward an eco-friendly future is educating future generations. It is important that children learn about the changing environment to encourage them to live a more sustainable life. This unit will only address one aspect of human impact on the environment, but it is my goal to have this unit have a snowball effect on the lives of my students and those around them.

My unit is focused on current methods of waste processing and the influence those methods have on our environment. The two main waste removal systems we will focus on are landfills and incineration. Landfills have always been around, the entire earth was our landfill for many years, as people just dropped whatever they no longer needed on the ground until it hopefully decomposed. Modern day landfills are now in select locations with close monitoring, systematic procedures to limit methane release, and regulated safety standards that must be maintained. This, however, does not mean that we are doing less harm to our planet than we were hundreds of years ago when the world was our trash can. It is estimated that each person disposed of 4.51 pounds of waste every day in 2017.[1] This is an increase from 4.48 pounds of waste a day in 2015.[2] My unit will also then spend time on composting, an eco-friendlier method of waste management that is becoming increasingly popular. The unit will wrap up with determining which method, or combination of methods students think should be used to dispose of our town's waste.

Beyond learning about current methods of waste processing and its influence on the environment, students will also learn to use critical thinking skills to solve real world issues. As we progress through the unit, students will have time to ask questions and think critically about the investigations and their real-world application. One of my secondary goals for this unit is for students to improve their skills of asking questions and being able to search for answers to their questions. I want my students to build the confidence and have the mindset that there is no limit to the things they can learn and do. That is a lifelong skill that is needed, especially when it comes to protecting our planet.

Content

Where We Started

Before attempting to understand where we are as a society with waste disposal and processing, we must first understand where we have come from. Up until the very end of the 19th century, when people had things that were of no use to them, they simply dropped them on the ground and continued with their day.[3] At that point, incineration became a booming business with hundreds of incinerators in use around the country. New York City was home to a mass incinerator that had the capability to burn up to 800 tons of refuse per day. For a time, we also used the technique of **reduction**, which was first introduced in Europe. Jennifer Carless explains reduction in her book, *Taking Out the Trash*, "Wet garbage and animal remains were literally stewed to produce a greasy substance that was then sold for use in manufacturing items such as soaps, candles, and even perfume." (pg. 12) That technique did not last for long as a putrid odor was emitted from the plants along with a residue that polluted nearby water. Since then, landfills and incinerators have remained the most popular methods of waste processing, swinging back in forth in popularity.[4]

Where We are Now

Over 30 years ago, the US Environmental Protection Agency (EPA) began publishing data on the creation and disposal of our nation's waste. According to 2015 data, in the United States, 52.5% of our waste goes to landfills, 25.8% is recycled, 12.8% is combusted with energy recovery, and 8.9% is composted.[5]

Waste management is important on a local level. State and local governments are increasingly using a combination of methods. Handling waste management through

multiple practices is a strategy that is endorsed by the EPA called **integrated waste management**. Approaching it this way allows for communities to mold their procedures in a way that is specific to their needs.[6]

It is important to note that there is a preferred hierarchy, as designed by the EPA, for management of municipal solid waste.[7] At the top of the hierarchy, the most preferred method is *source reduction and reuse*. This includes doing things such as donating clothing, buying items in bulk, and manufacturing products using less packaging, among other things.[8] Next on the hierarchy is *recycling and composting*. This process takes recyclable items and sorts them. Then, the items are returned to their raw material and re-manufactured into new products.[9] Next is *energy recovery*. Energy recovery can be implemented through several processes, but always use non-recyclable items to create renewable energy.[10] Last on the list, the least preferred, is *treatment and disposal*. Treatment includes things such as treating the chemicals released during mass combustion. Disposal includes things such as maintaining municipal solid waste landfill (MSWLF) standards.[11]

Methods of Waste Removal

Landfills

Municipal Solid Waste Landfills (MSWLF) are designated areas of land where household waste, and occasionally other nonhazardous waste, is kept. Federal regulations exist that must be met by individual states in order to continue operating their MSWLFs, although some states establish more rigid requirements.[12] These federal and state requirements often create issues that make establishing new landfills, and keeping current landfills open a challenge. One of the issues that arises, is finding a suitable location for a new MSWLF. Landfills cannot be located within a certain distance from airport runways, near wetlands, flood plains, faults, and other areas.[13] Another issue is finding a location where the local government has enough funding for the upkeep, closure, and post-closure care of the MSWLF.[14] Also, a general issue with landfills is the release of leachates. A leachate is the liquid that drains from a landfill that can contain harmful chemicals. It is important to have the bottom and sides of your landfill heavily coated with a geo-membrane lining, which is often made up of at least two feet of clay and soil. This protects the soil and groundwater from being exposed to potentially harmful chemicals.[15] The leachates cannot just sit inside of the landfill so there needs to be a system for leachate removal and disposal. Landfills also need the waste they are holding to be regularly covered with soil. This frequent soil covering helps control odor, keeps animals away, and reduces litter.[16]

Landfills also release **landfill gas** (LFG). According to the EPA, LFG is, "a natural byproduct of the decomposition of organic material in landfills".[17] LFG is half comprised of methane, and the other half is half carbon dioxide. LFG also contains trace amount of non-methane organic compounds.[18] This causes a vast problem because if large amounts of methane are released into the air, it can cause problems locally with smog and globally impact climate change.[19] Scientists have found a way to use LFG as a renewable energy source. Currently over 70% of LFG energy is used for generating electricity.[20]

Mass Incineration (Combustion with Energy Recovery)

Incineration had been popular in the early 1900s, when hundreds of incineration facilities spread across the United States.[21] In the 1970s, however, the Clean Air Act (CAA) was established and facilities could no longer burn MSW without restrictions.[22] By the 1990s, many combustion sites had installed new technology to control air pollution, or were unable to keep up with the new regulations and were forced to close. There are now 75 combustion sites using energy recovery in the United States, with the most recent site opening in 2015 in Palm Beach County, Florida.[23] Out of the twenty-five states that recover energy through the combustion process, most are in the north-eastern part of the country. [24]

Combustion is defined by the EPA as "confined and controlled burning", and **Mass burn/mass combustion** is when a large amount of waste is burned at a combustion site.[25] Through mass combustion, we can get the third level on the EPA's hierarchy of waste management – energy recovery. Energy recovery is above disposal in the EPA hierarchy and reduces the volume of solid waste going into landfills.[26]

The mass burn process is complex. Once the MSW arrives at the facility, it is placed in an area where a large crane sorts the waste and carries it to the correct combustion chamber. As combustion occurs, the heat generated is used to convert water to steam, which then travels through and powers a turbine generator to produce electricity.[27] What is left after incineration is ash that then gets filtered. Ash particles from this step are wetted and combined with any ash that is remaining at the bottom of the chamber. This residue is then carefully transported to a MSWLF and used as a protection layer so soil and groundwater does not get contaminated with leachates or LFG.[28]

So, why don't we have more incinerators in the United States? The simple answer is that at least for now, we have enough land for landfills and combustion sites are much more expensive to operate.[29] Other countries have a much denser population than the United States, so they don't have many locations available to open new landfills. This forces them to spend the money on maintaining or opening combustion facilities. Another issue that the United States has faced with combustion sites relates to public opinion. Since there were so many incinerators in the 1900s that ended up being harmful to the environment, people associate combustion sites with air pollution.[30]

Recycling & Composting

Recycling is the process of taking items and breaking them down into their raw materials, and then using those materials to create something new.[31] The first step of recycling is *collection and processing*. The collection portion of this step can be done in a multitude of ways such as curbside pickup, drop off locations, and local recycling programs.[32] Once collected, recyclable items are brought to a recycling facility and are processed. Processing turns the items back into their raw materials.[33] The next step is *manufacturing*. This is when the raw materials are used to create a new item.[34] Newspapers, aluminum cans, and paper towels are common items made from recyclable materials. The last step is when people purchase items that are made from recyclable materials. [35]

Composting is "controlled decomposition," according to the EPA.[36] There are five important areas in composting that need to be controlled for it to be a success. First is *feedstock and nutrient balance*. A compost must have a balance of green organics, which are rich in nitrogen, and brown organics, which are rich in carbon.[37] Green organics can include cut grass and food scraps. Brown organics include things like dried leaves and small pieces of wood. The next area is *particle size*. Things put in your compost should be large enough that there is space for air flow, but small enough that there is proper insulation.[38] Third is *moisture content.* Compost piles can get moisture from the green and brown organics, rain, and watering.[39] Next is *oxygen flow*. Oxygen needs to be able to aerate the compost so that decomposition can occur. Too much air circulation, however, can cause a compost pile to dry out.[40] The final factor is *temperature*. If the temperature is not right, a compost pile can rot.[41]

Strategies

Activating Prior Knowledge

Prior to introducing new concepts, I will see what paradigms students have in regard to waste and waste management. Knowing these things will help me see what students already know and show me what misconceptions they have that I will need to correct. This will also allow students to refresh their memories on things they already know about waste and waste management.

To find out what prior knowledge my students have, I will have them each write down what they know about waste. I will go through several guiding questions to help them come up with things to write down. The questions I will ask are listed below.

1. What is waste?
2. Where do garbage trucks go after they collect garbage?
3. What is a landfill? How does it work?
4. What does combustion mean? What does it have to do with garbage?
5. Why do we recycle?

After students have enough time to write down all their thoughts, I will give them two minutes to share their ideas with the people around them. This will allow students to start having discussions about the things we will be learning. I will collect their papers and look them over before the next lesson. If there are any common misconceptions, I will address them as we get to that concept in the unit.

Investigations

My students are going to be doing a lot of investigating and will reach conclusions on their own, rather than having me teaching everything directly to them. From my experience, students are more engaged when they can do hands on activities and make educational discoveries with their peers. By conducting their own investigations, students will be able to find the answers to the questions they have without the typical direct instruction. This process will teach them that they can conduct investigations and answer their own questions. Hopefully they will learn how to use their curiosity to take control of their learning.

Discussions

Throughout the investigations, students will be given time to stop and reflect on what parts of the investigation have been successful and unsuccessful. They will talk with their peers about what the successes and struggles would look like when constructing or running the real-world version of that investigation. For example, if students are making a mock landfill and they put too much clay down in the first clay layer, they might not have enough left for the other clay layer. We would discuss how that might happen in the development of a real landfill and what extra steps would need to be done to fix it and the problems that could arise in the future if it wasn't fixed. Having the opportunity to take a step back during the investigations and dig deeper into the true meaning of the task at hand will help students develop a stronger understanding of the content.

Assessment

I will be assessing my students through their final project. They will be making a poster about what they think should be done with our waste. They will have two days to complete the project. Their poster will need to include a statement saying what they think should be done with our MSW (can be one method or a combination of methods with percentages of amount of waste going to each method). Students will need to defend their statement with facts, diagrams, and pictures.

Activities

This unit will be spread across six days with 50-minute sessions each day. Vocabulary for the unit is listed below.

Vocabulary-

1. Environmental protection agency (EPA)- a government agency in charge of making sure we have clean air, water, and land.
2. Municipal solid waste (MSW)- trash; items people throw away after they are used or no longer needed
3. Bacteria- microscopic single-celled living things that break down waste
4. Sanitation- keeping things clean
5. Municipal solid waste landfill- a landfill that houses non-hazardous household waste
6. Leachates- the chemicals that are released from waste when water runs through it
7. Mass combustion/incineration- the supervised process of burning MSW and retrieving energy from the gases released
8. Compost- decomposing of food and yard waste into fertilizer

Session One

On the first day, the focus will be on understanding what waste is, who is responsible for waste management, and why waste management is important. Complete the activating prior knowledge activity mentioned above. Read pages 4, 7, 11, and 15-19 of the book "Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling".[42] Discuss vocabulary words as they are mentioned in the book. As a wrap up at the end of the lesson, I will pose the question "What is waste?" and we will discuss as a class.

Session Two

This session is focused on landfills, the methodology behind landfill design, and the pros and cons of this form of waste disposal. Read page 12 of the book "Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling".[43] Discuss vocabulary words as they are mentioned in the book. Then, complete landfill investigation explained below.

Landfill Investigation

On the second day, we will be conducting investigations on the pros and cons of using landfills for municipal solid waste management. Students will be working in groups of four to create their own mock landfill. Each group will get to create their own model landfill because in the United States, there are an abundance of landfills, as that is our main method of waste management.

Each group will have a soda container with a layer of soil several inches thick. The next layer will be clay to represent the actual clay used in a landfill to protect the soil underneath from being contaminated by leachates. On top of the clay layer, there will be a layer of plastic. This represents the additional layer protecting the soil from leachates. In a landfill, there are typically pipes that remove the liquids. We will use cotton balls to represent this in our landfill models. Next is a layer of pebbles and gravel. This is another layer with the purpose of protecting the soil from leachates. Waste will be the next layer. We will get the waste from what we have collected within the past two days of school. The next layer will be dirt covering the waste. Finally, we will close our landfill by adding one more layer of clay, plastic, gravel, and soil. We will plant seeds in the top

layer of soil. Our model landfills will remain in our classroom for the rest of the unit and we will continue to observe them to make more discoveries about the pros and cons of landfills. Observations will include things like an odor being release after several days of our mock landfill sitting in our classroom, trash not decomposing, and watching the plants grow (or possibly not grow). We will be able to discuss why those things are occurring and if there is anything that can be done to either encourage or stop the things we observe from happening.

Session Three

The focus of this session is for students to understand the process of mass combustion and the pros and cons of using mass combustion to manage waste. We will read page 20 of the book "Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling".[44] We will discuss vocabulary words as they are mentioned in the book. Then, complete the incineration investigation.

Incinerator Investigation

This investigation will start by telling the students that this time, they are not able to create their own model of a combustion site. I will explain that unlike landfills, the United States doesn't have many combustion sites. There are only 86 across the nation. Because of the lack of facilities, all the towns (groups) from yesterday must share this one incinerator facility.

For this investigation, I will have one cheap candle. I will light it and students will be able to see the black smoky soot that is released. This represents the hazardous gases that are released in a mass incinerator. I will put a glass jar with two holes on top of the candle. One of the holes will have cheese cloth stuffed in it. After several minutes, I will remove the cheese cloth and we will observe the residue on it. This residue represents the ash that is remaining after incineration that can be used as a protective layer in municipal solid waste landfills.

Session Four

This session is about composting, how it is different from a landfill, and what happens to waste when it is composted. We will read pages 8 and 23-30 of the book "Where Do

Garbage Trucks Go? And Other Questions About Trash and Recycling".[45] Then, we will discuss vocabulary words as they are mentioned in the book. Then, complete the composting investigation.

Composting Investigation

Each student will make their own compost in a bag. We will need plastic bags, dirt, and waste from a kitchen or garden. We are going to put ½ a cup of "green organics" such as grass clippings, coffee grounds, or fruit peels in our bag. Next, we will add ½ a cup of "brown organics" such as dried leaves or twigs. Then, we will add one cup of dirt, one tablespoon of alfalfa pellets, and one ounce of water. We will mix the contents of the bag up and seal it closed. Each day we will mix the bag and we will leave the bags open every other day.

Prior to this investigation, I am going to make several composting bags. One bag will be made six weeks prior so it will likely be composted already. I will also make bags two and four weeks prior so students will be able to see what the process looks like at different time points. After students make their own composting bags, I will show them the ones I previously started, and we will make observations. Observations will include things such as an odor, soil, seeing food at different points in decomposition, and the feeling of the different bags.

Appendix

Next Generation Science Standards

MP.5 Use appropriate tools strategically.

MP.2 Reason abstractly and quantitatively.

3-5 ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Common Core Standards

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

Resources

Carless, Jennifer. *Taking Out the Trash: A No-Nonsense Guide to Recycling*., Washington D.C.: Island Press, 1992.
This is a book written about the basics of recycling from the past to predictions of the future.

Environmental Protection Agency. "Basic Information About Landfill Gas". *EPA.* Accessed October 12, 2019. https://www.epa.gov/lmop/basic-information-about-landfill-gas.
This is the EPA's website information on general information regarding landfill gas.

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This is the EPA's website information on how combustion sites recover energy through the burning of municipal solid waste.

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This is the EPA's website information on the regulations and process of municipal solid waste landfills.

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This is the EPA's website information on the national data collected during 2017 on waste and recycling.

Environmental Protection Agency. "Recycling Basics" *EPA.* Accessed October 12, 2019. https://www.epa.gov/recycle/recycling-basics.
This is the EPA's website information on the benefits and steps of recycling.

Environmental Protection Agency. "Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy". *EPA.* Accessed October 12, 2019. https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy.
This is the EPA's website information on hierarchy for managing waste.

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This is the EPA's website information on the different the process of composting municipal solid waste.

"Protection of Environment," Title 40 *Electronic Code of Federal Regulations.* P.t 258. 2019 ed. Accessed November 26th 2019. https://www.ecfr.gov/cgi-bin/text-idx?SID=4a6d41be27689793bf8ed57bd6e45489&mc=true&node=sp40.27.258.b&rgn=div6
This is the Code of Federal Regulations regarding location restrictions for municipal solid waste landfills.

Richmond, Ben. *Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling*, New York: Sterling Children's Books, 2016.
This is a book that answers many questions children have about trash and recycling.

Notes

[1] "National Overview: Facts and Figures on Materials, Wastes, and Recycling," Environmental Protection Agency, Accessed November 16th, 2019, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

[2] Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes, and Recycling."

[3] Jennifer Carless, *Taking Out the Trash: A No-Nonsense Guide to Recycling* (Washington D.C.: Island Press, 1992), page 11.

[4] Carless, *Taking Out the Trash: A No-Nonsense Guide to Recycling*, page 11-12.

[5] Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes, and Recycling."

[6] Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes, and Recycling."

[7] Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes, and Recycling."

[8] "Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy," Environmental Protection Agency, Accessed October 12, 2019, https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy.

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[19] Environmental Protection Agency, "Basic Information About Landfill Gas."

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[21] Carless, *Taking Out the Trash: A No-Nonsense Guide to Recycling*, pages 11-12.

[22] "Energy Recovery from the Combustion of Municipal Solid Waste (MSW)," Environmental Protection Agency, Accessed October 14, 2019, https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw.

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[31] "Recycling Basics," Environmental Protection Agency, Accessed October 12, 2019. https://www.epa.gov/recycle/recycling-basics.

[32] Environmental Protection Agency, "Recycling Basics."

[33] Environmental Protection Agency, "Recycling Basics."

[34] Environmental Protection Agency, "Recycling Basics."

[35] Environmental Protection Agency, "Recycling Basics."

[36] "Types of Composting and Understanding the Process," Environmental Protection Agency, Accessed October 12, 2019,

https://www.epa.gov/sustainable-management-food/types-composting-and-understanding-process.

[37] Environmental Protection Agency, "Types of Composting and Understanding the Process."

[38] Environmental Protection Agency, "Types of Composting and Understanding the Process."

[39] Environmental Protection Agency, "Types of Composting and Understanding the Process."

[40] Environmental Protection Agency, "Types of Composting and Understanding the Process."

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[42] Ben Richmond, *Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling* (New York: Sterling Children's Books, 2016), pages 4, 7, 11, and 15-19.

[43] Richmond, *Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling*, page 12.

[44] Richmond, *Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling*, page 20.

[45] Richmond, *Where Do Garbage Trucks Go? And Other Questions About Trash and Recycling*, pages 8, 23-30.