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Composting Food Waste: A Method That Can Improve Soil Quality and Reduce Greenhouse Gas Emissions

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*Composting Food Waste: A Method That Can Improve Soil
Quality and Reduce Greenhouse Gas Emissions*

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Professor Van Buren

Senior Thesis in Environmental Policy

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Table of Contents

I: Introduction: Food Waste Problem and the Compost Solution.....page 3

II: A Closer Look At the Environmental Issues.....page 4

III: A History of Composting.....page 16

**IV: Designing for Composting: Industrial and Home Systems, and Compostable
Products.....page 20**

V: Policy: Regulating Food Waste Composting.....page 27

VI: Conclusion: Moving Towards Better Composting Regulations.....page36

VII: Citations.....page 39

Introduction: Food Waste Problem and the Compost Solution

Greenhouse gas emissions and the loss of soil fertility worldwide are two important environmental issues that we are facing today as part of global climate change. As the human population continues to rise and harmful environmental practices persist, environmental degradation is sure to worsen. Landfills are a major source of the potent greenhouse gas, methane. The food waste we sent to landfills is the reason that landfills emit methane and carbon dioxide. Through poor soil management, soils are increasingly becoming degraded and unable to support plant life and the synthetic fertilizers used to enhance soils contribute to environmental issues. One solution—among many—to mitigate greenhouse gas emissions and improve soil fertility is diverting food waste from landfills and turning it into compost that we can apply to soils.

In this thesis I will support food waste composting and recommend steps toward improving regulation to promote composting throughout the United States. I will first examine data and information on food waste, landfill emissions, soil degradation, and the science behind the food decomposition processes. I will then explore how people have used composting throughout human history. I will then look at various composting systems designs that are used to make compost. Finally, I will look at the federal and state composting regulations and make comparisons. I will use these three disciplines and data to support my thesis of increasing food waste composting and support more stringent policy action for food waste composting on the federal and state levels

A Closer Look At the Environmental Issues

Municipal Solid Waste In Landfills. Household waste or municipal solid waste (MSW), which we often refer to as trash or garbage, is comprised of both organic and inorganic material. The organic material is all of the material that is biodegradable and decomposes such as food scraps and yard trimmings. Inorganic materials, on the other hand, include items that are not biodegradable such as metals and plastics. It is estimated that around three- fourths of household waste consists of organic material that comes from the consumption of food and from yard waste; organic waste is largest component of municipal solid waste in the United States.¹

As the human population continues to grow exponentially, the consumption of food and food waste also increases. Around 79 million are added to the human population every year.² In the United States, the population has risen over 300 million.³ All of these people must be fed and as result waste increases. During the year 2010, municipal solid waste in the United States reached 250 million tons compared to 88.1 million tons in 1960.⁴ As shown in Figure 1, since the 1960s, the amount of municipal solid waste generated has been following a generally increasing trend, but after 2000 total municipal solid waste has been slowly decreasing. The decreasing trend is a result of increased recycling and composting rates throughout the United States.

¹ Campbell, *Let it Rot! The Gardeners Guide to Composting*, pg 8.

² Cunningham, William P. and Mary Ann Cunningham, *Principles of Environmental Science*, pg 78.

³ "United States Population Growth." *CensusScope*

⁴ "Municipal Solid Waste Generation." Environmental Protection Agency, pg 4

Of the 250 million tons of MSW generated in 2010, 13.4 percent was yard trimmings and 13.9 percent was food scraps. The per capita generation during this same year was 4.43 pounds, and 1.51 was recycled and composted.⁵ When these numbers are combined we see that over 27% of Municipal Solid Waste in the United States could have been be composted in 2010.⁶ However, about 20 million tons of food waste was composted in 2010.⁷ The quantity waste being composted has been increasing since 1990. During 1960 until 1980 composting rates were so low they were negligible; however, this changed in 1990 with 4.3 million tons of food waste being composted.⁸ Composting rates will continue to increase as people look to divert their food waste from landfills.

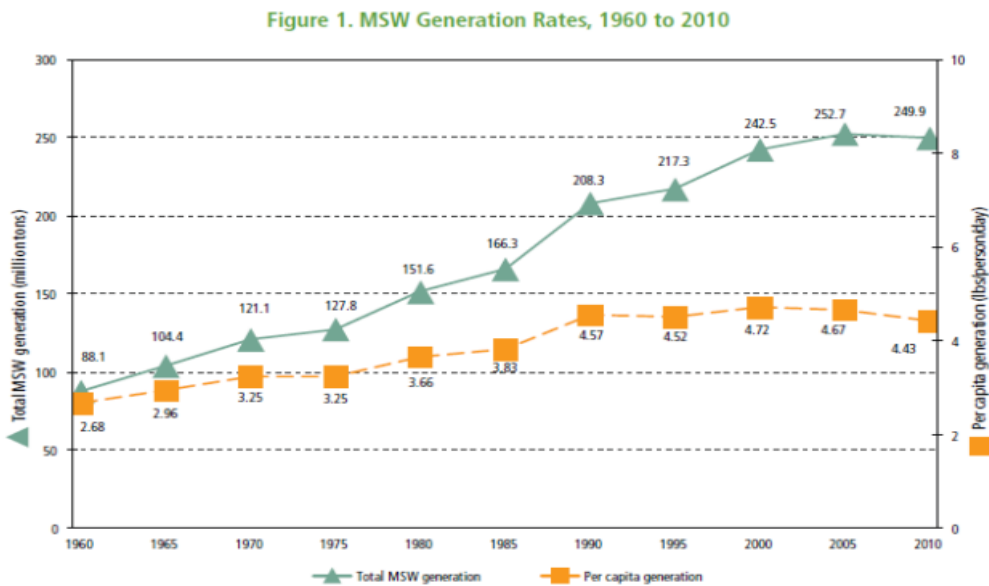


Figure 1: Courtesy of “Municipal Solid Waste Generation.”

The organic material from MSW that is not composted ends up being buried and densely compacted in landfills across the country. Of the 250 million tons of MSW generated in 2010, an

⁵ “Municipal Solid Waste Generation.” Environmental Protection Agency. Pg1.

⁶ EPA composting

⁷ “Municipal Solid Waste Generation.” Pg 2.

⁸ Ibid., pg 8.

estimated 136 million tons was discarded into landfills.⁹ The way in which landfills are built and the material is buried causes the production and release of greenhouse gases into the atmosphere—mainly carbon dioxide (CO₂) and methane (CH₄). The combination of methane, carbon dioxide and other greenhouse gases emitted from landfills are commonly referred to as landfill gas (LFG). 50-60% of the gas emitted from a landfill is methane and 30-40% is carbon dioxide, and the remainder is traces of other gases such as nitrogen, carbon monoxide and hydrogen.¹⁰ The Environmental Protection Agency “has identified landfills as the single largest source of methane” contributing to about 34% of man-made methane in the United States alone.¹¹ Methane is 21 times more potent as a greenhouse gas than carbon dioxide. In the year 2000, it was estimated that of the 282.6 million tonnes of the global methane, 36.7 million were a result of landfill emissions.¹² To put this into a clearer perspective, one tonne of MSW (one tonne is equal to 2204.62 pounds) produces around 0.148 tonnes of methane or 328.49 pounds.¹³

Organic waste in landfills produces most of the methane and carbon dioxide emissions through the four stages of the bacterial decomposition process as a result of oxygen deprivation. This decomposition process occurring without oxygen is anaerobic decomposition. As the amount of organic waste material sent to landfills increase, the level of methane carbon dioxide emitted from the landfills also increase.¹⁴ Decomposition of organic waste as it occurs naturally under aerobic conditions—in the presence of oxygen—does release carbon dioxide, however,

⁹ Ibid., pg 2.

¹⁰ Abushammala, Mohammed F. M., Noor Ezlin Ahmad Basri, and Abdul Amir H. Kadhum. "Review on Landfill Gas Emission to the Atmosphere." *European Journal of Scientific Research*. Pg 428.

¹¹ “Keeping Organics Out of Landfills.” US Composting Council.

¹² Themelis, Nickolas J., and Priscilla A. Ulloa. "Methane Generation in Landfills." *Renewable Energy* . 32. (2007). Pg 1249.

¹³ Ibid., 1248

¹⁴ “Chapter 2: Landfill Gas Basics.” 2001. Agency for Toxic Substances & Disease Registry.

this carbon dioxide is part of the natural carbon cycle.¹⁵ Anaerobic decomposition implies that oxygen is very limited or completely absent at the site, and the anaerobic bacteria that break down the organic material release large traces of landfill gases.¹⁶

During the first phase of waste decomposition under anaerobic conditions, aerobic bacteria consume the oxygen that is present in the landfill while they break down the carbohydrates, proteins, and lipids making up the organic waste.¹⁷ The first phase continues until most or all of the oxygen is used up, and the byproducts during this phase are carbon dioxide and water lasting from a few days up to months depending on the oxygen content.¹⁸ Once the oxygen content in the landfill is depleted, the second phase of decomposition begins. During this second phase of the anaerobic decomposition process, the anaerobic bacteria turn the organic material acidic and alcohols, and carbon dioxide and hydrogen are released. If oxygen returns or is added into the landfill then the landfill could potentially revert to stage one with the return of aerobic bacteria.¹⁹

Anaerobic conditions continue to stabilize into the third phase in which methane-producing bacteria begin to accumulate and forming the organic acid, acetate.²⁰ It is during the fourth stage that the anaerobic bacteria begin to break down the organic acid and produce methane and carbon dioxide and convert the hydrogen and carbon dioxide into methane.²¹ During the fourth stage, methane and carbon dioxide are produced at a stable rate and this

¹⁵ Ibid.,

¹⁶ Abushammala, Mohammed F. M. Pg 428

¹⁷ "Chapter 2: landfill gas basics."

¹⁸ Abushammala, Mohammed F. M. Pg 429

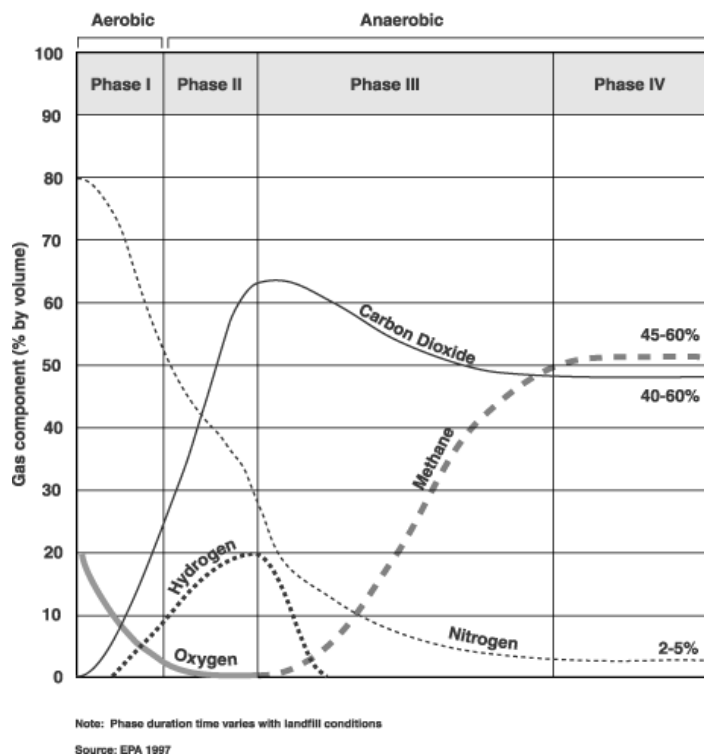
¹⁹ "Chapter 2: Landfill Gas Basics"

²⁰ Ibid.,

²¹ Abushammala, Mohammed F. M. Pg 429

production may continue for up to 20 years and the landfill will continue to release landfill gas for up to 50 years.²²

Figure 2: GHG Emissions During Stages of Anaerobic Decomposition



Source: Courtesy “Chapter 2: Landfill gas basics.”

There are currently 1,908 landfills across the United States that have replaced town dumps. This number has dropped from 7,924 in 1988, a 79% decline.²³ Although the number of landfills has decline, it does not mean that we are running out of space to throw our garbage

²² “Chapter 2: Landfill Gas Basics.”

²³ “The Facts About America’s Landfills.” *PostCom: Association for Postal Commerce*.

because the landfills have increase in carrying capacity throughout the years.²⁴ Since there has been a decline in the number of landfills, food waste now must travel longer distances to reach landfills.²⁵ Some landfills have larger capacities than others as well as longer lifetimes. For this reason some states will sent their trash in border states with more available landfill space.

Soil Degradation and the Use of Synthetic Fertilizer. Industrial agriculture and poor soil management has proved to cause sever soil degradation or topsoil loss around the world. Contrary to common misconception, soil is a finite resource and essential for human survival. Soils support plant growth because they are the “living reservoir that buffers the flow of water, nutrients, and energy through an ecosystem.”²⁶ There are six main components that form healthy soil: sand and gravel, silts and clays, decayed organic material, soil animals and plants, water, and finally air.²⁷ Different variations of soil will have different traces of these six components. We can measure soil fertility and it’s capacity to support plant life based on the presence of these components. Soil will become fertile through the accumulation of mineral particles from the weathering of rock, and from absorbing the nutrients from decaying of plant material.²⁸ Without the presence of minerals, water and decayed materials, soils are unable to support plant life and the may even turn into deserts.

Decayed organic matter, in particular, provides the soil with essential nutrients in addition to helping form the soil into a texture that can retain water and prevent erosion.²⁹ Sixteen distinct nutrients are necessary for plant growth. Carbon, hydrogen, and oxygen are three

²⁴ Palmer, Brian. “Landfills are safer than dumps, but rash must travel farther to reach them.” *The Washington Post*. 21 February, 2011

²⁵ Ibid.,

²⁶ Sustaining Our Soils, Pg 13

²⁷ Cunningham, Pg 162-163.

²⁸ Sustaining Our Soils, pg 8

²⁹ Ibid., pg 9

nutrients that the soil receives from the carbon dioxide present in the atmosphere and from water. The thirteen other nutrients include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and smaller quantities of other nutrients. Some of these nutrients are released from the weathering of rocks, but most of them come from the decayed materials and from animal wastes.³⁰ Topsoil is the second layer of soil where the organic material and minerals are highest in concentration; soils that have a healthy topsoil layer are used for agriculture because they are better with supporting plant life.³¹

It is important to maintain a natural ecosystem where plants and animal wastes are returned to the soil for purposes of maintaining it fertile and recycling these nutrients. However, this is especially problematic in urban and densely populated areas where soils are highly neglected. One of the main reasons for this is because food waste or plant waste is sent to landfills.³² Urban soils, more often than not, are not uniform in their properties because they are often moved to different locations and mixed in with non- native soils.³³ In addition, low nutrient level, low organic matter, and high soil compaction often characterize urban soils.³⁴ For these reasons, most urban soils are unable to support abundant plant life.

Carbon Recycler. Another important role that soil plays is that of a carbon recycler. Soil, like the oceans, is a carbon sink sequestering carbon but it is important to keep in mind that carbon sinks will also emit carbon. Soil humus holds twice as much carbon dioxide than is

³⁰ Ibid., pg16-17.

³¹ Cunningham, pg.164.

³² Sustaining Our Soils, pg 30

³³ “Evaluation of Urban Soils: Suitability for Green Infrastructure or Urban Agriculture.” Environmental Protection Agency. No. 905R1103.

<http://water.epa.gov/infrastructure/greeninfrastructure/upload/Evaluation-of-Urban-Soils.pdf>

³⁴ EPA evaluating our soils.

present in the atmosphere, and soil stores three times more carbon than plants.³⁵ Healthy soils will absorb carbon from the atmosphere. A European Commission report states that soil in Europe contains 73 to 79 billion tonnes of carbon.³⁶ By degrading soils we are increasing the concentration of carbon in the atmosphere.

Poor Soil Management. Soil mismanagement includes any human activity that depletes soil of its nutrients making the soil less fertile. The United States first felt the severe impacts of soil degradation during the Dust Bowl of the 1930s in the Great Planes region, which caused massive dust storms whose particles reached even New York City. A combination of drought and poor soil management damaged the soils of the Great Planes and thousands of people relocated. Mismanaging soil may result in soil erosion, salinization, depletion of nutrients, and contamination that lead to costly environmental damages.³⁷

Soil mismanagement includes overgrazing, overplowing, deforestation, native plant removal and extensive synthetic fertilizer use. Overgrazing is the grazing of given area of land by too many livestock over a long period of time.³⁸ Overgrazing causes the land to be stripped off of its natural vegetation making more susceptible to wind and water erosion. The Dust Bowl was affected by overplowing through extensive farming that quickly stripped the soil of its nutrients. Deforestation also causes erosion because plants no longer hold the soil particles together. Soil erosion, particularly, is the most severe consequence of soil mismanagement. Furthermore, soils become contaminated with the use synthetic fertilizer, pesticides, cleaning

³⁵ “Sustaining Our Soils.” Pg 15.

³⁶ “Poor soil management could speed climate change, report warns.” *edieEnergy*. 11 March 2009. <http://www.edie.net/news/6/Poor-soil-management-could-speed-climate-change-report-warns/16126/>

³⁷ “Sustaining Our Soils.”Pg 33.

³⁸ “Excessive Grazing and Browsing.” *Food and Agriculture Organization of the United Nations*. <http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Grazing/overgraz.htm>

fluids that end up reach groundwater.³⁹ Soils can also become contaminated with salts from the irrigation with saline water, and the salt will decrease plant growth and if they are too high then plants will not grow at all.⁴⁰

It is estimated that around one third of the world's cropland has been abandoned over the last forty years because the soil in these lands have been degraded making it insufficient to support crop growth.⁴¹ An estimated 46.4 % of all soil is experiencing "decreased productivity" implying that these soils no longer support the same abundance of plants that they once did.⁴² Degraded soil does not occur only on farmland but also in urban areas and in our own backyards. The ISRIC World Soil Information data shows that 15.1% of soil cannot be used for farming and any restoration projects will take years and be expensive; 0.5% of soil has been damaged to the extent that it is irreparable.⁴³

Using Synthetic Fertilizers. To improve soil quality and counteract soil degradation, people rely heavily on the usage of chemical or synthetic fertilizers. As has previously been noted, plants extract the necessary nutrients from soil for growth. As we continue to grow crops to feed the growing population and use soil at faster rates than we allow nutrients to feed it, the soil is quickly depleted of its nutrients and unable to further support plant life. Synthetic fertilizers, however, are a quick and easy way to enrich the soil with the necessary nutrients it requires for fertility. Nitrogen, phosphorous, and potassium—three of the essential nutrients present in soil—are the main ingredients in most of the synthetic fertilizers produced.⁴⁴ The nutrients present in synthetic fertilizer are produced either chemically or they are mined and then

³⁹ "Sustaining Our Soils", pg 40

⁴⁰ Ibid.,

⁴¹ "Soil Health." Cool2012.

⁴² "Soil Degradation." Good Planet Info. 2009.

⁴³ Ibid.,

⁴⁴ "Pesticide and fertilizer use." Cool2012.

manufactured into grains resembling salt.⁴⁵ The salts are soluble and become immediately available to plants through the soil.

Different environmental and health disadvantages occur as consequence of applying synthetic fertilizers to land. Currently, 40- 60% of agricultural yields are a result of using synthetic fertilizer. In addition, 50-60% of people have used synthetic fertilizer to grow their crops.⁴⁶ Large amounts of chemicals such as phosphates and nitrates in fertilizers sometimes end up in waterways, polluting the water and creating dead zones that kill fish.⁴⁷ Excessive use of these fertilizers also harms the soil itself, turning it more acidic from the high rates of nitrogen.⁴⁸ Moreover, synthetic fertilizers release greenhouse gases because carbon dioxide, methane, and nitrogen are all ingredients in fertilizers contributing to global climate change. By reducing the amount of synthetic fertilizer, we can also move towards minimizing negative environmental impacts.

Compost Happens Naturally. Food waste compost happens naturally in nature because organic material decomposes and returns to the soil. As previously mentioned, organic matter in landfills is decomposed through the anaerobic process, but the decomposition of organic matter through composting occurs aerobically. Food waste undergoes aerobic decomposition when there is enough oxygen for aerobic bacteria in particular to survive and decompose the food. Microorganisms living in the compost pile are largely responsible for sustaining the decomposition process; these microorganisms include bacteria, fungi and most importantly

⁴⁵ Molnar, Chris. "The Dirt on Fertilizer- Organic vs. Synthetic." *Organic Authority*.

⁴⁶ "The Disadvantages of Using Fertilizer." *Environment911*.

⁴⁷ <http://environment.nationalgeographic.com/environment/green-guide/buying-guides/fertilizer/environmental-impact/>

⁴⁸ *Ibid.*,

aerobic bacteria.⁴⁹ Macroorganisms such as earthworms, insects, spiders, and nematodes assist in the decomposition of the material.⁵⁰ Both microorganisms and macroorganisms require oxygen, moisture, carbon, and nitrogen to grow and maintain the decomposition process of a compost pile.⁵¹

Carbon is the energy source for the decomposers while nitrogen provides them with protein essential for their growth and reproduction.⁵² The materials that contain carbon are leaves, sawdust, and straw—composters call these the ‘browns’. Nitrogen rich material is green vegetation, grass clippings, or simply the food scraps—composters call these the ‘greens’. When making the compost recipe, there needs to be a proper carbon- nitrogen ration for the decomposition to run more efficiently and rapidly. The ideal carbon- nitrogen ratio ranges between 25:1 and 30:1.⁵³ Anything above a 30:1 ratio will slow down the decomposition process or anything below a 25:1 ratio will cause a foul odor. As a note, it is always better to have more browns than greens.

Aeration into the pile is necessary for the survival of the decomposers and it is often considered as being the most crucial ingredient in the compost recipe. Compost piles can quickly become oxygen deficient because the weight of the material leaves leeway for air to move into the pile. In addition, the microorganisms and macroorganisms use up the oxygen through respiration and metabolism; the organism will convert the oxygen into carbon dioxide through respiration.⁵⁴ Mixing or turning the compost pile regularly is a common way of aerating. Using

⁴⁹ “The Science of Composting.” University of Illinois Extension: Composting for the Homeowner.

⁵⁰ Campbell, pg 13

⁵¹ Campbell, pg 13

⁵² “The Science of Composting.”

⁵³ Ibid.,

⁵⁴ “The Science of Composting.”

ventilator stacks that run through the pile and blow air into it is another way of aeration that removes the need for laborious mixing.⁵⁵ If the compost pile is depleted of oxygen then it will start to emit foul odor.

In addition to the oxygen factor, moisture and particle size are also important for the decomposition process. Too much moisture in a compost pile can force out oxygen while too little moisture will slow down decomposition.⁵⁶ Ideally, the moisture content should be similar to what a wrung- out sponge would be.⁵⁷ If the pile is too dry then water can be added to it or if the pile is too moist then additional carbon material can soak the water.⁵⁸ It is also important that the material is reduced to small sizes (chopped up) so that the microorganisms can digest it more easily; this will speed up the decomposition.

Compost Improves Soil. One of the benefits of compost is its ability to improve soil quality. Compost is rich in nutrients such as nitrogen, phosphorous, potassium, manganese, copper, and iron that plants need to grow—it is very similar to topsoil.⁵⁹ Applying compost to any soil type will change the soils texture so that it can “better retain nutrients, moisture, and air for the betterment of plants.”⁶⁰ Improving the soil texture will help soils sequester carbon to mitigate global climate change and prevent erosion. Furthermore, soil helps to reduce pest problems and plant diseases. Because compost has a neutral pH level, this helps reduce the acidity in soils.⁶¹ Compost can also improve urban soils. Studies have shown that adding

⁵⁵ “The Science of Composting.”

⁵⁶ Campbell, pg 15

⁵⁷ “The Science of Composting”

⁵⁸ Ibid.,

⁵⁹ “Benefits and Uses.” *Composting for the Home Owner*. University of Illinois Extension.

⁶⁰ Ibid.,

⁶¹ Ibid.,

compost to urban soils “improved the physical properties and the nutrient content of the soil.”⁶²

The compost will actually counteract the compaction that results from construction. Since urban soils improve in quality, they are then also able to retain runoff much more effectively and when they are applied to lawns it reduces the need for the usually irrigation.⁶³

A History of Composting

An Ancient Fertilizer. Food waste composting is gaining a newfound appreciation and popularity; however, composting is not a recent method for enriching soil, but has been around since the beginning of the Neolithic Revolution when people first transitioned to agriculture. The application of manure and food waste compost to cultivate crops is prehistoric. We cannot attribute the use of compost in agriculture to one individual or a group of people because it is a method discovered by people all over the world who practiced agriculture.

The benefits of applying compost to fields were most likely discovered through direct observation; people noticed that crops and plants grew better near animal manure and so they began to apply manure throughout their fields.⁶⁴ This connection between crop growth and manure led to the development of manure composting. Sometimes these ancient farmers spread manure directly onto the soil, and other times they turned it into compost by mixing the animal manure with straw and other plant waste turning it into a material closely resembling topsoil or humus, which provided essential nutrients for crops to thrive.⁶⁵

The earliest human civilizations such as the Romans and Greeks in addition to the Akkadian Empire in the Mesopotamia Valley, 1,000 years before Moses was born, have used

⁶²“Evaluation of Urban Soils.” pg 5

⁶³“Can Urban Soil Compaction Be Reversed?” Polytechnic of Namibia.

⁶⁴ Gershuny, Grace, and Deborah L. Martin. *The Rodale Book of Composting: Easy Methods for Every Gardener*. Pennsylvania: Rodale Books, 1992. Pg 1

⁶⁵ “Composting- History.” Science Encyclopedia

some form of composting for fertilizing the soil and enhancing farming.⁶⁶ During the Golden Age in Greece, Greek writers wrote about the use manure and plant ashes on crops for making “thin rich soil”.⁶⁷ There a number of references to composting made in the Bible; the Arabs and medieval monks have written about its benefits; and there are references of composting in Renaissance literature.⁶⁸ Furthermore, studies of the soil in Scotland have shown that during the Stone Age, people planted crops in middens, which were the places the people buried their organic waste such as vegetables and manure.⁶⁹

Manure and waste compost was also a common practice in China, Japan and Korea. In 1911, the American scientist Dr. F.H. King published *Farmers of Forty Centuries* in which he writes about the use of compost in these areas. He concluded that these farmers composted almost all of the plant material instead of just throwing them away.⁷⁰ Records show that in China people they used both human and animal waste, along with plants for compost making for over 3,000 years.⁷¹ All of these ancient peoples understood early on that by mimicking a process occurring in nature they could improve the crop yield by feeding the soils.

Modern Composting. In North America, the European settlers and the Native Americans also practiced composting methods. Similar to the Europeans, the early settlers during the 18th century initially used stable manure from horses and applied the manure directly to soil.⁷² However, this method was not very convenient because of the limited manure and the increasing area of cropland. Settlers soon discovered a more convenient method; they mixed two loads of

⁶⁶ “A Brief History of Composting”; Gershuny, Pg 2

⁶⁷ Beaton, James. “History of Fertilizer.” Efficient Fertilizer Use Manual. Mosaic.

⁶⁸ Gershuny, Pg 3.

⁶⁹ Rudnicki, Alicia, “Ancient Composting”. Green Living. National Geographic.

⁷⁰ “A Brief History of Composting.”

⁷¹ Beaton, James.

⁷² Gershuny, Pg 3

muck with one load of stable manure, and the end product was the equivalent to three loads of manure.⁷³ This particular method was highly praised even by scholars of the time, and farmers were encouraged to use it.

Farmers in the New England area also made use of the abundant source of menhaden fish to make compost. Because the fish was so abundant, farmers could make compost on larger scales. The recipe for this compost included an initial layer of muck followed by one layer of fish. This pattern of a layer of fish and a layer of muck continued until the heap reached a height of five to six feet; they applied ten to twelve loads of muck to one load of fish.⁷⁴ Farmers then turned or mixed the compost heap to help it ferment and until all of the fish broke up.⁷⁵ The finished compost was odorless and “preserved perfectly all the manorial values of the fish—the farmers used up to 220,000 during one season.”⁷⁶

Notable people in US history have recognized the benefits of composting and they have been strong advocates of it encourage farmers to apply compost if they wanted to continue growing crops. One such example is George Washington who, surprisingly, experimented with different compost recipes hoping to make the perfect compost to restore his land after the Revolutionary War; he finally concluded that using sheep dung rather than horse dung makes the best type of compost.⁷⁷ Thomas Jefferson and James Madison were also avid users of compost using their own recipes and recommendations for dung and plants. George Washington Carter advised farmers to make their own compost on their fields and refrain from buying compost to

⁷³ Ibid., pg 3

⁷⁴ Ibid.,pg 4

⁷⁵ “History of Composting”

⁷⁶ Gershuny, pg 4

⁷⁷ Ibid.,

maintain soil fertility so that they could save their money.⁷⁸ The colonists did not often use plant material because dung was readily available; however, the people in the South preferred to compost cottonseed and muck.⁷⁹

Modern composting methods have developed from a method discovered in the 1920s by Albert and Gabrielle Howard along with Yeshwant Wad in India. This composting method called the Indore method follows an organic approach requiring plants and manure.⁸⁰ Indore method of composting was a mixture of a collection of plants, dung, and urine- rich soil that required some addition of water and three turnings — this method made compost within ninety days.⁸¹ In addition, this method included attention for the importance of heat, carbon- nitrogen ratios, and aeration to form compost. In the 1940s, J. I. Rodale began to publishing *Organic Farming and Gardening* in which he included information about the Indoor method of composting and expanding on this method.⁸² Rodale is largely credited with introducing the composting for gardens. Modern composting methods continue to be based off of the Indore method.

A Shift to Chemical Fertilizers. With the start of the Industrial Revolution, a rapidly growing human population, and an increasing demand for food, commercial synthetic fertilizers were produced to increase soil fertility to yield large quantities of crops. Commercial fertilizer was imported between 1840 and 1870 from Peru in the form of bat guano that is rich in nitrogen.⁸³ By the mid 1800s, chemical fertilizers were being used all over the United States initially started with the finding of phosphate rock in South Carolina, Florida, North Carolina,

⁷⁸ Ibid., pg 6

⁷⁹ Ibid., 7.

⁸⁰ “A Brief History of Composting”

⁸¹ “A Brief History of Composting”

⁸² Gershuny, pg8

⁸³ Roberts

and the West, and then synthetic nitrogen was produced in the early 1900s.⁸⁴ Sodium nitrate was the first source of nitrogen and it was mined in Chile beginning in the 1930s and imported to both Europe and the United States.⁸⁵ By the 1920s the United States used 600,000 tons of sodium nitrate from Chile every year, and by 1994 this decreased to 34,700 tons.⁸⁶ Ammonium sulfate also began to be manufacture in the 1920s, and it remained an important fertilizer until the 1980s.⁸⁷ Consumption of these various synthetic fertilizers in the US correlate with increasing crop yields; use of synthetic fertilizer has increased from four million tonnes in the 1940s to 22 million tonnes today.⁸⁸ Today, the United States produces the most synthetic fertilizer in the world.⁸⁹

Designing for Composting: Industrial and Home Systems, and Compostable Products

There are various types of composting systems and designs that are used to make compost. These systems are divided into categories—home systems or small-scale systems and industrial or commercial systems. Choosing a compost system depends largely on personal preference and factors such as space, location, time availability, desired compost quantity, amount of organic waste produced, as well as tools.⁹⁰ A compost system should best suit a situation, a given area and environment. Home systems are generally used to make compost for gardens, and larger compost systems create larger quantities of compost that can be sold be used for creating more compost to be sold and or used in farms. With the increased popularity of

⁸⁴ Ibid.,

⁸⁵ Beaton, James.

⁸⁶ Ibid.,

⁸⁷ Ibid.,

⁸⁸ Roberts

⁸⁹ Roberts

⁹⁰ Smith 37

composting, compostable products are being designed and tested by BPI, which labels products certified compostable.

Home Systems. Available home systems for compost making include compost bins, compost heap or pile, cone digester systems, rotating barrels, stationary bins, and indoor systems.⁹¹ Home systems are relatively easy to maintain, they are not highly technical, and they are often inexpensive. Some of these systems can be built from items lying around the home, while other systems are specifically manufactured to accommodate compost. Furthermore, there are also indoor systems that work well in apartments; composting is not exclusive to urban areas or homeowners but those living in cities also have the opportunity to compost.

Composting bins or containers are simple to construct and they must be placed outdoors. One of the main benefits of choosing a composting bin is that it helps to neatly hold the compost pile in place.⁹² They can be constructed into boxes out of wood planks, which do not require a top or a bottom closing, or they can also be built into a circular shape using chicken wire.⁹³ These bins can be constructed through do it yourself methods, and there isn't particularly one correct way of building the bin (there is room left for creativity).⁹⁴ Using a container such as a trashcan can also function as a compost bin.

Commercial plastic composting bins can be purchased, they more modern type of design aesthetically pleasing compared to chicken wire and planks. Some commercial bins are often referred to as stationary bins. The compost in these stationary bins must be mixed manually

⁹¹Smith , Kelly . *How to Build, Maintain, and Use a Compost System: Secrets and Techniques You Need to Know to Grow the Best Vegetables*.Pg. 27

⁹² Campbell, pg 72

⁹³ Ibid., pg 75

⁹⁴ Smith, pg 96

because they only function as containers.⁹⁵ Rotating or tumbling barrels are barrel-shaped bins that can be rotated to mix the compost. These barrels are completely closed off, but air enters through small openings.⁹⁶ The tumblers are convenient because the mixing and aeration is “made vastly simpler by the spinning design” and every time new material is added, a spin provides fresh oxygen.⁹⁷ The main disadvantage with these commercial bins is that they are not large, and most often hold around 1 cubic yard of material, and they will be more expensive the larger they are naturally.⁹⁸

Compost heaps or piles are the simplest and most common form of a composting system used. Unlike in composting bins, compost in compost heaps are not contained in any sort of bin but, instead, the compost is exposed to the open air and shaped or formed into windrows.⁹⁹ The heaps can be periodically turned or mixed with a pitchfork to aerate the compost. Piles can also be placed over a ventilator stack, which functions to shoot oxygen into the pile and eliminating the need for periodic manual turning. Compost heaps and piles require, depending on the size, an open area so they can be build in backyards or rural areas. Because heaps and piles are not contained in a bin, it is important to keep them in a neat windrow shape so that decomposition occurs more quickly and efficiently and so that rodents are not attracted to it.

One of the most efficient indoor composting systems is vermicomposting, otherwise known as worm compost. Vermicomposting is composting by using earthworms to turn food scrapes into fertilizer. This design system in particular works well for those looking to compost in apartments and condos. A bin is necessary as well as purchasing worms. Red Wigglers or Red

⁹⁵ Smith, pg 32

⁹⁶ Ibid., pg 31

⁹⁷ “Composting: The Benefits of Compost.” *Ferncreek Design & Build: Sustainable Landscape Solutions*. <http://ferncreekdesign.org/compost.html>

⁹⁸ Campbell, pg 85

⁹⁹ Smith, pg 28

Earthworms are the two species of worms used in vermicomposting. These species are rarely found in soil, instead they have “adapted to the special conditions in rotting vegetation, compost and manure piles.”¹⁰⁰The bin must have small openings about three inches apart in the sides and on the cover to allow aeration into the bin.¹⁰¹ Those who fear anything resembling a snake do not need to fret because worms do not like light and so it is not necessary for the bin to be translucent, and it is okay to cover it with a cloth. The worms will eat the food waste and dead leaves, and the end product is compost.¹⁰²

All of these systems need to be well maintained through sufficient aeration, carbon-nitrogen ratio, and moisture. The compost piles must have a source of oxygen or the aerobic bacteria will begin to die off and the pile will start to undergo anaerobic decomposition and produce ammonia.¹⁰³ Frequency of turning a compost pile varies with the size and temperature of the pile; however, the pile should be turned a few times a week during its beginning stages and this can be reduced to once a week. It is also recommended to keep track of the carbon to nitrogen ratio in the pile; if there is there are more greens than browns, the compost will start to emit an unpleasant smell. New material can be added in the center of a compost pile, but add new material too often can slow the rate of decomposition. A strong unpleasant stench is definite indicator of too much moisture, lack of oxygen, or not enough carbon. For these home compost systems it is important that dairy and meat food products are not added to the compost because they attract rodents and cause the pile to smell. Overall, compost requires careful but not tedious maintenance.

¹⁰⁰ Dunn, Collin. TreeHugger.

¹⁰¹ Ibid.,

¹⁰² Ibid.,

¹⁰³ “Compost Pile Maintenance.” Composter Connection.

Commercial Composting Systems. Commercial composting facilities or plants are large scale composting systems that utilize machinery and technology. Commercial systems are similar to home systems in many aspects except for scale. These commercial system designs include turned windrows, passively and static aerated windrows, an in- vessel system. Similar to choosing home systems, choosing a large scale composting depends on factors that include the quantity of food waste, space availability, equipment, and the surrounding environment.

The most widely used commercial composting system is turned windrows and aerated static windrows. As their name suggests, turned windrows involve mechanical turning while aerated windrows have oxygen supplied through ventilators. Tractors with loaders turn turned windrows. Essentially, the loader scoops food waste material and drops them back and mixing the layers of the windrow, the bottom and top layers, and forming a new windrow next to the old one.¹⁰⁴ The windrows can be up to 90 centimeters high for dense materials like manure and food waste, and up to 360 centimeters for light materials such as leaves and width that can vary from 300 to 600 centimeters.¹⁰⁵

Passively and static aerated windrows receive oxygen flow through pipes. The food waste material is placed on top of a perforated pipe that has both ends open.¹⁰⁶ Because air is supplied to the pile through the pipes, turning the windrow periodically is unnecessary, however, the material should be well mixed before they are formed into a windrow. They are windrows that do not require turning. As air naturally flows into the pipe, oxygen rises up and spreads throughout the pile. Passively aerated windrows should be built on range from 90- 120 centimeters to make sure that air reaches the top of the windrow. On the other hand, statically

¹⁰⁴ “Large- Scale Composting.” FAO Corporate Document Repository.

¹⁰⁵ Ibid.,

¹⁰⁶ Ibid.,

aerated windrows use a blower to supply oxygen through the pipes to the windrow.¹⁰⁷ They can be up to 245 centimeters high. With this system, compost can be finished within five weeks.

The in- vessel composting system is similar to home scale bin composting, where the compost is contained within a building, large vessel, or even a bin. Oxygen can be supplied through turning or forced aeration.¹⁰⁸ In- vessel bins contain compost within three walls that do not need to have a roof. The compost is protected from outside weather elements. Air is blown into the bin and sometimes mechanical turning is required. Rectangular agitated beds are two long and narrow walls that contain the compost. This bin system includes forced aeration and mechanical turning. Oxygen is provided through openings on the side of the walls and a mixing machine is located near the beginning of the beds mixing in coming material and moving it along the rails.¹⁰⁹ The beds can be up to 100 feet long and if the material is turned everyday the compost will finish within ten days.¹¹⁰

Two other types of in- vessel composting systems are silos and rotating drums. In silos, an auger moves material from the bottom to the top of the silo while an aeration system blows air into the silo. However, silos cause temperature, odor, and oxygen problems.¹¹¹ Rotating drums composters, on the other hand, are horizontal cylinder shaped containers that can be as large as 11 feet in diameter and 120 feet long.¹¹² The material is tumbled; it is a great mixing vessel. The rotating drums are aerated through an opening on the discharge end of the drum—the air will

¹⁰⁷ Ibid.,

¹⁰⁸ Gouin, Francis R. et al. "On- Farm Composting Handbook." Northeast Regional Agricultural Engineering Service. Pg 37.

¹⁰⁹ Ibid., 37.

¹¹⁰ Ibid.,38.

¹¹¹ "Large scale- composting."

¹¹² Gouin, Francis R.

flow from one end to the other.¹¹³

Passive and aerated static windrows are more widely used because they are cheaper compared to in- vessel composting systems. Because passive and aerated static windrows require more labor, it also requires daily mixing and maintenance.¹¹⁴ However, aerated static windrows are more efficient than passively aerated windrows. In- vessel systems are independently designed and their maintenance can also be costly.¹¹⁵ The main advantages to the in- vessel systems is that they require little manual labor, compost is not exposed to weather problems, odors are blocked off, and faster compost making.¹¹⁶

Certified Compostable: Manufacturing Compostable Products. In an attempt to divert more waste from landfills and reduce waste, many companies are designing products such as plates, cups, and utensils with materials that can be composted. The Biodegradable Products Institute (BPI) was created to provide information and testing on to manufacturers looking to make compostable products. When a product becomes BPI certified and receives the BPI Compostable Logo it means that the product can be added to a compost pile. Manufacturers print this logo on their product to let consumers know that their product can be composted—they are certified compostable products.¹¹⁷ BPI runs tests and follows the ASTM D6400 and the ASTM D6868 standards to ensure that the product is one hundred percent compostable. The ASTM D6400 standards are a set of specifications for plastic products, while the ASTM D6868 standards cover the plastic sheet or lining of packages. Any product containing the BPI

¹¹³ “Large scale-composting.”

¹¹⁴ Gouin, Francis R. Pg39

¹¹⁵ Ibid., Pg 40.

¹¹⁶ Ibid.,

¹¹⁷ “What is certified compostable product?” Biodegradable Products Institute.

Compostable logo is recognized as biodegradable and should be composted. Using compostable products will decrease the use of plastics and waste sent to landfill.

Policy: Regulating Food Waste Composting

Municipal food waste compost and facilities are regulated mainly at the state level and by local governments. Existing Federal laws pertain specifically to the animal industry and manure or biosolids (this is also commonly referred as sewage sludge) composting. Biosolids are fertilizer like material generated from the treatment of sewage sludge that are applied to farm soil. Without any strictly enforced laws specific to food waste composting, states often regulate composting facilities under the broad Federal laws and under state water and air pollution control laws.¹¹⁸

Federal Regulation. Sewage sludge is regulated as part of Clean Water Act under the rule Standards for Use or Disposal of Sewage Sludge, which was published in 1993.¹¹⁹ The Clean Water Act, established in 1972, calls for regulating pollution entering waterways and setting standards for water quality; the Environmental Protection Agency is required to set the standards and monitor the pollution.¹²⁰ Exposing sewage sludge to water greatly increases the potential that the water will be contaminated leading to adverse health hazards. To minimize and hopefully eliminate any risk of water contamination from sewage sludge, Congress saw it absolutely necessary to implement standards for safe disposal and application of sewage sludge as a fertilizer. Consequently, the Section 405(d) or Standards for Use or Disposal of Sewage Sludge (this is also known as the Biosolids Rule) was added to the Clean Water Act. Under this rule, standards for sewage sludge apply when it is: “(1) applied to land as a fertilizer or soil

¹¹⁸ Chapter 7, page 77

¹¹⁹ “Laws/Statutes” EPA

¹²⁰ “Summary of Clean Water Act”

amendment; (2) placed in a surface disposal site, including sewage sludge- only landfills; or (3) incinerated.”¹²¹ The standards that are set in this rule are also applied to food waste compost because both biosolids and food compost are used as fertilizer.

In addition to the Clean Water Act, the Clean Air Act, established in 1970, is a Federal statute requiring the EPA to set air quality standards and to reduce air pollutants emitted into the atmosphere from both “stationary and mobile sources.”¹²² The goal of Clean Air Act is to have every state achieve National Ambient Air Quality Standards (NAAQS), but many states have failed to achieve NAAQS and the Act has been amended numerous times to set new goals and dates of achieve the standards.¹²³ The EPA also sets emission standards for sources that emit large amounts of air pollution required these sources to reduce their emissions to a particular level.

Under the Clean Air Act, the EPA has established the Landfill Methane Outreach Program (LMOP). LMOP is a voluntary assistance program partnering with states, communities and landfills to help them capture and utilize landfill gas.¹²⁴ According to the EPA, burning and recovering LFG is a good way of reducing and controlling methane concentrations emitted into the atmosphere.¹²⁵ When methane is combusted, it is broken down and turned into carbon dioxide, the less potent greenhouse gas. Since the EPA recognizes that methane is more potent than carbon dioxide and that landfills are the third largest source of methane emissions and other organic compounds, it requires larger MSW landfills to capture and combust LFG.¹²⁶ Landfills

¹²¹ “Biosolids Biennial Review.” Environmental Protection Agency.

¹²² “Summary of Clean Air Act.” Environmental Protection Agency

¹²³ Ibid.,

¹²⁴ “Landfill Methane Outreach Program: Public Health, Safety, and the Environment.” Environmental Protection Agency.

¹²⁵ “An Overview of Landfill Gas Energy in the United States.” Environmental Protection

¹²⁶ “Landfill Methane Outreach Program: Public Health, Safety, and the Environment.”

that participate in this program flare or recover 60-90% LFG by using reciprocating engines, gas turbines, and boilers; the gas must be collected and monitored throughout all areas of the landfill.¹²⁷ MSW landfills that have a smaller capacity than 2.5 million metric tons are not required but encouraged to capture LFG. The EPA estimates that 3- megawatt LFG electricity project reduces around 6,000 tons of methane or 125,000 tons of carbon dioxide annually.¹²⁸ As of May 2012, EPA states that there are 590 projects across the United States capturing LFG and supplying 14.8 billion kilowatt hours of electricity to over 1 million homes.¹²⁹ Under this voluntary program and the Clean Air Act, there is no existing regulation requiring the diversion of food waste from landfills.

Two other Federal statutes important to consider for food waste composting regulation is the Pollution Prevention Act (PPA) enacted in 1990 and the Resource Conservation and Recovery Act (RCRA) enacted in 1976. The goal of the PPA is to prevent or reduce pollution at the source level and that pollution should be disposed only when there is no better alternative. Under this statute, the Environmental Protection Agency is required to provide industries with information and technology assistance to prevent and reduce their pollution.¹³⁰ In addition, facilities are required to release an annual report of toxins and pollutants. The Act states that Congress finds that there “are significant opportunities for industry to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw

¹²⁷ Ibid.

¹²⁸ Ibid.

¹²⁹ “An Overview of Landfill Gas Energy in the United States.”

¹³⁰ “Pollution Prevention Act of 1990, United States.” Jonathan Herz(Topic Editor) "Pollution Prevention Act of 1990, United States".

materials.”¹³¹ Industries are focused much more on finding a way to dispose of the pollution rather than invest to prevent the pollution in the first place.

The Resource Conservation and Recovery Act pertains to the disposal of solid waste and hazardous waste. The goal of the act is to protect people and the environment from “potential hazards of waste disposal, to conserve energy and natural resources, [and] to reduce the amount of waste generated.”¹³² Under this act, the EPA has the authority to track hazardous materials from its point of origin to the point of disposal. Of particular interest is Subtitle D of RCRA concerning nonhazardous solid waste like food. Subtitle D gives the state and local governments control regulating and managing non- hazardous solid waste.¹³³ Furthermore, under Subtitle D, open dumps are prohibited and states must close any landfill that does not meet EPA criteria. RCRA also gives the Department of Commerce responsibility to encourage the use of resource recovery technology, but the Department of Commerce has failed to take this responsibility seriously.¹³⁴

State Regulations. Composting and facilities regulation vary among states. They also regulate composting under current environmental protection laws such as air pollution laws.¹³⁵ State regulations focus on large-scale composting facilities rather than on composting requirements to be met by all the people living in the state. Regulation for composting yard waste is more widespread than for MSW composting because it is less complicated.¹³⁶ Some states have even banned disposing yard trimmings in landfills. Laws for MSW composting are

¹³¹ “Pollution Prevention Act of 1990.” Environmental Protection Agency.

¹³² “Resource Conservation and Recovery Act (RCRA)”

¹³³ "Resource Conservation and Recovery Act (RCRA), United States". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment).

¹³⁴ Ibid.,

¹³⁵ U.S EPA 1994, 77

¹³⁶ EPA composting and yard trimmings

more stringent than they are for yard trimmings. However, as composting benefits are more widely acknowledge, many states have moved towards improving composting regulation. Most states have some set of regulations regarding permits, siting, design, education programs, and operation requirements. The goal of these composting regulations is to minimize environmental harm or any annoyance to nearby neighbors of composting facilities.¹³⁷ Large - scale composting facilities are required to have state permits to operate, but usually home and agricultural composting is exempt from having to receive a permit.¹³⁸ Currently, states with existing composting regulations are looking to making modifications to regulations or implementing new regulations as a result of the increased interest in food waste.¹³⁹

For composting facilities to operate, the main requirement is to receive a permit from the state; however, these permits are not uniform among the states. Sometimes facilities have to meet local requirements before they can even apply for a permit.¹⁴⁰ Permits include information about compost facility design, operations, information on materials being composted, markets for compost, and potential environmental damages.¹⁴¹ States that do not require permits for compost will still make sure that composting facilities do not local communities or cause any environmental damage by prohibiting the siting of these facilities in specific areas.¹⁴² In Illinois, a compost facility cannot be within 200 feet of any residence. An assessment of composting regulation showed that most states require permits for operating composting facilities.¹⁴³

¹³⁷ Yesiller, Nazli, Vigil, Samuel A., and Hanson, James L. "Assessment of State Composting Regulations in the United States. California Department of Resources Recycling and Recovery". 2010, 1290

¹³⁸ Ibid., 1290).

¹³⁹ Ibid., 1290).

¹⁴⁰ Cool2012

¹⁴¹ EPA "Laws/Statues"

¹⁴² EPA composting and yard trimmings

¹⁴³ Yesiller, 1283

Some states have taken steps to implementing local composting education programs and giving local governments authority to manage MSW composting. Many states (Connecticut, Maine, Massachusetts, New York, New Jersey) are leading composting programs to encourage local composting.¹⁴⁴ Other states are making strides in school composting guides. Localities in Minnesota are required to establish composting programs under state regulation.¹⁴⁵ There are also Master Composter training program where volunteers are taught the science and benefits of composting so that they can go out in the community and teach locals about how they can start composting.¹⁴⁶

Regulations in New York and California. New York and California are two examples of states that have different regulations for food waste composting. The New York Department of Conservation regulates composting under 6 NYCRR Subpart 360- 5: Composting Facilities. Regulations under Subpart 360-5 are set to “ensure proper management of facilities that compost organic material in a safe, nuisance-free manner, and to protect against potential environmental and human health risks associated with metals and disease bearing micro-organisms known as pathogens.”¹⁴⁷ Compost facilities are required to get permit and giving a description of siting, facility design, quantity of compost produced, compost market, among other factors. Facilities are also required to submit an annual report of their operations to the NYS Department of Environmental Conservation.¹⁴⁸ Composting facilities are exempt form Subpart 360-5 if they do not accept over 3,000 cubic yards of waste a year. Some facilities are eligible to register if they are located 200 or more feet away from a body of water and 500 feet or more from a densely

¹⁴⁴ <http://www.epa.gov/compost/live.htm>

¹⁴⁵ EPA composting and yard trimmings

¹⁴⁶ EPA Composting and yard trimmings

¹⁴⁷ <http://www.dec.ny.gov/chemical/8798.html>

¹⁴⁸ Ibid.,

populated area; accept no more than 10,000 cubic yards of yard waste annually and no more than 1,000 cubic feet of food waste.¹⁴⁹ If a facility is not exempt or does not qualify to register, then it must apply for a permit. There are four food waste composting facilities in New York.

Composting rules in California are more detailed specific to food waste composting rather than regulating largely under sewage sludge regulations. They regulate composting under Chapter 3.1 Composting Materials Handling Operations and Facilities Regulatory Requirements under Title 27, Environmental Protection—Division 2, Solid Waste. Facilities are required to have permits, but they have a longer list of exemptions than New York. Exemptions include vermicomposting, in- vessel composting of less than 50 cubic yards, and facilities that have less than 500 cubic yards of compost.¹⁵⁰

California regulations also include information on facility design requirements, operating standards, sampling requirements, green material composting, agriculture material composting, and even requirements for facility site restoration. Their prohibitions in compost include medical waste, hazardous waste, and “mammalian tissue, including but not limited to, flesh, organs, hide, blood, bone and marrow” unless they come from collected food scraps.¹⁵¹ In addition, there are also requirements for composters who sell compost, that are seldom present in other states including New York. The state has to be notified before a composter is permitted to sell compost and the facility must pass annual inspections.¹⁵² Overall, there are 120 food waste commercial composting facilities across California.

Composting in Major Cities. Major cities around the country are taking individual steps to promote and implement composting policies. Two of these cities are New York City and San

¹⁴⁹ Ibid,.

¹⁵⁰ Platt, Brenda.

¹⁵¹ “Chapter 3.1. Compostable Materials...”

¹⁵² Platt, Brenda. “California- Composting Rules.” Institute for Local Self- Reliance.

Francisco. In New York City, for example, the Department of Sanitation has created the Bureau of Waste Prevention, Reuse, and Recycling that has included a composting program. This compost program aims to educate people about composting in addition to starting composting projects throughout the city to promote composting among the residents.

The NYC Composting Project was established in 1993 to educate New Yorker's about the benefits of composting their food waste.¹⁵³ It is not mandatory for New York City residents to compost their food scraps, but this project has encouraged residents to start community based compost sites. Since the initial start of the program, there are now hundreds of these sites throughout the city that receive information, compost bins, and other materials from NYC Composting Project to help with their composting efforts.¹⁵⁴

In addition to the formation of community compost sites, the NYC Compost Project Local Organics Recovery Program was formed in 2012. This particular program aims to provide residents with more drop-off sites and local composting opportunities. Residents can save their food scraps and come drop off their scraps in one of these drop off sites. The food scraps will then be taken away to small scale composting facilities throughout the city. There are currently three organizations in the city that are part of the NYC Compost Project Local Organics Recovery Program: BIG! Compost, Earth Matter NY and New Amsterdam Market.¹⁵⁵ The drop-off sites for these organizations are located in areas of Western Queens, Manhattan and Governor's Island. Unfortunately, the sites operate a few times a week for only a number of hours. The compost from these organizations are not sold but distributed to New York City public parks.

¹⁵³ "NYC Compost Project"

¹⁵⁴ "Community-based composting sites."

¹⁵⁵ "NYC's Locals Organic Recovery Program."

Build It Green! NYC: BIG! Compost Case Study. I had the opportunity to intern with Build It Green! NYC for their compost program, BIG! Compost. Their drop-off sites and compost processing sites are located in Western Queens. Currently, they have six food drop off site locations at greenmarkets and most recently they started a Commuter Composting Pilot site.

At their processing site located under the Queensborough Bridge, BIG! Compost brings all of the food scrap they collect to compost. They use a compost heap system as well as an aerated static windrow system to compost. The aerated static windrows are not manually turned, but the heaps are. During the 2012 year, BIG! Compost collected 109,855.30 pounds of residential organic waste in the Western Queens area.¹⁵⁶ In addition, BIG! Compost distributed 13,920 pounds of bagged compost to street tree stewards and community parks.¹⁵⁷

While NYC is setting composting programs and raising awareness, San Francisco has taken further steps by making curbside composting mandatory for businesses and for residents. Instead of having recycle and garbage bins, San Franciscans are also required to have compost bins. San Francisco, in 2009, was the first city to enact the most stringent composting regulations and make curbside composting mandatory through the San Francisco Mandatory Recycling and Composting Ordinance.¹⁵⁸ Their goal is to divert all of the food waste from landfills by 2020 and create zero waste. By 2011 San Francisco collected one million tones of compostable waste.¹⁵⁹ The law requires all residents and businesses of San Francisco to separate compost from their

¹⁵⁶ Louise Bruce, (personal communication)

¹⁵⁷ Louise Bruce, (personal communication)

¹⁵⁸ Schwartz, Ariel. Inhabitat, "San Francisco Implements Nation's First Mandatory Composting Law."

¹⁵⁹ Berg, 2011

trash. Fines ranging from one hundred to one thousand dollars are imposed on those who do not comply with this law.¹⁶⁰

When the food waste in San Francisco is composted, the compost is distributed in local green areas around the city and farms. Everyday San Francisco collects 600 tons of food to compost.¹⁶¹ The city has also implanted a public outreach program to educate locals about compost and how they should separate their waste. As of January 2013, no fines have been given out in San Francisco, only warnings.¹⁶²

Conclusion: Moving Towards Better Composting Regulations

We live in a society in which consumerism and waste have become a part of our daily routine. It is essential that the federal, state, and local governments step in to change our harmful waste habits. When it comes to learning more about the harmful impacts that waste has on the environment and that our soils are losing their fertility, education programs and raising public awareness is a good start. Many states have already set such programs in schools and in major cities. Composting has been a part of human history for thousands of years and there are numerous compost system designs to fit many different situations. The first step to take is to educate people on how they can start to compost and why it is important.

As composting around the country continues to rise and people looking to send their food waste to facilities, regulations must adjust to better regulate compost facilities. Regulation adjustments must first be met at the Federal level. Currently, Federal law does not say anything

¹⁶⁰ "S.F. to impose fines for tossing food scraps." NBC News.

¹⁶¹ Heimbuch, Jaymi. "600 Tons of Compost Collected A Day?!How San Fransico Deals With It All."

¹⁶² Michels, Spencer. "San Francisco on Track to Become Zero Waste City." PBS. 25 January 2013.

specific about food waste composting. However, the Environmental Protection Agency has the authority to regulate and set standards on food waste diversion from landfills under the Pollution Prevention Act and the Resource Conservation and Recovery Act. The EPA's voluntary Landfill Methane Outreach Program does not solve landfill gas emission problems, but it might even promote landfill gas emissions because companies will want to profit from burning LFG. The Resource Conservation and Recovery Act specially says that emitting pollution should only be a last resort and we should try to reduce waste as much as possible. The EPA should set food waste composting programs and assist the states to have composting facilities and divert food from landfills.

State and local governments have been given authority by the Federal government to regulate food waste composting. The states that do not have many people interested in composting are the ones who lack specific composting regulation; this can change if they start composting education programs. California is the state with the most thorough food waste composting regulations because people in California are looking to compost. A state like New York, where people are becoming more aware and interested in composting, can adopt many of California's regulations, which work well and promote composting. States should tailor compost regulations based on individual state needs and data; how much food do they waste, space availability, and landfill locations.

Curbside composting is working well in San Francisco because the state regulations call for certain standards and requirements. Many small cities throughout the country can begin to do the same thing once states update regulations. For a larger city like New York City, mandatory curbside composting may be problematic because of the population density and the infrastructure; however, it is not impractical if the city begins a gradual movement towards zero

waste like it is start do so. Upcoming compost pilot programs in State Island and in various public schools along with more drop- off sites sponsored by the NYC Compost Project Local Organics Recovery Program, can move the city towards composting more food waste.

Nonetheless, composting regulations in cities should be tailored to the individual cities. Since urban soils are of very poor quality, the compost that the cities generate can go towards feeding those soils.

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