THE EFFECT OF THE RECENT SINGLE-USE PLASTIC BAN ON UVA'S WASTE MANAGEMENT

HAZARDS RESULTING FROM CONTAMINATION IN COMPOSTING FACILITIES AND THEIR SOCIETAL IMPLICATIONS

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Pollution from plastic waste is a major problem affecting the Earth's ecosystems with 14 million tons of plastic entering the ocean every year (Condor Ferries, 2021). This plastic can be ingested or otherwise physically harm marine life, leading to energy depletion, stunted growth, and damaged fertility (Ritchie & Roser, 2018). Plastics have also been shown to be a vehicle for toxic contaminants such as polychlorinated biphenyls (PCBs), which can pose a threat to human health when bioaccumulated up the food chain (Ritchie & Roser, 2018). About 300 million tons of plastic is produced each year worldwide, half of which is single-use plastic (Lindwall, 2020). Single-use plastic (SUP) is intended to be used once and then disposed. Common types include bottles, wrappers, straws, bags, and cutlery. In recent years, the United States has developed a heavy reliance on single-use plastics, consuming 96kg of plastic packaging per capita per year (Chen et al., 2021). Additionally, the burdens created by excessive waste production and the management of waste are not equally distributed among the population (Mohai & Saha, 2015).

To combat this, Governor Ralph Northam of Virginia has ordered that all state agencies immediately discontinue purchase and distribution of single-use plastics as well as completely phase out their use by 2025 (Exec. Order No. 97, 2021). As a public institution of higher education in the Commonwealth, the University of Virginia (UVA) must adapt its waste management strategy to comply with this executive order. UVA is at a crossroads with composting. The recent ban on SUPs across the Commonwealth pushes the University to quickly adapt the status quo waste management system to allow for more compostable materials in the waste stream. The UVA Sustainability 2020-2030 Plan is another driving factor, with goals to reduce landfilled waste to 30% of the University's 2010 tonnage, while simultaneously striving to make university operations carbon neutral and eventually fossil fuel free (University of

Virginia, 2020). This project seeks to analyze the effect of the recent single-use plastic ban on UVA's waste management, with respect to various sustainability metrics.

Effect of SUP Ban on UVA's Waste Management

The 2021-2022 "Un-fantastic Plastics" capstone project team consists of seven members committed to addressing these challenges on behalf of the University of Virginia Office of Sustainability and Facilities Management by April 2022. The team's main objective is to analyze the solid waste management (SWM) of the University against the backdrop of relevant priorities, evaluate possible structural changes to the system, and identify and compare the performance of the current SWM to those alternatives. The team will plan the methodology of the analysis and identify any assumptions by creating a model which reflects the following parameters: landfilled mass in tonnage, composted mass in tonnage, global warming potential (GWP) in kg Carbon Dioxide-equivalent (CO2-eq), energy in MJ, and cost in U.S. dollars (USD). These parameters were chosen to reflect the goals of the UVA Sustainability Plan, and show tradeoffs between the various priorities.

In order to plan the methodology of analysis, the team must consider the relationships between the model parameters. Global warming potential is calculated by adding the various greenhouse gas emissions associated with the transport and decomposition of each waste stream, and converting each to CO2-eq using the standards laid out in the AR6 global warming potential report (IPCC, 2021). Transportation emissions are calculated based on the mass of waste and distance that it must be transported. Therefore, the location of disposal facilities is a significant contributor to greenhouse gas emissions. Landfilled waste decomposes under a mixture of aerobic and anaerobic conditions, and therefore produces both carbon dioxide (CO2) and methane (CH_4), with CH_4 being 27.2 times more potent than CO_2 (IPCC, 2021). Composted waste, however, decomposes under strictly aerobic conditions and produces primarily CO_2 and small amounts of Nitrous Oxide (N_2O), which is 273 times more potent than CO_2 (IPCC, 2021). Therefore, changing the ratio of landfilled to composted waste impacts global warming potential. Similarly, increasing the amount of composted waste has implications on energy usage. Processing waste at both landfills and composting facilities consumes energy. However, the methane produced by landfilled waste can also be used to generate electricity. Compost primarily produces CO_2, and therefore cannot be used to generate energy. Because of this difference in gas composition, there is another tradeoff between GWP and energy production.

A major challenge faced by the project team is the inconsistent data records of SWM at the University. In light of the insufficiency of data, the team will use ranges of historical and projected data, as well as values sourced from scholarly investigation, to evaluate the target parameters. The team may also conduct a solid waste audit to aid in data projections. The target parameters will be evaluated annually for 2018 to represent the status quo and for the 2021 academic year to represent post-ban. The model will be created using Microsoft Excel software and Google Sheets collaborative network technology through Google Drive. The model will be optimized in Spring 2022 for presentation of viable, alternative waste stream options to UVA Facilities Management.

The results of the team's analysis will help inform decisions made by UVA Facilities Management about future SWM practices and will reveal the most environmentally responsible path for the university to take in light of the SUP ban. The lack of preexisting data and analysis of SWM at the university shows that this topic has not been explored in depth previously. The abrupt change in UVA's waste management strategy due to the executive order necessitates this kind of comprehensive analysis, and can set a precedent for continual optimization of the university's waste management. The analysis could also potentially uncover the environmental risks associated with composting, which is generally considered to be a "green" form of SWM. It is important to analyze both the environmental and social implications of composting in practice as this form of waste management grows. This ties into the STS problem of externalities that arise due to the presence of improper materials in the composted waste.

Improper Waste Management and Negative Consequences

While the technical work focuses on the role of composting in UVA's waste management strategy, the balance of this paper will explore the hazards that result from improper waste sorting practices in composting facilities. Composting is intended to be a more sustainable way of managing organic waste. Ideally, the process recycles organic matter into useful fertilizer. However, when integrated into the existing system with imperfect sorting, abundant plastic waste, and inequitable distribution of waste management facilities, unintended consequences occur that have negative impacts on both the environment and human welfare. I will be using Michael Harrison's Interactive Sociotechnical Analysis (ISTA) framework to analyze the unintended consequences of implementing new technology. Harrison argues that unintended consequences are often not due to technical flaws, but rather due to sociotechnical interactions between the new technology and the existing social system. This framework is centered on the importance of examining technology-in-use, rather than the uses intended by the designers (Harrison et al., 2007). Harrison uses the framework to analyze the unintended consequences of healthcare information technology, but it can also be applied to SWM.

Due to imperfect sorting practices, contamination is an inevitable challenge for composting programs. A study done on composting facilities in Spain found that composted waste contained an average of 10.7% improper materials (Rodriguez et al., 2020). When improper materials such as plastics, metals, and glass are put through the composting process, a variety of environmental issues result. One challenge specifically comes from implementing large scale composting in an existing system where packaging is often made of a mixture of compostable and non-compostable materials. Plastic coated paper products are a prevalent example of this type of mixed-material packaging. These products are often still collected by composting programs, or mistakenly composted by individuals who are not educated on proper composting practices. A study of plastic-coated paper products determined that the plastic coatings did not biodegrade, the coatings inhibited the biodegradation of the paper, and that microplastics were shed from all plastic-coated samples (Brinton et al., 2011). In this case, the presence of improper materials not only prevents the successful decomposition of the compostable material, but also creates an environmental hazard. Plastic debris is often consumed by a variety of species and has been shown to bioaccumulate up the food web. Additionally, microplastics can migrate from the gut to the circular and lymphatic systems, transporting contaminants with them (Brinton et al., 2011).

The presence of plastics in the composted waste stream also creates toxic heavy metals pollution. A study of heavy metal production at a food waste treatment plant in China concluded that the leachate produced during food waste composting contains highly hazardous amounts of cadmium (Cd), likely from plastics mixed with food waste (Chu et al., 2019). Similarly, the presence of improper materials in the waste stream is also linked to the presence of heavy metals in the compost product itself (Rodriguez et al., 2020). Heavy metals pollution threatens ecosystems by causing loss of soil nutrients, and therefore adversely affecting plant life and crops (Jiang et al. 2020). Heavy metals also have a variety of negative human health impacts.

Cadmium specifically is a highly persistent and toxic endocrine disrupting chemical that is linked to development of prostate and breast cancer (Pan et al., 2009). Instead of creating a usable fertilizer as intended, when plastic contamination is present, the compost product poses risks to environmental and human health.

In addition to improper sorting practices and excessive plastic waste generation, the existing social system in the U.S. also has a history of longstanding systemic racism. When a growing technology such as composting is integrated into a system where the burdens of waste management are unequally distributed, unintended social consequences occur. As composting grows as a solid waste management method, the environmental justice implications of this practice must be considered. The environmental justice movement seeks for everyone to enjoy equal protection from environmental hazards and have equal involvement in the development and implementation of environmental policies (EPA, 2021). Historically, the hazards caused by excessive consumption and waste generation disproportionately impact low-income communities of color. Over half of all people in the US who live within 3 kilometers of a hazardous waste landfill are people of color (Mohai & Saha, 2015). Additionally, black Americans are three times more likely to die from exposure to pollutants than white Americans (Di et al., 2017). Because of the hazards enumerated in this paper, when siting composting facilities, decision-makers must consider geographic equity. This type of equity refers to the location of communities and their proximity to environmental hazards and locally unwanted land uses (Bullard, 2001).

However, there are many actors within the existing social system that hold the “not in my backyard” (NIMBY) mentality when it comes to SWM facilities. There are many political and economic challenges associated with NIMBY which pose an obstacle to the equitable siting of composting facilities. Michael Gerrard in his essay “The Victims of NIMBY” (1994) seeks to identify the parties hurt by the NIMBY mentality. Gerrard argues that in the future, NIMBY battles by the affluent could cause waste management facilities to be moved to minority neighborhoods. For this reason, he states that "minority communities should be given the technical and legal resources they need to participate in the siting decisions" (Gerrard, 1994). This is particularly relevant to composting, which has a large potential to grow in the future. Similarly, researchers in Taiwan created a decision-making model for composting facility site selection. Their model results identified resistance from residents as the most influential obstacle in location selection and determined that decision-makers give strong preference to areas with lower NIMBY resistance (Liu et al., 2018). When composting is integrated into a social system with high NIMBY resistance, the burdens of waste management are pushed onto vulnerable populations.

It is also important to consider the environmental justice implications of occupational hazards posed by composting facilities. In his paper "Environmental justice in the 21st Century: Race still matters," Robert Bullard (2001) outlines the concept of "economic blackmail." He argues that dangerous industries are often forced on poor communities of color who lack other job opportunities. Disinvestment in minority neighborhoods causes the fleeing of industries. When this happens, the residents are forced to choose between no job and a job that threatens their health and safety (Bullard, 2001). A major occupational health hazard of composting is the presence of airborne microorganisms. The high counts of potentially pathogenic microorganisms within composting facilities may pose an occupational health risk for compost workers. This is evidenced by their measurements of high microbial counts, as well as qualitative evidence of employees reporting symptoms such as fatigue, headaches, fever, and diarrhea much more frequently than in a control group (Reinthaler et al., 1997). Additionally, composting facilities produce odorants that can be potentially harmful to olfactory function which decreases quality of life, and makes individuals more susceptible to hazards such as fire or chemical toxins (Tsai et al., 2008).

Research Question and Methods

My work on this topic seeks to answer the question: What are the environmental and social implications of contamination in composting facilities in Virginia? With increasing concern for the severity of climate change and pollution, the world is moving toward alternative waste management techniques. Through this transition, composting has become an increasingly prevalent form of waste management. Moving forward, it is important to consider not only the sustainability impacts such as greenhouse gas emissions and energy use, but also the social implications and unintended consequences of this form of SWM. This topic will be analyzed by reviewing the geographic distribution of composting facilities in the Commonwealth of Virginia. Next, I will collect information from county websites about the localities where the facilities are located, such as population and demographic information. I will also contact the composting facilities to inquire about the amount of improper materials in their waste stream and how they deal with this challenge. This information will be used to evaluate the environmental and human health risks of living near a composting facility in Virginia, as well as gather information on the populations most effected. The results of this research can be used to draw conclusions about the severity of compost contamination in Virginia.

Conclusion

Excessive production of plastic waste is a threat to ecological and human health and is a major SWM challenge. This issue has led to an increased focus on composting as a sustainable alternative. In Virginia, this took the form of an executive order issued by Governor Northam banning single-use plastics in government facilities. As a public university, UVA must adapt its waste management strategy to comply with this executive order by increasing the amount of compostable materials in the waste stream. The technical work of this project seeks to analyze the SWM of the university with respect to various priorities of the university such as landfilled mass, GWP, energy, and monetary cost. The STS component of the work seeks to explore the externalities created when composting is introduced on a large scale into a system with imperfect sorting, excessive plastic waste, and inequitable facility siting practices. As composting grows as a waste management strategy, it is important to be aware of the severe hazards created by improper sorting and work to minimize the presence of improper materials in the compost waste stream. The results of this research paper can help to inform decision-makers about the environmental justice implications of composting facility siting, and help them to not repeat historical patterns as new facilities are built.

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