Santa Monica Pier Solid Waste Collection and Organic Processing Study

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Abstract

Waste management is an integral part of both municipal functionality and maintenance of sustainable practices. Efficient administration of urban waste not only improves environmental stewardship but also provide economic benefits to cities who implement it. In this study, we examined alternative options for organic waste processing at the Santa Monica Pier, as well as options to address transportation of waste around the pier in a more aesthetically pleasing manner. We performed two waste audits to get a sense of the scale of the amount of refuse the Pier's businesses produce on slow and busy days, which allowed us to more accurately suggest solutions for the pier. Additionally, more appropriate collection and disposal of waste on the Pier can help mitigate some of Santa Monica's greenhouse gas emissions, which is a part of the City's Climate Action Plan. We then performed cost-benefit analyses for various organic waste processing options and waste transportation methods to determine the most feasible for the city. Through our research, we recommend Santa Monica pursue installing conveyor belts along or below the pier to transport waste along the length and transport their organic waste to anaerobic digestion facilities closer than their current processing facility in Oxnard, California.

Introduction

Santa Monica, California: a city known for its its idyllic beaches and manicured lawns, is ground-zero in the fight against climate change and its many effects. Warmer temperatures, persistent drought, and rising sea levels all threaten the quality of life of Santa Monica and Southern California residents. In its own attempt to mitigate some of the causes of climate change, the city adopted the Zero Waste Strategic Operations Plan in 2014, which provides a roadmap for achieving 95% diversion of waste from the landfill by 2030, one of the community's primary goals (The City of Santa Monica). In doing so, less organic waste from food waste and packaging, such as food-soiled paper and cardboard, will go to landfills, where it would ferment and produce methane, an even more potent greenhouse gas than its better known cousin, carbon dioxide. The city's plans will also aid in reaching statewide goals for diverting more organic waste from landfill as laid out in Assembly Bill 1826. The law requires commercial businesses to implement organic waste recycling programs with the ultimate goal of reducing statewide disposal of organic waste to 50% of the disposal levels from 2014; if the state does not reach its goal reached by 2020, it will implement stricter requirements on businesses (Chesbro).

The Santa Monica Pier is home to many businesses subject to this legislation, in addition to its status as a historic landmark and one of the most visited tourist attractions in Southern California. With about 6 million visitors annually (City of Santa Monica, 2014), the Pier's numerous restaurants throw out 600 tons of organic waste, or 120,000 pounds each year, or about 3000 pounds each day (City of Santa Monica). Most of this food comes from post consumer waste, or the waste produced when a material has reached the end of its life cycle and will serve no other future needs nor serve as future products, though some portion of it is a byproduct of the food preparation process. Not only does the waste generated contribute to climate change as it gets sent to landfills, the contamination and mixture of organic and inorganic waste prevent effective processing of waste to neutralize potential production of greenhouse gases. Nationwide, food waste makes up about 20% of landfills (Gunders & Bloom, 2017).

To determine the appropriate scale solution to deal with the amount of organic waste coming off the pier, our team conducted two waste audits, both on busy and "off-season" days. Doing so allowed us to get a sense of the scope of the total amount of waste the pier produces on a daily basis, as well as the proportions of different types of waste that each restaurant produces.

We took the information collected at the audits to generalize to larger scale data provided to us by the city of Santa Monica to extrapolate.

Another facet of waste management on the pier is the transportation of large amounts of waste between several points along the pier. The current infrastructure for waste collection at the pier includes a trash enclosure in a central location by the parking lot and entrance to the Pacific Pier, separate compactors for trash and recycling, and a trolley driven by pier workers to transfer waste among these locations. For instance, most restaurants take their full bags of trash to a trash enclosure at a centralized location near the parking lot and entrance to Pacific Pier. Restaurant employees do so by hand or with the assistance of manual carts. However, the restaurant Mariasol, located at the far west end of the pier out on the water, has two three-yard bins into which it throws its restaurant waste. When those bins fill up, pier workers must drive a trolley and tow two empty bins about 1000 feet down the length of the pier, trade the full bins for the empty ones, and transport the full bins to the trash compactor, another 1500 feet back on land. All of this happens when pier visitors are milling about, creating potential for accidents and generally being unsightly and malodorous.

To find solutions to these problems, we surveyed industry experts and companies that manufactured products that might fit our needs, including various makers of anaerobic digesters and local digester operations. We considered ways to improve the collection of waste by researching methods to improve separation of organic from solid waste, education of workers who dispose of waste from restaurants, and transportation of large amounts of waste to and from different transfer points along the pier. This likely requires both infrastructure changes to make waste separation more intuitive and behavioral changes to teach workers how to make the best use of improved infrastructure.

Methodology

Waste Audits

The goal of our waste audits was to collect data describing the quantity and composition (i.e. landfill, recycling, organics, and liquids) of waste produced by businesses on the Santa Monica Pier, specifically restaurants and food stands. We conducted two audits, one on a relatively slow day and one on a busy day, so the data would provide a holistic look at the Pier's needs considering its varying traffic over the course of a regular year. We consulted

Before conducting the audits, we provided colored 30-gallon garbage bags to each business. The restaurants Seaside on the Pier, the Albright, Pier Burger, Mariasol, and Pacific Park received individually colored bags; stores as a whole were given one color as a category, while waste from public receptacles remained in the bags the pier normally uses to ensure the entire pier was taken into consideration in the audit. The only entity left out of our audit was Bubba Gump Shrimp Co. because they already have their own organic waste programming in place separate from the rest of the pier.

During each waste audit, all waste from the Pier was collected and weighed. For each business, we sampled 25% of the total number of bags of waste for each restaurant to evaluate composition, specifically landfill, organics, recycling, and liquids. We did not sample 25% of the Public Waste because it would pose a serious hazard to the auditors to be sampling from such an uncontrolled waste stream. For the second audit, we added cardboard as its own category because it made up a significant portion of the recycling waste. This provided a sample of the Pier's waste components for the day. The organic waste we sorted consisted mostly of food scraps and disposable packaging. Recyclables include bottles, both plastic and glass, cans, clean

paper, cardboard, and other non-film plastics. Comparing the data gives an estimate of the scale of each individual waste stream at the Pier as well as the Pier's overall waste output.

Cost-Benefit Analyses

Solid Waste Collection

To compare improvements to the solid waste collection system at the pier with the current system, we conducted a cost-benefit analysis. This analysis included several different categories to which we assigned quantifiable values. The end result is a sum total cost or benefit for the improvement in comparison to the current system.

After learning more about the current collection system, we decided to explore the implementation of one of two different technologies in substitute of the trolley cart collection system. Our client had discussed safety concerns about the trolley's use for transporting 30-yard bins along crowded walkways and disturbing the peace of the tourist attraction. The first option is a pneumatic tube system similar to that on Roosevelt Island in New York City, and the second is a classic conveyor belt system used to move the waste from checkpoint to checkpoint. Either technology would be implemented under the Pier, addressing the main challenge of moving waste from the west end and center of the Pier, where the restaurants and trash enclosure are, to the east end of the Pier, where the compactors are.

Pneumatic tubes, or automated vacuum collection (AVAC) systems, are beginning to see huge success in waste collection innovation across the globe and satisfy many of the Pier's needs. For example, they are quiet, odor free, safer than collection vehicles, perform at high capacity for decades, and will be almost invisible to Pier visitors. Their success has even warranted their adoption at Walt Disney World as the primary mode of waste collection throughout its parks (Forestor Network).

Conveyor systems are a more general technology that have been used in a number of fields for different purposes. However, after reaching out to multiple conveyor companies about the feasibility of including them in this project we have determined that due to the outdoor nature of the system it would not be possible. Future research should look into the possibility of including an enclosed conveyor system on the pier as a potential solution.

For the cost-benefit analysis, the main inputs for the current system we looked at were wages for Pier workers who operate the trolley, operation and maintenance costs of the trolley, and potential safety risks of the trolley with respect to its hazards to people and cars on the Pier. The inputs we looked at for improvements were installation cost, operation and maintenance costs, as well as training time needed for Pier workers to understand how to use the new system.

For both the current system as well as the potential improvements, lifetime usage was considered when calculating the final cost-benefit analysis. The final analysis took into account replacement costs that would be necessary for each piece of machinery.

Organic Waste Processing

Because the Pier produces a large amount of organic waste, there is an opportunity to utilize this material in some way. To determine the best utilization for this waste, we conducted a cost-benefit analysis of implementing some sort of organic waste processing technology on site at the Pier and compared it with the cost incurred by landfilling this material instead in addition to the cost of sending the organics to a nearby anaerobic digester.

After some preliminary research, the organic waste processing technology on which we decided to run a cost-benefit analysis is anaerobic digestion, "a natural process that converts a portion of organic carbon...into methane (CH_4) and carbon dioxide (CO_2)" as well as a byproduct of biogas, a renewable energy source (U.S. Department of Agriculture). This technology mimics the natural process by decomposing organic waste in an oxygen-free environment, producing biogas, which could be used as an energy source, and a compostable effluent. Because food waste is so energy dense, it is the most suitable for material for anaerobic digestion, making this technology particularly appropriate for the pier.

The main inputs we looked at for organics processing cost-benefit analysis are landfill fees, transportation costs, installation cost, operation and maintenance costs, output processing costs, compostable bag cost, and wages of personnel to operate the digester. As with the solid waste collection CBA, we took into consideration the lifetime of the anaerobic digester for our analysis.

Results

Waste Audit

The results of our first waste audit on Thursday, April 12 are listed in Table 1, and the results of our second on Saturday May 5 are listed in Table 2. We weighed almost 180 bags of waste during the first audit, about 2,600 pounds, from nine different sources. Of this weight, about 40% was organic, almost 20% was clean recyclables, while the remaining 40% were landfill or liquid. For the second waste audit, we weighed almost 600 bags, or about 7,800 pounds of waste, from the same nine sources in the first waste audit. Extrapolation of our 25% samples of restaurant waste found a similar composition to the first audit -- about 50% of the waste was organic, 13% was recycling (including cardboard as separate category), and 30% was landfill, mixed waste, or liquid.

Upon completion of the second waste audit at the Pier, it became clear that some sort of organics diversion program beyond what the city already has planned is required. With the Pier producing almost 8,000 pounds of waste on a warm day in spring, even before the tourist season is in full swing, and over 50% of this being organic waste, it is evident that diversion of organic waste could drastically decrease the overall landfill waste produced by the Pier, helping the City to reach its zero-waste goal, as well as helping to reduce greenhouse gas emissions.

Table 1. *April Waste Audit Data (All weight in pounds)*

Restaurant	# of Bags	Initial Weight	Organics	Recycling	Landfill	Liquid	Component Total
Pier Burger	32	236.9	121.5	48.5	46.8	20.1	236.9
Albright	40	450.2	363	81.6	5.6	0	450.2
Mariasol	23	465	265	181.5	12.3	6.2	465
Seaside	16	156.3	74.7	68	6.7	6.9	156.3
Pacific Park (Kitchen waste)	11	57.4	45.9	1.1	4	6.3	57.4
Pacific Park (Food court)	28	407.6	192.9	178.9	23.1	18.3	413.2
Public Waste	96	719.6					
Shops	5	31.6					

Unknown	23	110.4					
Pier Total	178	2635	1063	559.6	98.5	57.8	1779

Table 2. *May Waste Audit Data (All weight in pounds)*

Restaurant	# of Bags	Initial Weight	Organics	Recycling	Landfill	Liquid	Cardboard	Component Total
Pier Burger	41	428.1	271.4	24	83.4	43.8	5.4	428.1
Albright	58	1098.7	979.5	56.9	41.5	2.4	18.4	1098.7
Mariasol	68	1400.1	996.4	232.9	138.3	19.1	60	1446.7
Seaside	16	273.4	238.4	4.6	30.5	0	16	289.4
Pacific Park (Kitchen waste)	108	937.7	696.9	62.8	137.1	42.7	0	939.5
Pacific Park (Food court)	136	2011.7	1183.5	227.5	182.2	73.8	339.6	2006.6
Public Waste	156	1369.9						
Shops	9	95.2						
Unknown	3	189.2						
Pier Total	595	7804	4366.1	608.7	613	181.8	439.4	6209

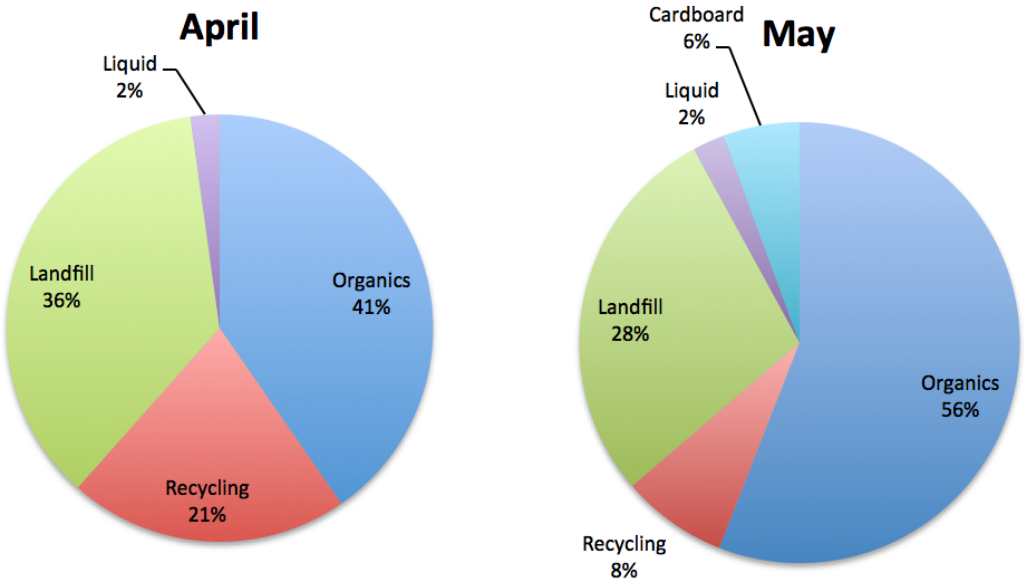

Figure 1. Santa Monica Pier waste composition by category

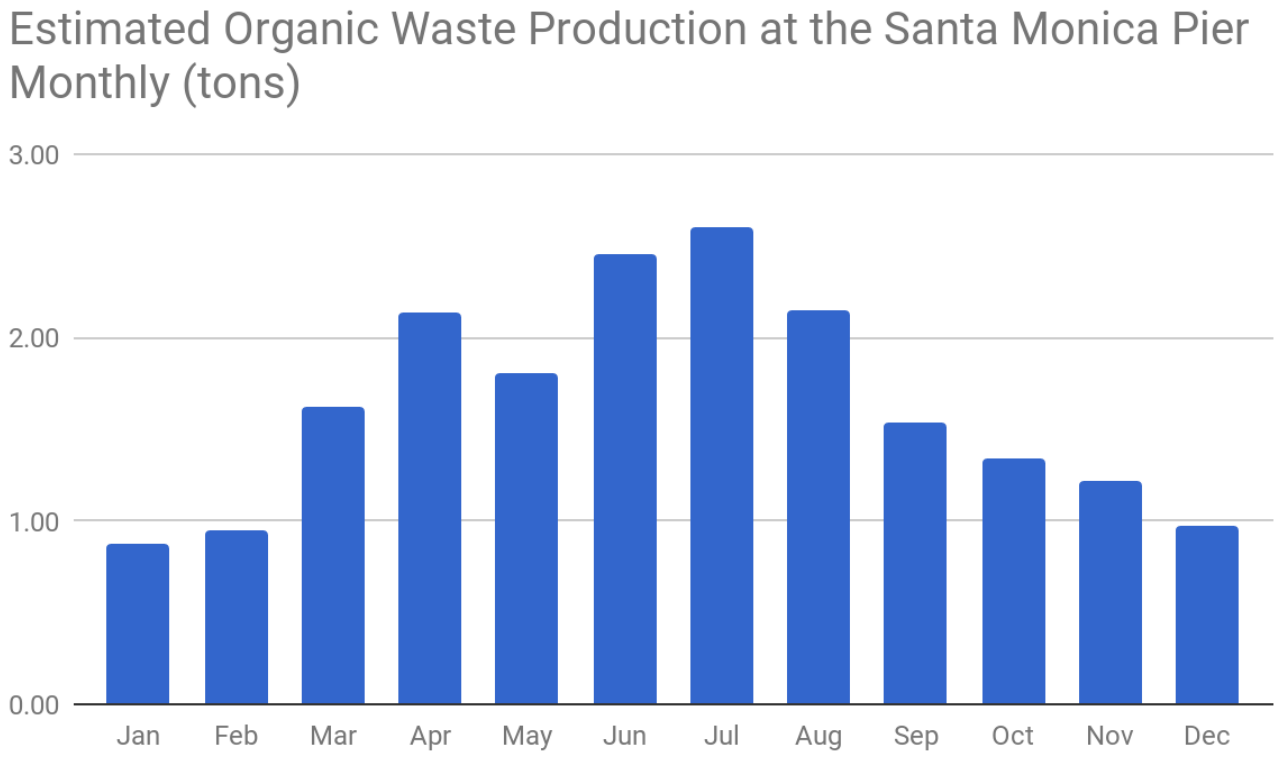

Figure 2: Estimated organic waste in tons generated by the pier daily by month

Cost-Benefit Analysis: Organic Waste Processing

After conducting cost-benefit analysis on organic waste processing (Table 3) we have concluded that neither aerobic composting nor dehydration are feasible options, due to space limitations. An on-site, anaerobic digester would not be a feasible option due to the fact that the Pier does not produce enough organic waste, even for a small-scale digester. An option that may be feasible is to transport the organic waste from the Pier to other closer, large scale digesters in LA County, rather than to Agromin.

Cost-Benefit Analysis: Waste Collection and Transportation

The cost-benefit analysis for waste collection and transportation (Table 4) indicated that AVAC/pneumatic tubes would not be a feasible option as they incur a high capital cost, and the distance of transport along the Pier might not be far enough to meet general economy of scale requirements to be cost effective. Regarding a conveyor belt system, most companies only do indoor systems, so we were unable to determine in our research what the effect of weather and ocean corrosion on the equipment lifetime would be. However, this could be worth looking into in the future.

Table 3: Organic Waste Processing Cost Benefit Analysis

Organic Waste Processing Method	**Status Quo (Transport Organics to Agromin)**	**Installation of On-Site Anaerobic Digester**	**Transport to Closer Anaerobic Digester**
Collection Fee ($/ton)	$78.16	$100	$100
Transportation Fee ($/ton: to SCD then to Agromin)	$34.42		
Processing Fee ($/ton: Agromin cleaning & processing)	$73.50		
Installation Cost		$114,000--$362,000	
Operations and Maintenance ($/year)		$5,700--$18,100	
Compostable Bags ($/bag	$91.32	$91.32	$91.32
Wages for Pier workers ($/hour)	$11.00		
Output Effluent Benefit ($/ cubic yard)		$35.00	

Citations:
(NRCS 3-6)

Table 4: Waste Collection and Transportation Cost Benefit Analysis

Method	**Installation Costs**	**Annual operations and maintenance costs**
Status Quo (Trolley)	$0	
Conveyor Belt	$1,600,000	
AVAC (Roosevelt	$8,390,000-$9,260,000 (1970	$879,000-952,000 (1970

Island)	dollars)	dollars)
AVAC (High Line / Chelsea Market)	Terminal (6,900 sqft)- $2,892,362 Trunk Pipe (1,729 m)- $5,671,724 Inlets/Valves (24)- $2,005,734 Total- $10,569,820	Labor (2 employees)- $301,231 Electricity (126,774 kwh)- $63,352 Minor repairs/spare parts- $19,332 Employee Vehicle- $10,423 Office Supplies- $2,170 Telephone/Water- $3,510 Component Replacement- $66,671 Debt Service (over 34 years)- $627,211 Truck Labor (100 shifts) $36,085 Diesel (1577 Gallons) $5,281 Vehicle Cost and Maintenance $7,776 Tolls (74 crossings)- $1,997 Total- $1,145,039
AVAC (2nd Street Subway)	Terminal (4300 sqft)- $2,600,000 Trunk pipe (1185 m)- $2,409,625 Inlets (192)- $5,760,000) Total- $10,769,625	Labor (2 employees) $301,231 Electricity (302,330 kwh) $73,885 Minor Repairs and Spare Parts $36,454 Employee Vehicle $10,423 Office Supplies $3,180 Telephone/Water $3,510 Component Replacement $128,141 Debt Service (34 years) $639,068 Dray Labor (121 shifts) $62,072 Diesel (2,393 gallons) $8,017 Vehicle Cost and Maintenance $12,346 Tolls (338) $9,119 Total- $1,287,446

Discussion

In order to devise appropriate waste management solutions, we first needed data on how much waste is actually produced on the Pier and how much of that waste is organic. A large portion of the waste was expected to be organic waste due to national data stating 30% to 40% of food supply ends up becoming food waste; however, the magnitude could vary both day to day and business to business for a large and diverse attraction like the Pier. Considering that food waste makes up about 20% of landfills, diverting more waste from sizable landmarks such as the Santa Monica Pier could make a significant impact on reduction in waste to landfill and set a precedent for what sweeping improvement in waste management can look like (U.S. EPA).

Some limitations from the April audit include not differentiating cardboard from organic waste and recyclable waste and a lot of compostable cups mistakenly being classified as recyclable; both of these inaccuracies were corrected during the May audit, but they were at least partially responsible for the 20% increase in organics from April to May. In addition, the May audit still included wet or soiled cardboard as organic waste; dry cardboard was given its own category since it comprised a large portion of recyclables from April. Additionally, public waste was not sorted during the May audit, so the percentage of organic waste is unknown. An additional limitation was our method for weighing the bags of waste. In the first audit, we let bags spill over the scale, resulting in some weight not being recorded as part of the total. We partially corrected for this problem by using a box to contain the bags in the second audit, allowing the scale to capture the full extent and weight of bags.

Although we encountered these limitations, we were still able to obtain valuable data regarding the state of waste management and organic waste at the Pier. Producing more than 1,300 pounds of organic waste on a slow day in April and over 4,000 pounds of organic waste on a busy Saturday in May, before the summer season rush, the Pier is an ideal candidate for alternative processing solutions on site. This data exceeded the original expectation for what volume of organic waste produced could look like and makes solutions like on site digesters and energy production begin to look appealing and more feasible than shipping such large quantities the distance to Agromin, the waste processing facility the city currently uses for other organic waste sources.

While only small portions of each day's audit for restaurants were classified as landfill (230 pounds and 439 pounds respectively), some of that percentage was food soiled plastics, leaving another opportunity for improvement in restaurant infrastructure. If food stands instead switched these plastic containers and products (cups and plates) to paper products, all of that waste would contribute to the organics total rather than the landfill total. This would increase diversion of waste from the landfill, helping both Santa Monica and the environment.

Although we were not able to reach a conclusion regarding a waste management system for the Pier, due to issues of feasibility, this opens up opportunities for future research to be conducted on this issue. We recommend that future Practicum teams explore implementing an organic waste disposal system that combines organic waste produced not only on the Pier, but by restaurants and residents of the City of Santa Monica, as many of the technologies (such as anaerobic digestion) require the input of more organic waste than the Pier produces. Combining

organics from the City could both allow for the implementation of such technology as well as present an opportunity to divert more waste from the landfill than was originally anticipated.

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