Circularity Assessment Protocol

Santiago, Chile

University of Georgia

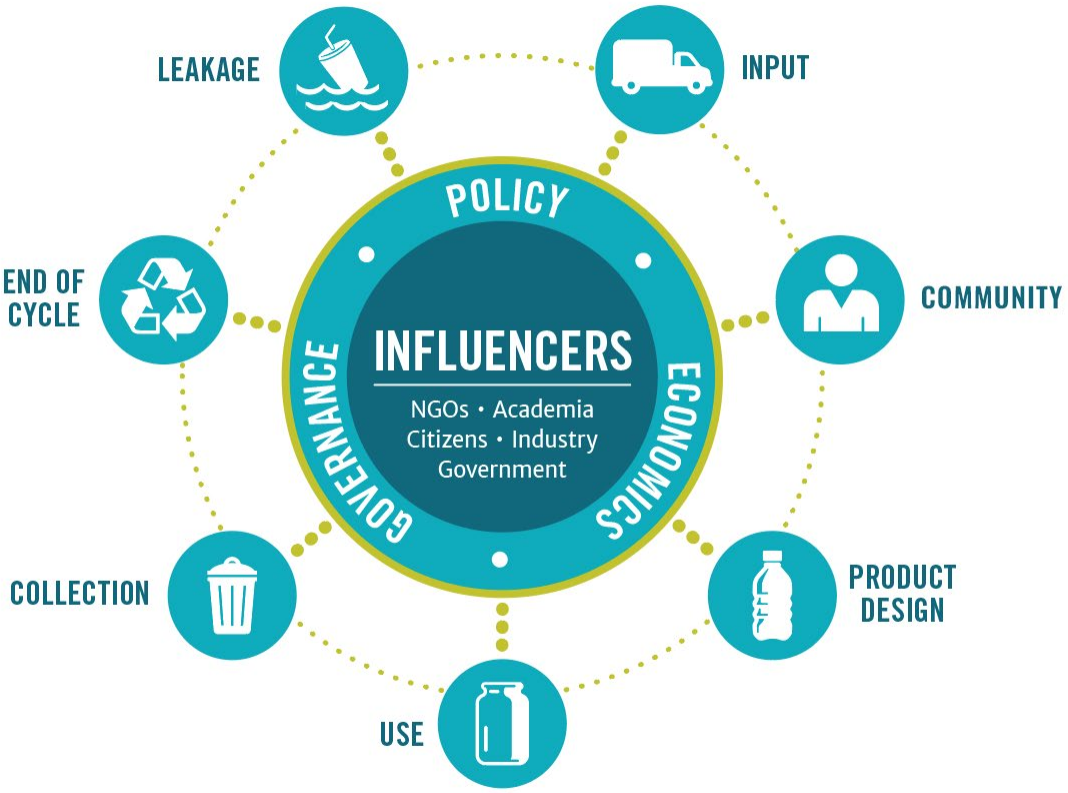
Circularity Informatics Lab

February 1, 2023

New Materials Institute
UNIVERSITY OF GEORGIA

Executive Summary

Developed by the Circularity Informatics Lab at the University of Georgia, the Circularity Assessment Protocol (CAP) is a standardized assessment protocol to inform decision-makers through collecting community-level data on plastic usage. Grounded in materials flow and systems thinking concepts, the CAP uses a hub-and-spoke model to holistically characterize how consumer plastic flows into a community, is consumed, and flows out, either through waste management systems or leakage into the environment. The model, shown below, is comprised of seven spokes: input, community, material and product design, use, collection, end of cycle, and leakage. At the center, the system is driven by policy, economics and governance with key influencers including non-governmental organizations, industry, and government.



In March – April 2022, a team from Circularity Informatics Lab (CIL) conducted fieldwork in Santiago, Chile, with field support from the Ministry of Environment and students from the Universidad de San Sebastián in Santiago. The CAP was also conducted with support from Ocean Conservancy (OC). Fieldwork included product and packaging assessments in stores across the city; key stakeholder interviews with government, industry, and non-profit organizations; material type characterizations for consumer plastic items; cost analysis of reusable products and alternatives to plastic available in the city; visual audits of recycling contamination; identification of public waste and recycling collection bins; and litter transects in three categories of population (high, medium, and low activity over a 24 hour period). Key findings from each spoke are summarized in the following table.

Key Findings and Opportunities

INPUT

Findings: The majority of convenience items are manufactured in Chile. Most parent companies were international, with 20% of brands headquartered in the U.S, 17% in Argentina, and 13% in Switzerland, whereas 28% of parent companies were headquartered in Chile.

Opportunities:

- The relatively proximity of manufacturing location for many common convenience items could present opportunities for engaging manufacturers in end-of-life packaging discussions, innovative product design, and alternative product delivery systems.
- Many parent companies were headquartered in Chile, potentially facilitating easier engagement and integration into Chile's EPR scheme.
- A few large parent companies – including PepsiCo, the Coca Cola Company, Mondelez, Arcor, and Nestle – represent a significant fraction of foreign parent companies selling common convenience products in Chile. Due to the high fraction of products coming from these companies, successful changes could produce significant impact.

COMMUNITY

Findings: Many interviewees felt current policy around bag bans, single-use plastics, and EPR had helped raise awareness among community members. Reuse and recycling were highlighted as solutions, though both technical obstacles and education challenges were named as barriers to expansion.

Opportunities:

- Current policy interventions have helped raise awareness on the issue of plastic pollution, which can be leveraged to create further change.
- Reuse practices have previously been successful in Chile, and this is a model that could continue to be expanded.
- Recyclers need fiscal, legal, and logistical support to increase their operations.
- Recycling education is an on-ongoing effort that can continue to reach more communities.
- Standardizing PLA labeling could lay the groundwork for successful composting programs, though composting collection and capacity would need to increase.

PRODUCT DESIGN

Findings: Multilayer film was the most common packaging type for convenience items, but a high fraction (30.5%) of wrappers were made of labeled polypropylene. Hard plastic (34.3%) and paper (26.7%) was the most common material type in restaurant to-go items.

Opportunities:

- Many food wrappers are made of polypropylene (PP), and existing clear labeling of these products could support an increase in PP recycling.
- The high proportion of multilayer film packaging could be targeted for redesign for recyclability in line with Chile's circular economy goals.
- The high fraction of paper-based products found in restaurant to-go items might suggest a higher willingness to switch to alternatives.

USE

Findings: Chile's plastic bag ban has been effectively applied in retail stores, but there are some loopholes. Reuse and refill systems like Algramo and EcoCarga exist locally and offer cost savings over traditional plastic packaging.

Opportunities:

- The successful transition to reusable bags in grocery stores could be expanded to other contexts both in terms of product and location. Street markets bags and produce bags used in large retail grocery stores might hold opportunities for adjacent expansion.
- Reuse and refill systems already have traction in beverage and household categories. Reuse systems could be implemented to reduce waste generation in other sectors, such as to-go food and shipping.
- Refill systems can be designed to provide products to customers at a cheaper cost than traditional single-use plastics by eliminating packaging costs for producers.

COLLECTION

Findings: While door-to-door household waste collection is nearly universal in the city, access to recycling varies and is primarily provided through drop-off centers.

Opportunities:

- Curbside collection is available only in limited cases and drop off centers may not be accessible equally to all residents, especially those that lack transportation.
- Access to recycling and recycling practices vary depending on drop off location, adding additional challenges to recycling education.
- Case studies have shown that integrating informal recycling workers into more formalized recycling systems can be successful.
- Municipalities may be able leverage the implementation of the new EPR system to improve collection capacity and offset their costs

END OF CYCLE

Findings: Waste from the metropolitan region is typically taken to a transfer station and then to one of three main landfills in the region. Systems for end of disposal of construction and demolition (C&D) debris is a significant gap that drives informal dumping. Industrial composting facilities do exist locally, although they cater to corporate clients with homogenous inputs of waste rather than municipal sources.

Opportunities:

- Most Municipal Solid Waste (MSW) is taken to a transfer station prior to a landfill, providing an opportunity to extract hazardous waste and recyclables.
- A wide variety of companies recycling and upcycling plastics exists in Chile, providing local markets to sell recyclables collected.
- New models to recycle C&D waste could help target the prevalence of illegal dumping, with appropriate policy incentives and enforcement mechanisms.
- Industrial composting exists locally for corporate clients willing to pay for services; these local resources could support expanding municipal composting capacity. Clearer labeling and standards of compostable products could support these efforts.

LEAKAGE

Findings: Tobacco products (38%), plastic fragments (15%), paper (14%), and food plastic (11%) were the main categories of litter found in surveys. Litter densities were 2.04 items/m^2 in the upper population areas, 5.28 items/m^2 in the middle population areas, and 2.34 items/m^2 in the lower population areas.

Opportunities:

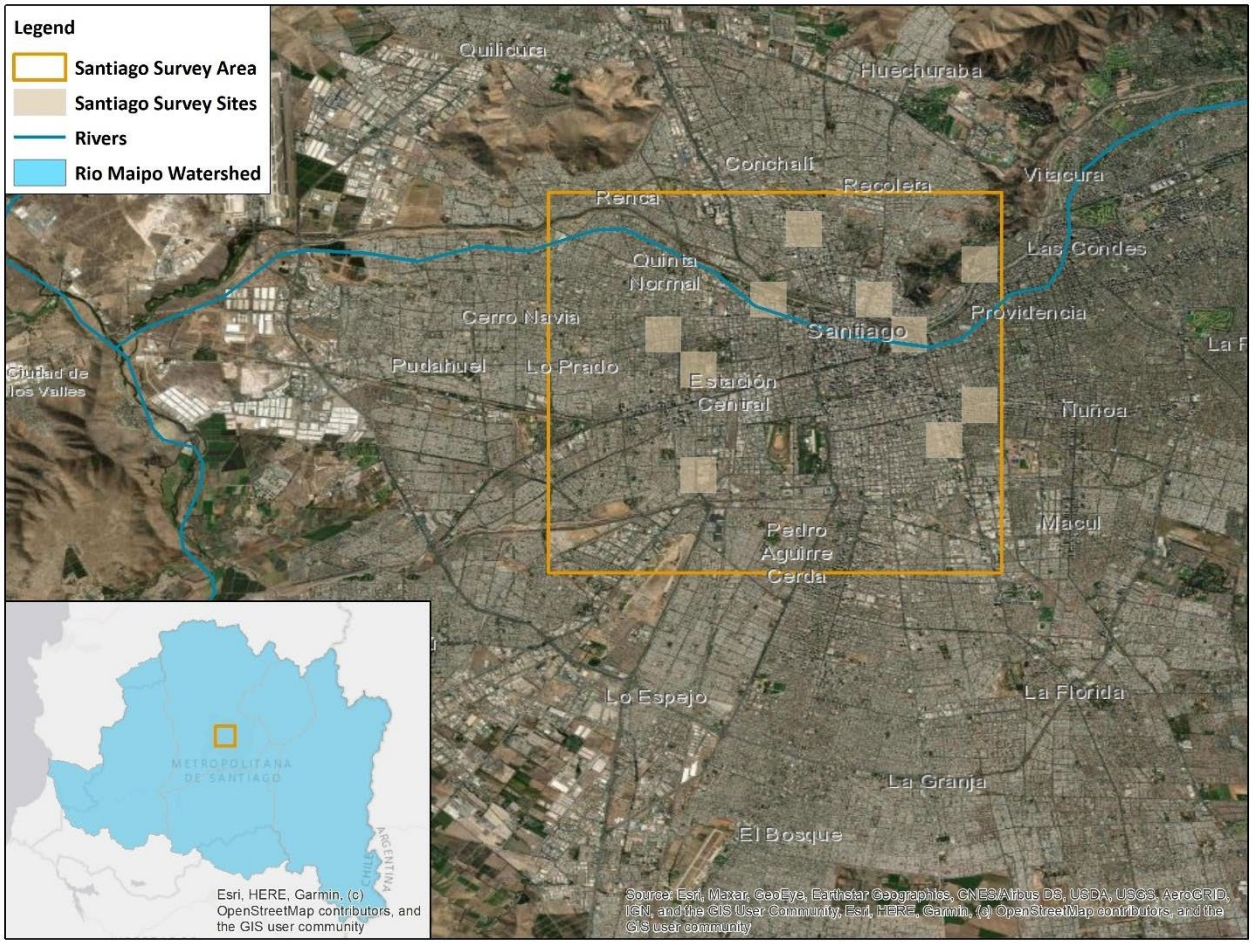
- Tobacco products (38%) and common plastic items (30%) comprised a majority of the litter, highlighting opportunities for targeted reduction and anti-cigarette-litter campaigns.
- Litter densities were higher in Santiago (average 3.34 items/m^2) than in environmental reservoirs, in a survey of Chilean rivers (average 1.6 items/m^2), implying an opportunity for more efficient last-chance capture by targeting litter closer to the source in the cities.
- The lack of plastic bags found in the litter (0.05%) highlights the effectiveness of policy in targeting problematic plastics like bags, which could (and is) being expanded to other unnecessary, avoidable, and problematic plastic products.

Table of Contents

Introduction

Over recent decades, Chile has seen rapid economic growth, resulting in the highest Gross Domestic Product (GDP) per capita among South American countries[1]. The metropolitan region of the capital of Santiago has a population of over 7 million people, generating an estimated average of 1.5 kg of waste per capita per day[2]. The Mapocho River runs through the heart of the metropolitan region, providing the majority of drinking water to the capital and connecting the city – and waste – to coastal Chile and the Pacific Ocean (Figure 1).

Figure 1: Overview of survey area in Santiago



Chile is highly industrialized and key industries include mining for copper, coal, and nitrate; manufactured goods including food processing, chemicals, and woods; and agriculture, specifically fishing, viticulture and fruit. Nine percent of the workforce is employed in agriculture, including in Chile's significant wine

[1] World Bank. World Bank Open Data Development Indicators. https://data.worldbank.org/ Accessed on October 1, 2022.
[2] Blazquez, C., & Paredes-Belmar, G. (2020). Network design of a household waste collection system: A case study of the commune of Renca in Santiago, Chile. Waste Management, 116, 179-189. https://doi.org/https://doi.org/10.1016/j.wasman.2020.07.027

sector. Industry employees 22.3% of the workforce, while 66.8% are employed in services. [3] Nearly 35% of workers have informal employment[4].

This backdrop – a growing economy with high per capita waste generation and environmental strain from industrialization – presents challenges. Chile has made significant commitments to reduce plastic pollution in the environment, including banning single-use plastic grocery bags and many single-use plastics, as well as becoming the first Latin American country to join the Plastics Pact Global Network.

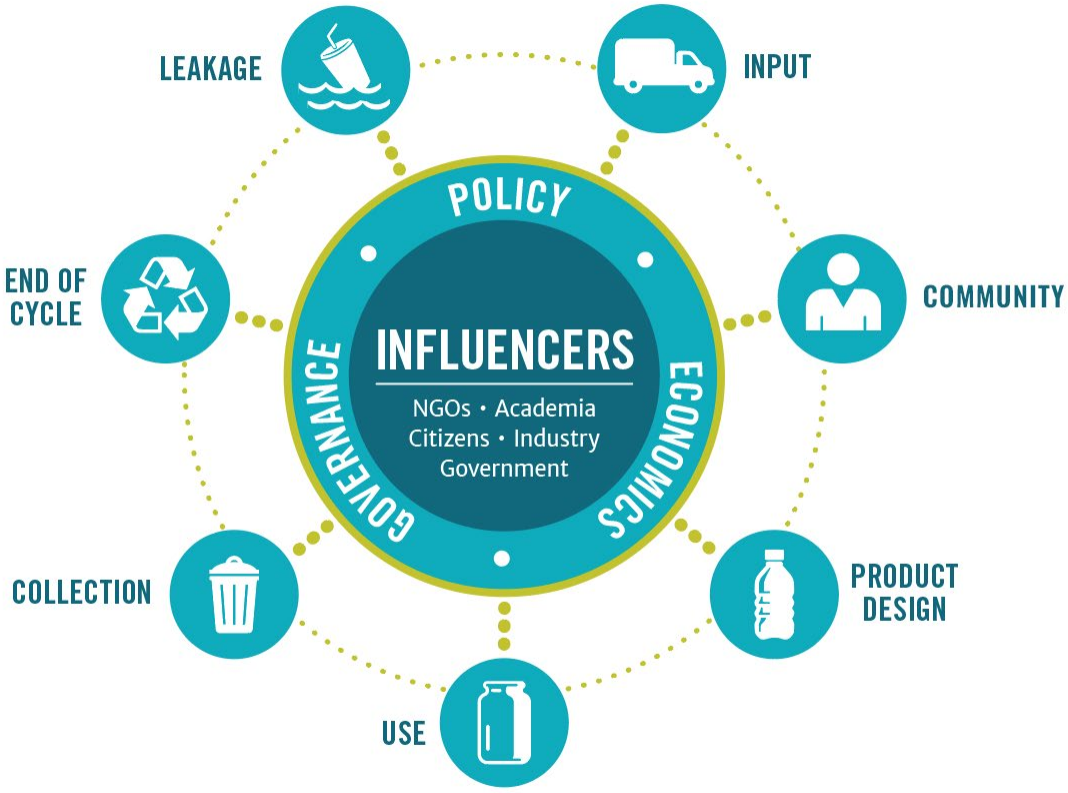
Notably, the Chilean government recently approved Law 20920. The law establishes a framework for Extended Producer Responsibility (EPR) with the objective to "reduce the generation of waste and encourage its reuse, recycling and other types of recovery.[5]" Implementation of the law is in progress, making this an especially interesting time to study circularity in Santiago.

The Circularity Informatics Lab (CIL) at the University of Georgia (UGA) developed the Circularity Assessment Protocol (CAP) in 2018, which is a standardized assessment protocol used to collect community-level data to inform decision-makers (Figure 2). The CAP characterizes seven community components:

1. **Inputs** — What products are sold in the community and where do they originate?
2. **Community** — What conversations are happening and what are the stakeholders' attitudes and perceptions?
3. **Product design** — What materials, formats, and innovations are found in products, particularly packaging?
4. **Use** — What are the community trends around use and reuse of product types?
5. **Collection** — How much and what types of waste are generated? How much is collected and what infrastructure exists?
6. **End-of-cycle** — How is waste disposed? What is the fate of waste once it is properly discarded? How is it treated?
7. **Leakage** — What waste ends up in the environment? How and why is it getting there?

[3] Santander Trade Markets. Chile: Economic and Political Outline. https://santandertrade.com/en/portal/analyse-markets/chile/economic-political-outline
[4] OECD. Economic Survey of Chile - September 2022. https://www.oecd.org/economy/chile-economic-snapshot/
[5] Ministerio del Medio Ambiente. LEY 20920 Firma electrónica ESTABLECE MARCO PARA LA GESTIÓN DE RESIDUOS, LA RESPONSABILIDAD EXTENDIDA DEL PRODUCTOR Y FOMENTO AL RECICLAJE.

Figure 2; Circularity Assessment Protocol (CAP) hub-and-spoke model.

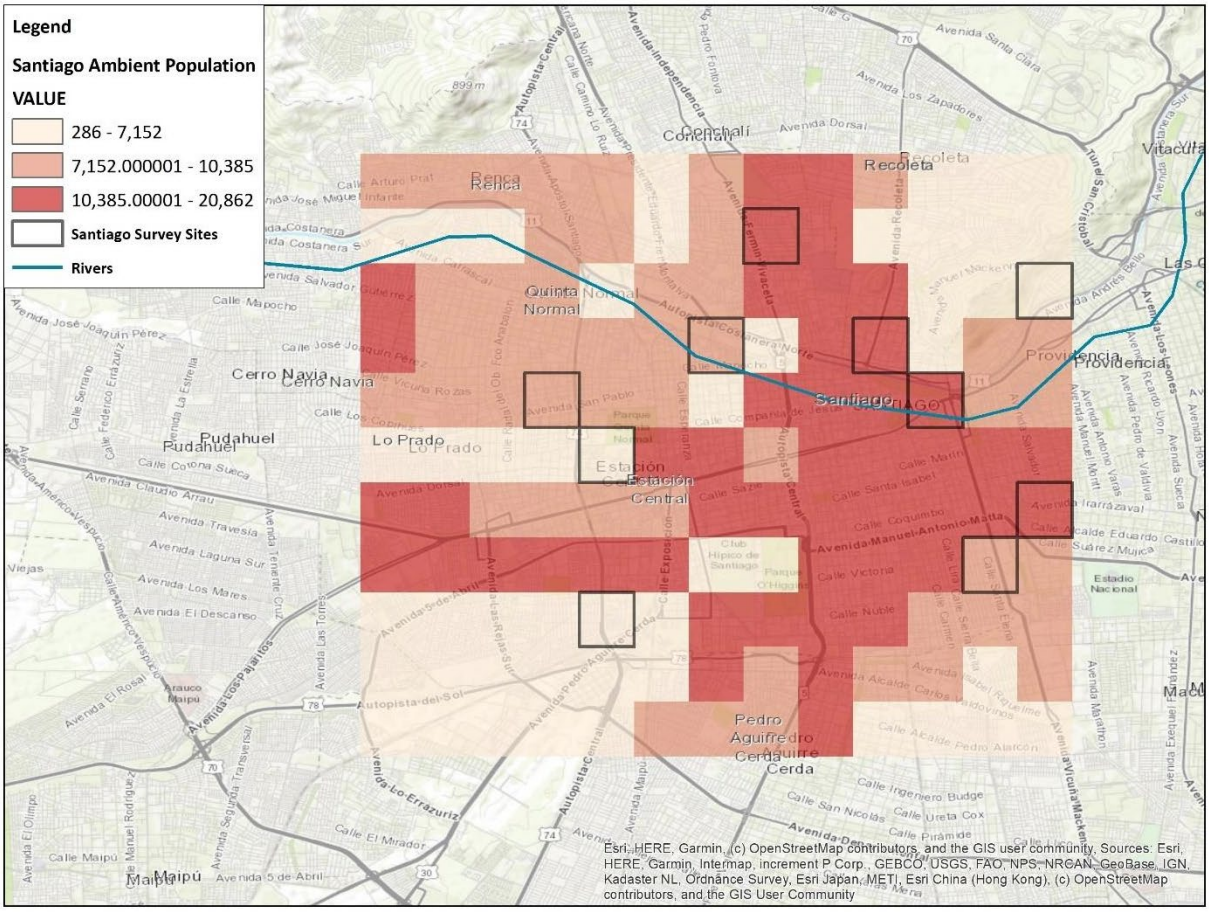


This report documents work conducted by CIL with support from the Ocean Conservancy, and the Office of Circular Economy in the Ministry of the Environment in Chile. Background information and a literature review were conducted in January - April 2022. Fieldwork was conducted in March - April 2022. The CAP report is split into the following sections, which include results and discussion of each: Input, Community, Product Design, Use, Collection, End of Cycle, and Leakage, followed by Opportunities. The intent is for the data in this report to inform ongoing stakeholder engagement around solutions to strengthen the circular economy and waste management in Santiago.

Sampling Strategy

In order to randomly sample various locations in a city, the CAP typically identifies a 10 x 10km area over the city (with the center of the city in the center of the area). In this area, the ambient population is sectioned into tertiles (three groups) (Figure 3). Ambient population count can be described as "where people go" and "societal activity" — it is not population density of where people live. These three areas typically form samples of different land uses, etc.

Figure 3: Population tertiles and survey sites in Santiago.



Typically, three 1 x 1 km areas for surveying are randomly selected within each population tertile using NOAA's Sampling Design Tool, resulting in a total of nine 1km^2 areas for surveying. In this case, in discussion with local collaborators, an additional site was added in the high population bracket to capture an area of interest near La Vega, a major market in Santiago.

In total, 10 sites were surveyed, four in the high population count tertile and three each in both the low and mid population count tertile.

Input

To get a snapshot of the characterization, scope, and source of common plastic packaged items that are entering Santiago, samples of fast-moving consumer goods (FMCG) in four popular categories were taken within ten 1km^2 transects in Santiago — four in the high population count tertile and three each in both the low and mid population count tertile. The team selected three convenience or grocery shops to sample within each 1km^2 transect area, where shops were present and open at the time of surveying. In total, 109 unique brands of convenience products were collected and sampled, including 44 candies, 13 chips, 21 drinks, and 27 cookies (Figure 4). Samples of identical brands were not collected multiple times, even when present in multiple stores. Common brands of tobacco products were also visually assessed in stores, although samples were not purchased; 4 brands of cigarettes are included in the input analysis.

Figure 4: Typical convenience store packaging in Santiago

For each of the top products documented, the team noted the type of packaging (including polymer, if possible), the brand, and the parent company. From there, the team was able to determine the manufacturing location, which was determined from manufacturing locations listed on product packaging or desktop research, as well as the headquarters location for the parent company of the brand (largely determined by desktop research). Manufacturer and parent company distances (Table 1) are intended to estimate the distance in kilometers between the city and the origin of each product.

Top brands of each category, based on a visual assessment of shelf space in a store, conversations with shopkeepers, and repeated occurrence across stores, included the following:

- **Beverages**: Benedicto, Cachatun, Coca Cola, Del Valle, Fanta, Gatorade, Inka Cola, Pepsi
- **Candy**: Bon o Bon, Kit Kat, Muibon, Prestigo Sahne-nuss, Super 8, Trencito
- **Chips**: De Todito, Doritos, Evercrisp, Lays, Marco Polo
- **Cookies**: Club Social, Costa, McKay, Oreo, Triton
- **Tobacco Products**: Lucky Strike, Marlboro, Pall Mall

Table 1: Distances between Santiago and manufacturer and parent company locations for top FMCG convenience items

	Distance Store to Parent Company (km)			Distance Store to Manufacturer (km)		
	Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
Beverages	0	12,838	6,110	0	12,801	933
Candy	0	13,869	5,304	0	13,869	2,463
Chips	0	11,016	6,310	0	9,510	1,229
Cookies	20	21,596	7,181	0	24,250	2,774
Tobacco Products	10,673	12,838	12,297	10,611	10,673	10,626

*Note: Distances were projected using an Azimuthal Equidistant projection. Values have been rounded to the nearest km.

In observing the pattern of origins for top FMCG items, Chile's national food processing industry is evident. Much manufacturing of convenience items is occurring locally, with the exception of tobacco products (Table 1). The average distance to parent companies is nearly twice as far as the distance to manufacturers for both beverages and chips. For both cookies and candies, it is over five times as far. The relatively close proximity of manufacturing is promising for developing successful EPR schemes. Especially considering that chip bags and candy and cookie wrappers and similar plastic food packaging are often lightweight multi-layer plastic that is difficult to capture and recycle, the proximity of manufacturing locations for this category could present opportunities for engaging manufacturers in end-of-life packaging discussions, innovative product design, and alternative product delivery systems.

Across all products sampled, 65% were manufactured in Chile, which was the most represented manufacturing location, followed by Argentina (7%), Colombia (6%), and the US (5%). On average, manufacturers for common drink and chip products were located within about 1,000km of Santiago. Candy and cookie products were further afield, typically within about 2,500km of the city. Tobacco products had the highest maximum and average distances to manufacturing locations (Figure 5).

Figure 5: World Map displaying manufacturing locations for top convenience items in Santiago

Figure 6: World Map displaying parent company locations for top convenience items in Santiago

Like the pattern for manufacturer locations, the largest fraction (28%) of top convenience item brands were owned by a parent company headquartered in Chile (Figure 6). In aggregate, the majority of parent companies were headquartered internationally. This was comprised 20% of brands headquartered in the U.S, 17% in Argentina, and 13% in Switzerland, at the top of the list. Parent companies driving these country trends were PepsiCo, the Coca Cola Company, and Mondelez International in the US. In Argentina, this was driven almost entirely by Arcor, and similarly in Switzerland by Nestle. While the physical distance between company decision-makers and on-the-ground waste management consequences certainly presents challenges, there are clearly a few 'big hitters' where successful engagement efforts could produce outsized impact.

Community

Policy Backdrop

Bans and Restrictions on Unnecessary and Problematic Plastics

Since 2018, Chile has gradually phased out the use of single-use plastic (SUP) bags in retail stores (although not all businesses are included; see Use). It is estimated that between 2018 and 2021, this shift reduced over 49,000 metric tons of plastic waste by eliminating more than 6.7 billion bags.[6]

In addition to the bag ban, other single-use, unnecessary, and problematic plastics are coming into the scope of Chilean legislative action. A 2021 bill, yet to be fully enacted, will limit the use of SUPs in food service, such as restaurants and bars. These products will include expanded polystyrene (EPS) takeout containers, plastic cutlery, straws, cups, and lids. For in-house dining, reusable foodware will be required, and biobased compostable products will be required for takeout. Additionally, supermarkets and convenience stores will be required to offer a minimum of 30% of beverages in reusable containers and to accept returns of that packaging. Implementation for these actions is planned to be completed by 2025.[6]

As part of the Chilean Plastics Pact, government and corporate actors have agreed to work towards the following four commitments by 2025.

1. Take action to eliminate plastic packaging and single-use utensils that are problematic or unnecessary by redesigning and innovating.
2. 100% of plastic containers and packaging must be designed to be reusable, recyclable or compostable.
3. One-third of domestic and non-domestic plastic containers must be effectively recycled, reused, or composted.
4. Plastic containers and packaging must have among their different formats an average of 25% of recycled material.[7]

One such public-private voluntary partnership is the #ElijoReciclar seal, a trial recyclability label for packaging. The seal certifies that:

- At least 80% of the weight of the packaging is made of technically recyclable materials.
- These materials can be separated from the rest of the packaging for recycling.
- There is currently a demand from the recycling industry.[6]

The need for increased design for recyclability applies in particular to multilayer film packaging, which was prevalent in CIL's surveys of FMCG in Santiago (see Product Design).

Extended Producer Responsibility for Packaging in Chile

The Waste Management, Extended Producer Responsibility and Recycling Incentives Act in Chile targets establishing collection systems for six priority types of waste: 1) tires, 2) packaging, 3) lubricant oils, 4)

[6] Global Commitment 2021 Signatory Report. Ellen MacArthur Foundation. https://ellenmacarthurfoundation.org/global-commitment-2021/signatory-reports/gov/government-of-chile

[7] Fundacion Chile. New Plastics Economy: Chilean Plastics Pact. https://fch.cl/en/initiative/new-plastics-economy/

electrical and electronic equipment waste, 5) automative batteries, and 6) portable batteries. Of particular focus in this report is packaging, specifically household packaging although the EPR law will apply to both household and industrial waste.

For household packaging, the overall target is to increase the average recycling rate to 60% by 2030. Household packaging covers five distinct categories, each with a unique recycling target: Beverage cartons (60%), Metal (55%), Paper and cardboard (70%), Plastics (45%), and Glass (65%).

Like EPR developed in Europe, notably the German model, Chile is in the process of implementing an EPR system involving Producer Responsibility Organizations, or PROs. PROs assist corporate clients in implementing EPR and complying with legal frameworks. PROs facilitate waste collection, ensure recycling targets are met, and verify data to report to authorities. Chile's EPR framework allows companies to facilitate collection of their own packaging content or to fulfill this requirement through a PRO, although small producers (less than 300 kg of packaging per year) are exempt from the requirements. The legislation ultimately requires both a curbside collection system for at least 85% of residents (in place of the current drop-off recycling centers), as well as integrating the informal recycling sector that is currently operating.[8]

Currently, one large PRO has been set up in Chile focusing on both household and industrial packaging. (There is another PRO that has been established primarily focusing on commercial and industrial packaging.) This PRO includes large, multinational FMCG companies like Coca-Cola, Unilever and Nestlé. Coca-Cola and Nestle brand products were prevalent in CIL surveys of common convenience products in Santiago (see Input). The EPR legislation stipulates that each district or municipality should only be served by one collection system for household packaging, and many municipalities are still in the process of negotiating collection systems and infrastructure needs with companies and the PRO.

Key Stakeholder Interviews

To understand current attitudes and perceptions of plastic waste, semi-structured interviews were conducted with 14 key stakeholders. Among those interviewed, five were government officials, six were from private waste or recycling companies, and three were from circular-economy businesses (Table 2). Circular economy business refers to those involved in regenerative business practices like reuse, refill, or composting.

[8] Agnes Bünemann, Jana Brinkmann, Dr. Stephan Löhle and Sabine Bartnik. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH PREVENT Waste Alliance. Bonn, Germany. https://prevent-waste.net/en/epr-toolbox/

Table 2: Summary of Stakeholder Interview List

Stakeholder Group	Number of Interviews
Government Officials	5
Private Waste and Recycling Company	2
Private Recycling Company	4
Circular-Economy Business	3

Most stakeholders interviewed agreed that the recent policy initiatives in Chile to design a more circular economy, including the bag ban and the EPR law, have been very successful in raising awareness, although the availability of alternatives to traditional plastics may be lagging awareness.

> **"The plastic bag policy has been very effective in raising awareness. There were complaints at the beginning, and it was in the news… but now it's in poor taste to forget your bag."**
>
> – Government official

> **"Awareness has gone up, but the problem is that we don't have enough options to give people. I think the EPR law will help."**
>
> – Circular Economy Business

Among alternatives to traditional consumption models, reuse is often cited as the best alternative by interviewees. Obstacles to expansion include maintaining brand standards and behavior change.

> **"We understand the value of a reusable [product] more than a compostable [product]. The best waste is one that isn't produced."**
>
> – Circular Economy Business

> **"When we started, reuse rates [of our products] were at 10%. They were up to 80% by 2018. [In a recent pilot launch in a large supermarket chain] reuse rates are around 50."**
>
> – Circular Economy Business

> **"Reuse requires a large behavior change for the consumer. More regular purchases help you not forget the packaging."**
>
> – Circular Economy Business

> **"40% of soft drinks are already reused so [reuse] is already in Chilean culture,"**
>
> – Circular Economy Business

> **"Product traceability is a key for larger brands with global quality standards."**
>
> – Circular Economy Business

Interviewees agreed that increasing recycling is also a significant piece of the puzzle for improving waste management in Chile, but financial, logistical, and technical obstacles are still significant. Political structures too – such as local permitting processes or legal frameworks – are not always easy for recyclers to navigate.

> **"We will have to build capacity for recycling slowly… it's a chicken and egg situation with supply and demand."**
>
> – Government official

> **"We need a new framework, so recycling is an obligation for companies."**
>
> – Government official

> **"We need to improve the logistics of the [recycling] process. For example, we need a forklift and a bigger compactor… we need to add a more mechanized system."**
>
> – Government official

> **"We have 40% contamination in our punto verdes. The biggest obstacle is that processing takes a lot of time, the process of sorting out contamination… We need more funds for better equipment."**
>
> – Government official

> **"Plastics will never go away, so there should be more companies that can recycle it… Logistics is our biggest obstacle [to growth]. I only own one truck, but I need three trucks."**
>
> – Private Recycling Company

> **"The economic structure [of recycling] requires high economic investment. Bigger companies will have to pay recyclers… I had to set up a foundation because I can't receive government grants, but I have to be a company to purchase equipment. Lots of money to fix up the [storage facility] and get the correct permits."**
>
> – Private Recycling Company

> **"The government doesn't help at all with recycling. They just come with the Ministry of the Environment for a photo op… I want to see more support and encouragement from the government… And more support for female entrepreneurs."**
>
> – Private Recycling Company

> **"More recycling means less waste [in the landfill], but to recycle is expensive. Here profit is the priority… people are only willing the pay the minimum to comply with the law."**
>
> – Private Waste Company

> **"Businesses that work with us have a higher level of environmental awareness. Laws should make all companies [recycle]. But it will cost a company 30,000 mil pesos to take their waste here, and 10,000 to have someone dump it illegally. Or they might not pay anything… They know this is the right option, but they know it's more expensive."**
>
> – Private Recycling Company

Effective recycling also requires lowering contamination rates. Therefore, private recyclers have taken on significant efforts to educate communities they operate in on best practices, although there remains a lack clarity on if responsibility for education lies with private industry or the government. Challenges include mistrust about the value and fate of recyclables.

> **"Recyclers work is not just collecting. They are also doing a lot to educate the community."**
>
> – Government official

> **"Environmental education is a long process… Overall contamination is about 2% but some punto verdes are worse than others [in terms of contamination rates] … While they are collecting, the operators are educating people… We have a mobile punto verde that we take to schools, and the kids are the most motivated."**
>
> – Private Recycling Company

> **"There's not so much environmental education. We're trying to use social networks for environmental education, to tell people about how to recycle."**
>
> – Private Recycling Company

> **"There is a mistrust from Chilean people when it comes to recycling. Some municipalities say they are recycling, and they are just landfilling."**
>
> – Government official

> **"Older people are used to [informal recycling collectors] coming to collect recyclables from their homes when the value was higher."**
>
> – Private Recycling Company

Some interviewees expressed concern that development of practices like recycling is left up to each municipality, and therefore there are significant differences between access to services in each

municipality. As individual municipalities negotiate with the PRO for collection systems as the EPR law in Chile moves towards full implementation, these differences may be exacerbated.

> **"Only people who have a car can drive to the punto verdes… the government intends to put one in each neighborhood, but they pay us per punto verde."**
>
> – Private Recycling Company

> **"We have a challenge with inequality because we will start [with recycling] in counties that already have waste management capacity, leaving behind the poorer communities."**
>
> – Government Official

> **"There are 52 municipalities in the metropolitan region, and they still understand very little about their role [in EPR implementation] and their mechanisms for negotiation… The producers of plastic have to negotiate with each city to figure out how they are going to get their plastic waste back. It is different for municipalities that [already] have recycling and those that don't."**
>
> – Government Official

As with recycling, expanding capacity also is an obstacle for making compostable alternatives more readily available. PLA is a particular challenge due to a lack of consistent labeling and quality.

> **"One of our biggest obstacles to supply is that we don't have a supplier of PLA in Latin America."**
>
> – Circular Economy Business

> **"Some PLA coming from Asia is not really compostable. A PLA bottle looks the same as PET… but there should be a stamp from the government or from the producers of PLA."**
>
> – Circular Economy Business

With ongoing conversations about implementation of Chile's EPR law, both government and industries are preparing, including in developing new technical expertise to identify circular economy practices.

> **"Diverse types of plastic packaging are a challenge to classify and to manage."**
>
> –Government Official

> **"In July, we will have to report how much plastic we put into the market and there will be a charge. We can reduce that charge by incorporating circular economy concepts. For example, we are working on switching out the stretch film used in our shipping process to reusable tarps… we are working with our suppliers to find ways to reduce along the supply chain"**
>
> – Circular Economy Business

> **"Demand for sustainability managers is increasing, and it is changing to a more technical field. Universities are already incorporating sustainability in their programs."**
>
> – Circular Economy Business

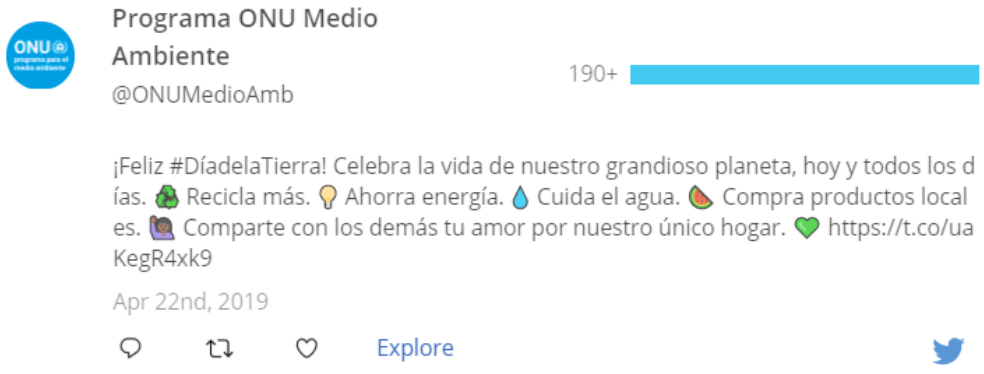
Social Media Analysis

To gain perspectives from a broader group, CIL also conducted an analysis of conversations about plastic pollution occurring on social media platforms in partnership with SEE Suite (Social media Engagement & Evaluation Suite) at the Department of Advertising and Public Relations at the University of Georgia. The data collection period was January 1, 2019, to December 31, 2019. SEE Suite analyzed 112,908 tweets about plastic pollution from Chile in both English and Spanish, including 69,338 tweets geographically from Santiago. A Boolean string of search terms related to key words of plastic pollution in both English and Spanish was used to identify relevant conversation both in original Tweets and well as re-Tweets and subsequent conversation; therefore, some conversations identified may include topics adjacent to plastic pollution.

Key themes in the conversation on plastic pollution in Chile were unsafe drinking water, circular economy, and marine wildlife. The conversation around unsafe drinking water (n = 23,741) was primarily driven by contamination events in Osorno and Puerto Octay. Unsurprisingly, 66% of the Tweets in this theme were negative. Conversations often called for higher levels of government and corporate action on environmental pollution.

Another theme emerging from the dataset focused on circular economy (n = 5,370), which included search terms relating to reusing products, reducing waste, and recycling. Notably, in other areas studied more solution-oriented topics have not emerged as a theme. For example, in Miami, a similar sentiment analysis of Twitter content showed that conversations around problematic single-use plastics and conversations around impacts to the ocean and wildlife were significant themes, but conversations around reduction, reuse, and recycling of plastics were more limited. For Chile, most Tweets on circular economy were of neutral sentiment, although 31% of conversations with negative sentiment- focused impacts of pollution and consequences of not implementing interventions. Positive sentiment, which comprised 17% of the conversations, primarily focused on Earth Day and actions people can take to protect the Earth (Figure 7).

Figure 7; Example Tweet from Earth Day



Marine wildlife (n = 5,105) was also a significant theme in the Twitter conversations. The majority (63%) of these posts were negative, focusing on impacts to wildlife like entanglement or ingestion.

Other themes made up smaller proportions of the dataset. In particular, we expected to see significant conversation around plastic bags due to Chile's plastic bag ban, as well as on fishing gear due to the

coastal nature of much of the country. Posts about plastic bags (n = 2,724) were 63% negative and mainly focused on negative environmental impacts of bags; other posts encouraged users to pick up plastic bag litter. Positive posts (4%) were more limited but focused on benefits and examples of reuse and recycling. Posts about fishing gear (n = 1,002) also largely focused on negative environmental impacts (Figure 8).

Figure 8: Example posts about recycling plastic bags and environmental impacts of fishing gear.

A spike analysis for the time period under consideration was also conducted (Figures 9a and 9b). Of particular note is the spike in adjacent conversation around significant water contamination events. Connecting plastic pollution to other environmental concerns seems to resonate with the Chilean audience and may present an opportunity for continued engagement. Holidays relating to the planet, such as World Water Day, World Oceans Day, Earth Day, and International Coastal Cleanup, also saw spikes in activity and may help to reach a broader audience not already concerned with environmental issues.

Figure 9a: Spike Analysis of Twitter conversation related to plastic pollution, Jan. – Dec. 2019

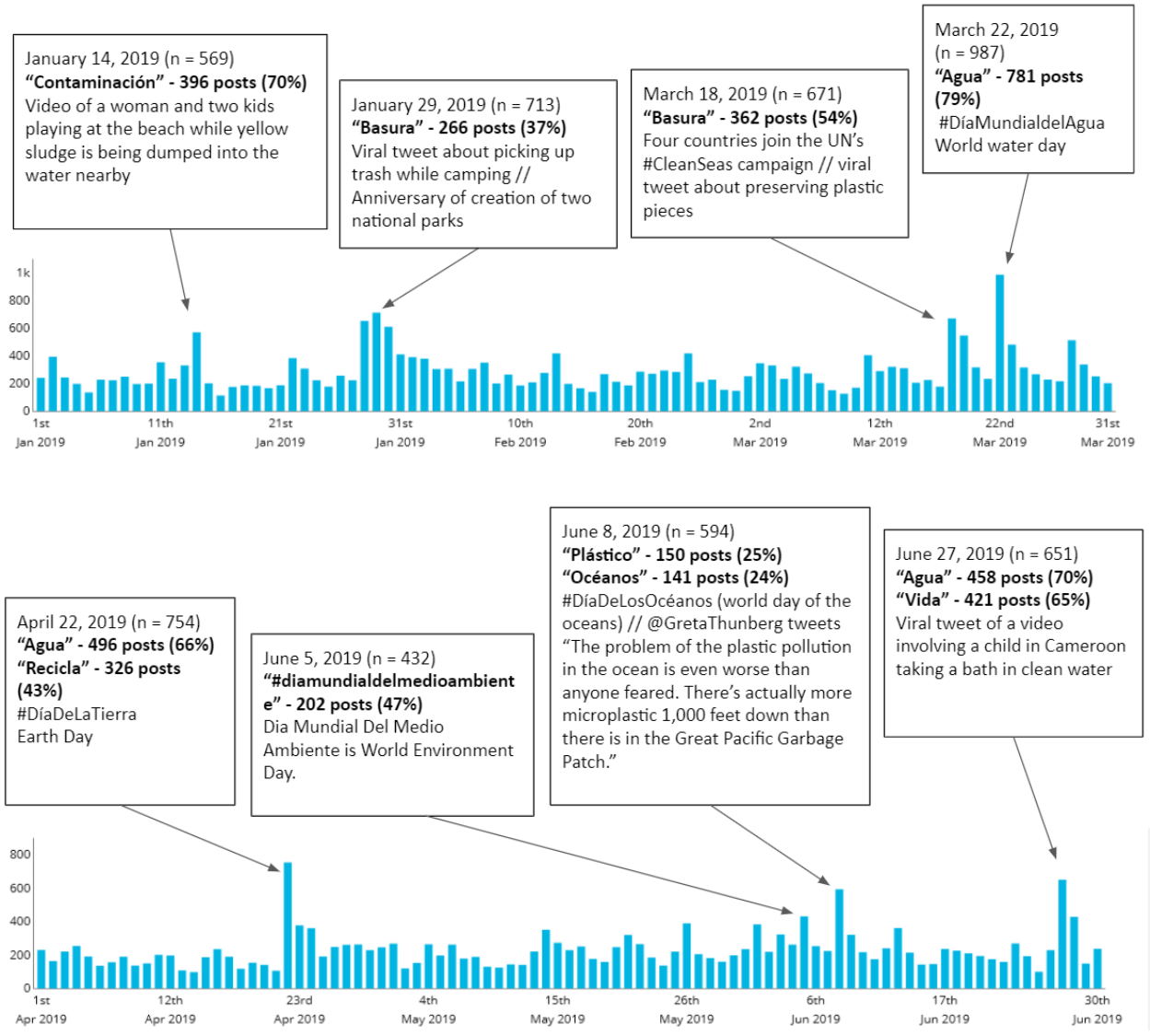
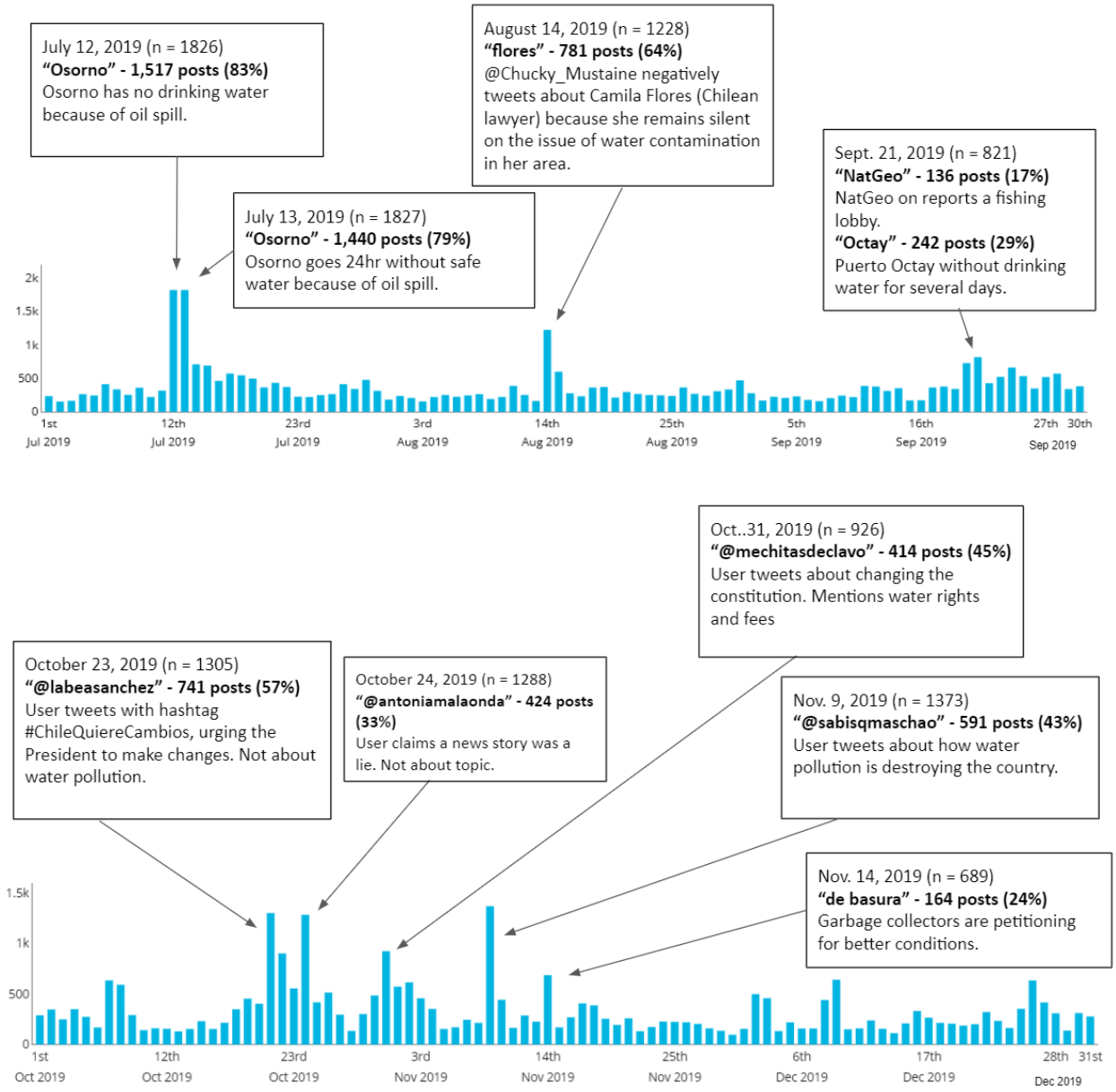


Figure 9b: Spike Analysis of Twitter conversation related to plastic pollution, Jan. – Dec. 2019 (continued)



Product Design

To characterize material types used in common consumer products, samples of common convenience were obtained as described in the Input section. The CIL team sampled stores in each of the ten 1km^2 transects areas. The average weight of both the packaging and the product itself was collected for all samples (Table 3).

Table 3: Average weight of products and their plastic packaging for common convenience items.

Product Type	Number of Samples	Average Weight of Plastic Packaging (g)	Average Quantity of Product (g or mL)
Beverages	21	27.2	528.2
Candy	44	1.1	36.5
Chips	13	8.2	100.4
Cookies	27	2.1	70.9

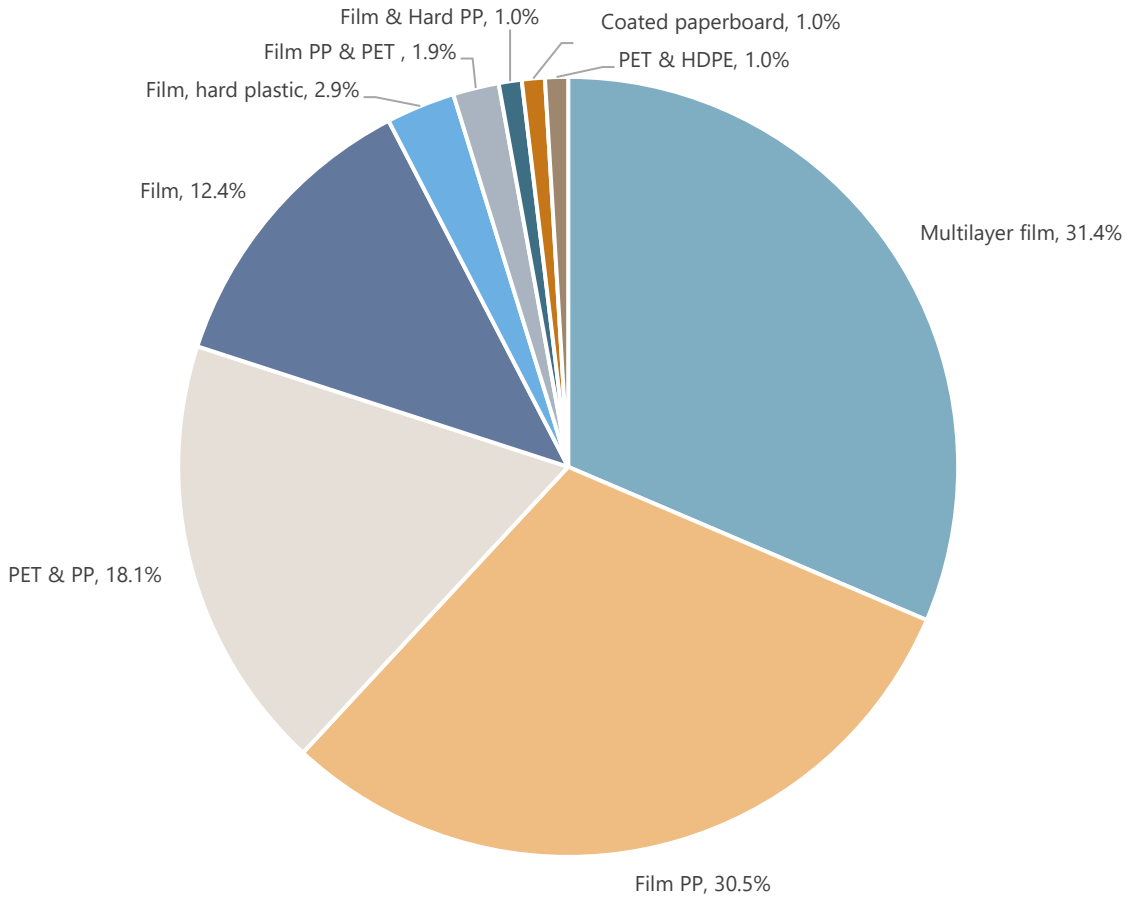
Not surprisingly, the packaging and product weights for beverages were nearly identical to what has previously been calculated in CAP cities in the US, due to standard size bottles. Candy is also similar in quantity and size to that found in the US. Compared to other international contexts however, while the ratio of product weight to packaging weight was similar, candy samples obtained were larger by weight than individually wrapped versions often seen elsewhere. For example, samples taken in several cities in India showed that the average product weight for candy items was around 3.8g and the average packaging weight was around 0.15g — those found in Santiago were around 10 times larger for both product and packaging weight. Smaller product sizes may lead to more frequent, less individually expensive purchases compared to larger product sizes, although there is often a "poverty tax" associated with these small packets compared to the price per quantity in larger sizes, in addition to the generation of more packaging weight in summation.

Cigarettes were excluded from our purchasing of samples in this case, but they are typically a standard size and we have previously found an average of about 10 g of plastic packaging to about 15 g of product. This relatively high plastic packaging to product ratio means cigarettes generate larger amounts of plastic waste per unit of product, which is likely driven by the cellulose acetate filters in cigarette butts, which typically weigh about a gram each.

For each convenience item surveyed, the CIL team documented the polymer type. Notably, many of the single-serve food wrappers in Chile were polypropylene (PP) and the majority of these were labeled clearly and identifiable. Multilayer film was the most significant fraction (31.4%), which is mostly used for products like chip bags (Figure 10) This finding is consistent with other sites across the world, and multilayer film is a problemtic material type due to the multi-faceted composition presenting challenges with recycling. Interestingly, in Santiago, PP was a close second as the most common material type at

30.5%. For comparison, in a recent survey in Miami 46% of products were in multilayer film. Less than 10% of the products were identified as PP, in part due to the lack of clear labeling. While PP recycling is not as well established in economic markets as PET recycling, the clear labeling and wide use of PP in Chile is a key step to supporting such a system,

Figure 10: Material breakdown of top convenience items in Santiago



In addition to the common convenience items characterized above, the CIL team noted during in-store-surveys that coated paperboard was a common packaging type among grocery items in Santiago (Figure 11). While most grab and go drinks we surveyed were packaged in PET, larger beverages, such as many juices and milks, were sold in coated paperboard aseptic packaging, often of the brand name Tetra Pak. Additionally, personal care products like shampoo, lotion, body wash, and lotion were often available in large containers made of flexible plastic like polypropylene, rather than hard plastics like HDPE. Both larger multi-serve beverages and personal care products like shampoo are excluded from our convenience store sampling as they are rarely observed in the litter, but the prevalence of these materials in the waste stream is important to note.

Figure 11: Other common packaging types observed in grocery stores.

In addition to surveying convenience and grocery stores, the CIL team surveyed restaurants in each of the ten 1 km^2 transects areas. Through visual assessments and discussions with restaurant owners, we assessed the material type for to-go food items like containers, cups, utensils, and straws. In total, we characterized 105 items in 37 restaurants (Figure 12).

Figure 12: Example to-go materials surveyed in Santiago, including hard plastic and paper

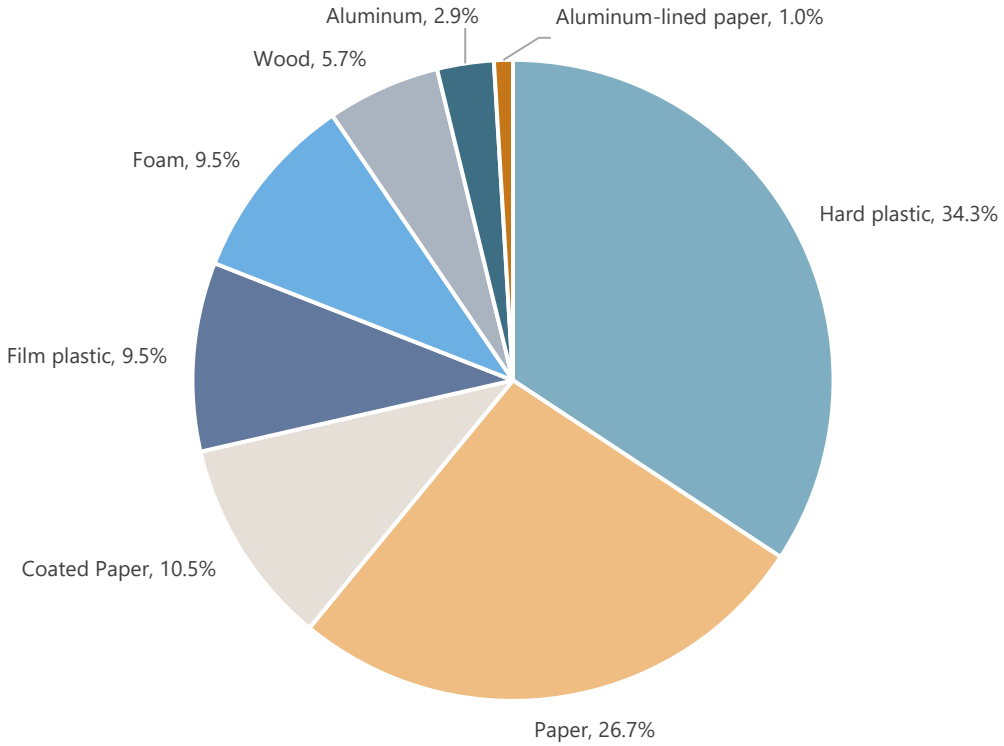
Table 4: Products and material types surveyed in restaurants and food vendors.

Product	Material Type	Number of Observations
Bags	Paper	18
	Film Plastic	10
To-Go Containers	Hard plastic	9
	Foam	8
	Paper	6
	Aluminum	3
	Coated Paper	3
	Aluminum-lined paper	1
Cups	Coated Paper	8
	Hard Plastic	8
	Foam	2
Straws	Paper	4
	Hard Plastic	5
Utensils	Hard Plastic	8
	Wood	6
Lids	Hard Plastic	10

Bags, especially paper bags, seemed to be a popular alternative to to-go containers (Table 4). Many restaurants also didn't provide to-go utensils; especially with food vendors, there was often a specialization of one product that limited the need for additional supplies. For example, ice cream vendors only have small cups and wooden spoons, so we were not able to assess all categories in our survey for each restaurant. Additionally, many restaurants offered pre-packaged drinks, most often soda in PET bottles or aluminum cans, rather than offering to-go drinks with cups and straws. These unique features

are already reducing waste generation from restaurants and could be leveraged to further reduce unnecessary consumption.

Figure 13; Material breakdown of to-go items surveyed in Santiago



Of the to-go items we surveyed, the majority were hard plastic, likely PET, PP, or occasionally HDPE. A significant fraction was paper (26.7%) or coated paper (10.5%) (for example, paper cups with a plastic lining). For comparison, in Miami only 11.1% of to-go items were paper, and 6.1% were coated paper (Figure 13). This high fraction of paper-based products in to-go items might suggest a higher willingness to switch to alternatives, even those with lower levels of durability.

Use

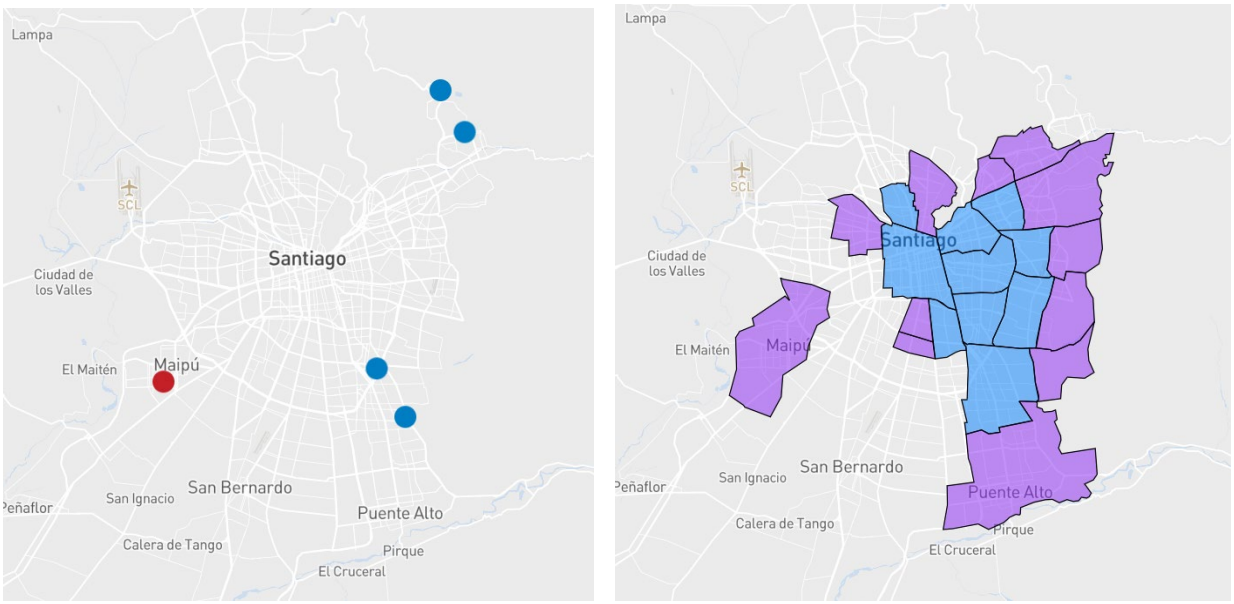
Chile was the first country in Latin America to enact a plastic bag ban, which went into effect in 2020. While plastic grocery bags are banned in retail stores (although produce bags were still in use) and were not observed by the CIL team in large grocery market chains, they are still widely used at street market stands selling produce and other goods (Figure 14). Prices for reusable bags typically ranged between 800 to 3,000 Chilean pesos (CLP) (approximately $0.80 to $3.00), depending on the size and durability of the bags. At one street market, more than 10 produce stalls were observed carrying plastic bags, although paper was also used to wrap produce in some cases and nearby stands also had reusable bags for sale. Excluding street market vendors from the plastic bag ban makes enforcement easier by focusing on brick-and-mortar stores and does not place additional financial burden for higher priced alternatives on small vendors. However, because these markets are open air, the likelihood of leakage in this scenario is high.

Figure 14: Plastic bags at street market in Santiago.

Companies built on circular economy concepts are present in Santiago. One business working to create innovative systems of use is Algramo. Originally created with the intent of reducing the poverty tax by making smaller purchasing quantities the same price as larger bulk items, Algramo has a system of both in-store refill stations as well as delivery trucks bringing products door-to-door (Figures 15 and 16). By purchasing the packaging once and then refilling, the company helps eliminate both cost to the consumer and packaging waste. With their current operations in four countries, the company reports that over 750,000 packaging items have been reused in their system to date.[9]

[9] Algramo. https://algramo.com/en/ Accessed October 3, 2022.

Figure 15; Refill station locations (left) and delivery truck coverage areas (right) for Algramo.



*Note: Images from https://algramo.com/en/map/, accessed October 3, 2022.

Figure 16: Algramo refill system in a Lider in Santiago

Table 5: Cost comparison of Algramo refill and identical product in plastic packaging

Product	Alternative	Cost of Alternative (CLP)	Cost of Product in Plastic Packaging (CLP)	Cost Difference for Alternative
Detergent	Refill	$2.663/L	$2.856/L	– 6.65%
Household Cleaner	Refill	$1.527/L	$1.833/L	– 16.7%

The refillable detergents offered by Algramo were 6.7 – 16.7% cheaper than the alternative packaged in single-use plastic (Table 5). In comparable CAP studies in the US, we have found that alternatives consistently cost more than the traditional plastic packaged product. For example, the CIL team calculated that a reusable silicone sandwich bag costs nearly 700 times more than a single-use sandwich bag in stores in Miami. Even with bulk refill options for shampoo and conditioner in the US, which are typically available in specialty eco-friendly stores, were still found to cost 12% - 146% more than the traditional plastic alternatives. Algramo is a notable contrast, both for the fact that refill is cheaper than plastic packaged products and in the availability of the refill systems in popular grocery stores like Lider. Users do have to purchase an original bottle before they can use the refill system.

EcoCarga is another refill company active in the metropolitan region. In addition to some brand partners, EcoCarga also facilitates refill systems for their own brands, which include detergent, fabric softener, multi-purpose cleaners, dish soap, and other cleaners. Their website reports that the company has refilled over 800,000 containers as of 2022.[10]

Another circular economy success story in Santiago is Green Glass (Figure 17). The company takes glass bottles and turns them into glassware, which is widely used in restaurants in Santiago. The company says they have recycled more than a million bottles to date.[11]

[10] EcoCarga Sustainability. https://ecocarga.com/pages/sustentabilidad
[11] Green Glass. https://www.greenglass.cl/. Accessed October 3, 2022.

Figure 17; Green Glass in a restaurant in Santiago

Algramo and Green Glass, among others, showcase an entrepreneurial energy around circular economy solutions in Santiago. Larger corporations have innovated in the reuse and refill space, notably the Universal bottle from Coca Cola that launched in 2018 (Figure 18). The Universal Bottle is a reusable PET bottle that can be used across multiple soda brands, including brands popular in Chile like Coca Cola, Inka Cola, and Fanta. Consumers can return universal bottles to the point-of-sale for refill; the company says these bottles are reused up to 25 times.[12]

Overall, the energy and creativity around new solutions is exciting, making Chile primed for further innovation.

Figure 18: "Universal" returnable Coca Cola and Inka Cola bottles observed in Santiago

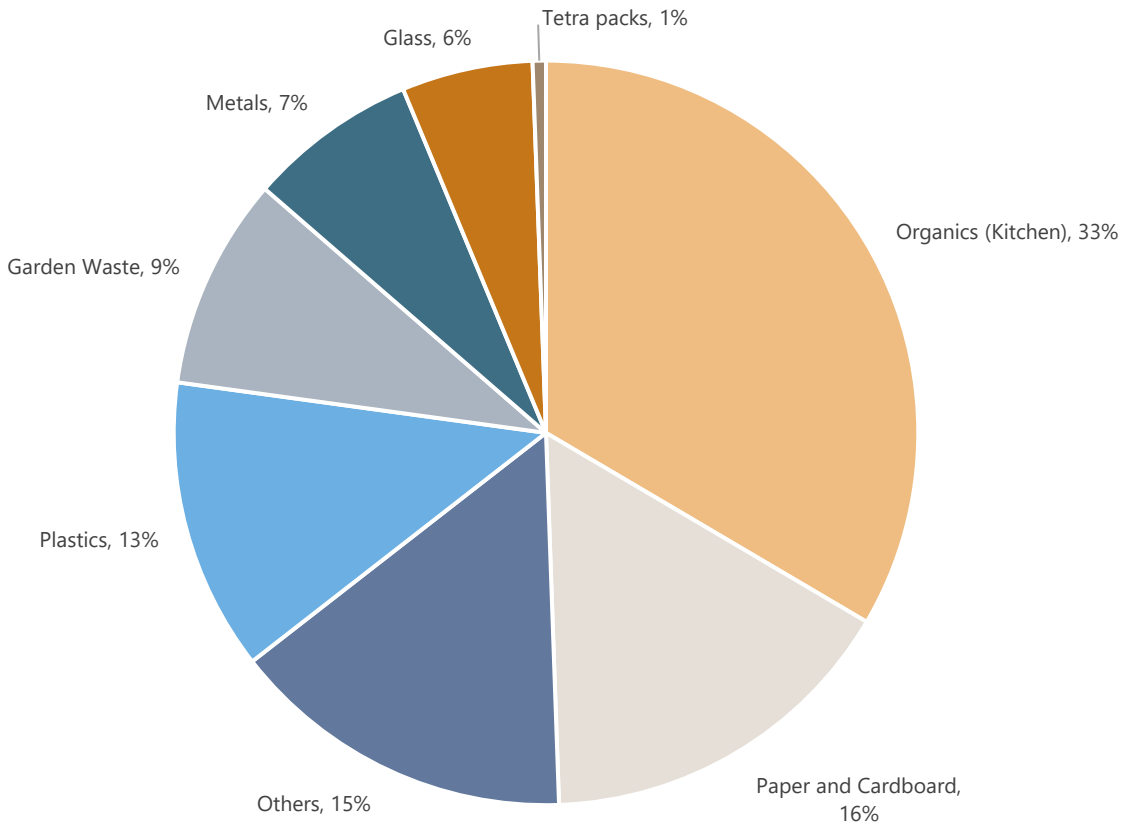
[12] Ellen McArthur Foundation. A reusable drinks bottle design for multiple brands: Universal Bottle. https://ellenmacarthurfoundation.org/circular-examples/a-reusable-drinks-bottle-design-for-multiple-brands-universal-bottle

Collection

The Santiago Metropolitan Region has 52 communes. Each municipality oversees its own waste collection, transportation, and disposal services, and most contract these services out to private companies. Nearly 100% of the population is served through waste management; gaps in collection typically lie outside of the metropolitan region in more remote areas of Chile.

Total waste generation in Santiago was estimated to be nearly 3.9 million metric tons per year in 2017 and projections showed approximately 4.4 million tons generated in 2020 and 5.3 million tons generated in 2030 in a business-as-usual scenario. A large proportion, more than 40%, of municipal solid waste (MSW) is organic, including kitchen and garden waste. The recyclable fraction – paper, cardboard, plastics, metal, glass, and Tetra packs –comprises approximately 43% of the waste stream[10] (Figure 19).

Figure 19: Approximate composition of MSW collected in Santiago.[13]



Most waste collection in Santiago – about 86% - is collected through curbside collection, prior to being taken to a transfer station. The price households pay for collection varies by municipality, and is

[13] Rojas C. A, Yabar H, Mizunoya T, Higano Y. The Potential Benefits of Introducing Informal Recyclers and Organic Waste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. Resources. 2018; 7(1):18. https://doi.org/10.3390/resources7010018

typically charged through a property tax, although many households may be exempt due to low property values. This exemption in turn creates challenges for financing collection for some municipalities. Frequency of collection varies depending on municipality. Average cost is to municipalities $40/ton for collection, transportation, and disposal.[14]

Figure 20: Public trash cans and collection bins in Santiago

Trash cans intended for public use, such as those in parks (see image on left), were generally observed to be well maintained (Figure 20). Receptacles used by households for disposal of trash bags, such as those located in residential areas (see images on right), are generally open grates. Escaped waste was observed below these disposal areas in some locations.

A recent case study for an alternative collection system in Renca in Santiago pointed out challenges with current door-to-door collection systems using truck transportation, including that the number of trucks and routes may not be adequate and not everyone is served consistently. Therefore, trash may be left on the curbside, where it is exposed to environmental factors – like wind or animals – that may lead to leakage into the environment. The study proposed that for La Renca – and potentially for other communes in Santiago – a bin-to-bin collection model might provide a more efficient system and decrease both cost to municipalities and CO2 emissions associated with trash trucks.[15]

Like waste collection systems, recycling practices vary by municipality. Cities are not legally required to recycle. Most Chileans (90%) see recycling as a solution to waste management problems. Fewer, though still a significant fraction (50%), have a positive attitude towards separation of waste. It is estimated that about 14% of waste is recycled; local campaigns and informal sectors play a critical role in these recycling efforts.[11]

[14] Rojas C. A, Yabar H, Mizunoya T, Higano Y. The Potential Benefits of Introducing Informal Recyclers and Organic Waste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. Resources. 2018; 7(1):18. https://doi.org/10.3390/resources7010018

[15] Blazquez, C., & Paredes-Belmar, G. (2020). Network design of a household waste collection system: A case study of the commune of Renca in Santiago, Chile. Waste Management, 116, 179-189. https://doi.org/https://doi.org/10.1016/j.wasman.2020.07.027

Figure 21: Examples of a variety of recycling drop off points observed, including neighborhood Punto Limpios and recycling outside of private businesses like grocery stores.

Progress in recycling efforts thus far is largely due to the creation of drop off centers sparked by the Santiago Recicla plan, which was established in 2019 in response to a national goal to recycle 25% of all inorganic materials by 2020. The plan, which includes 32 of 52 metropolitan regions, has drop off sites to sort and collect recyclables (Figure 21). Drop off sites may include one bell-shaped container for a single type of recyclable , where profits from recyclables are donated to charity (Figure 22) or may be set up as "clean points" or Punto Limpios with various containers for different types of recyclable waste. Drop off sites are managed either by the municipality or recycling companies, or in partnership. The largest clean point collected 0.3% of all recycled waste in Santiago in 2009 at the start of the program, but the Punto Limpio saw a 156% increase in amount collected by 2014.

Private recyclers may have a contract with municipalities to collect from recycling drop off points, or public locations may be maintained by the municipality themselves. Private businesses with recycling locations for their customers also contract collection to private recyclers. Recycler aggregators pay small scale recyclers and collectors – and may even pay municipalities – to bring their recyclables, if they are clean and uncontaminated.

Figure 22: Receptacle for a glass recycling campaign where profits are donated to children in need.

Three municipalities in Santiago have formalized recycling collection systems for recyclables. Vitacura and Nuñoa collect mixed dry recyclables, and La Pintana collects kitchen waste with source-separated recyclables. These formal systems contribute approximately 4.8% of the recycled waste collected in Santiago.

Much of the waste separation in Santiago is done by informal recycling workers who collect, separate, and commercialize materials like cardboard, glass, paper, or metal, as a source of income. Approximately 60,000 informal collectors in Chile collect 2 to 10 tons per month/person, contributing 86% of the waste that is recycled on a national level.[16]

Like waste collection, integration of informal workers into formal systems has varied city by city, though most municipalities are choosing to integrate them. Outside of metro Santiago the challenge of integrating informal workers is more significant.

> **"The idea is to make recyclers certified to be hired directly for recycling centers. Their work is not just collecting, they are also doing a lot to educate the public. Punto Limpios can be a public space for private sorting."**
>
> – Government official

> **"People live within the landfill as informal recyclers… these recyclers are the responsibility of the municipality. It's very dangerous work because of the bulldozers [and other equipment used to dump and compact waste], but it's complex because of the social issues. We need to know how to live with them."**
>
> – Private Waste Company (outside of Santiago)

> **"Since the origin of the project [landfill], we have never wanted to allow a sub-social standard of living. There shouldn't be people living off of trash in this way."**
>
> – Government official

However, even within the metropolitan region, there still remain unanswered questions about how integration of the informal sector will occur as the EPR law moves towards implementation.

> **"There are many [informal waste collectors], they collect the most valuable materials like white paper and dispose of the less valuable material… The [EPR] law incorporates the informal sector. The law says a certain percentage of waste must be managed by informal recyclers. There is a concern that informal recyclers may be an area of conflict. They [already] have different areas of each neighborhood, and they don't necessarily want to change their way of life."**
>
> – Government official

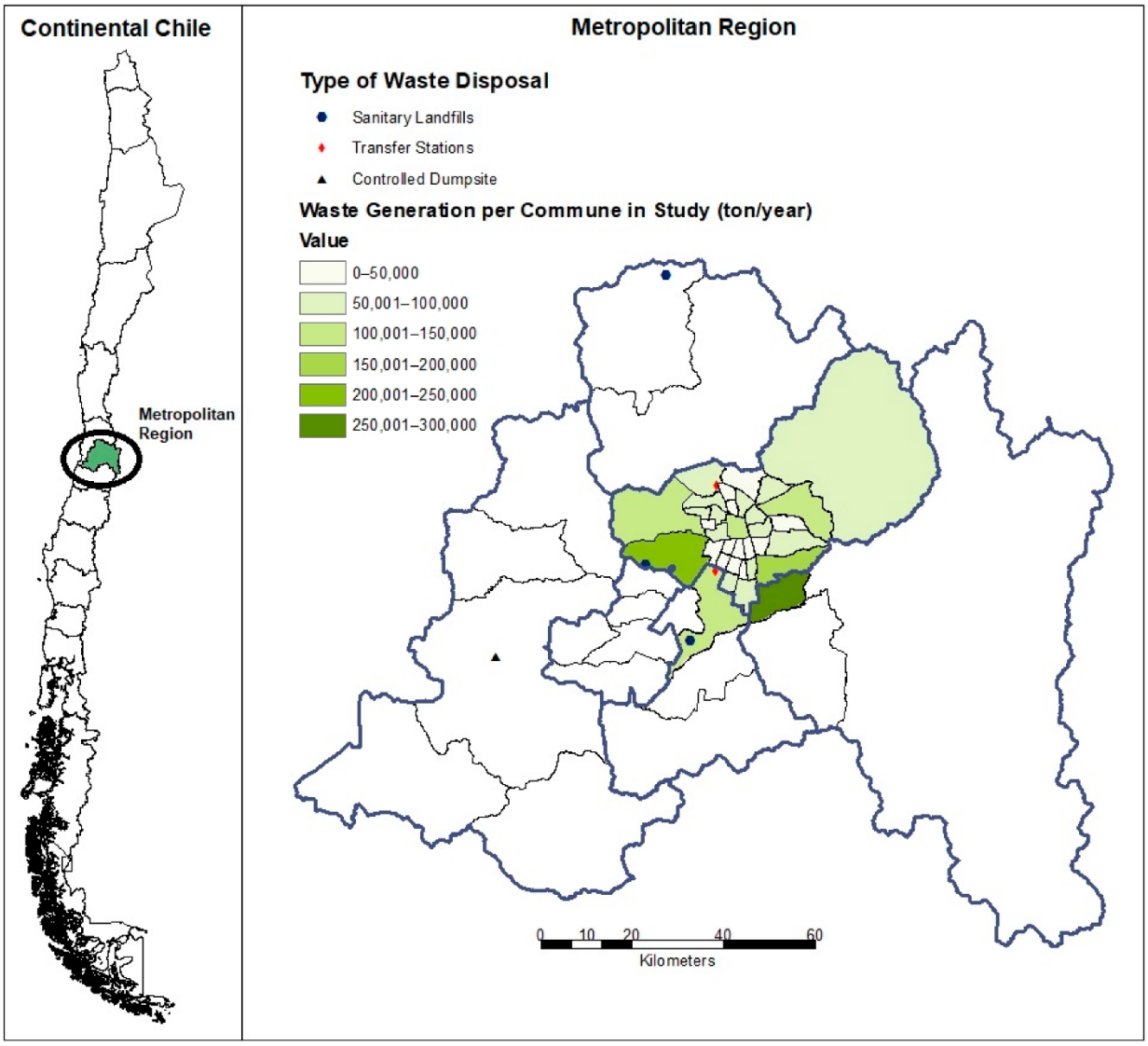
As municipalities begin working with PROs under the new EPR system, negotiations will be critical to ensure resources are adequately leveraged to improve collection systems. This will be especially important in municipalities challenged with funding collection due to a large proportion of tax-exempt households.

[16] Rojas C. A, Yabar H, Mizunoya T, Higano Y. The Potential Benefits of Introducing Informal Recyclers and Organic Waste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. Resources. 2018; 7(1):18. https://doi.org/10.3390/resources7010018

End of Cycle

MSW collected in Santiago is first taken to one of two transfer stations to streamline transport to landfill sites. Transfer sites are also an opportunity to remove hazardous waste materials and recyclables. From the transfer stations, waste is taken to three sanitary landfill sites (Figure 23), which are estimated to have a lifetime approximately 20 more years.[14]

Figure 23: Waste generation rates and locations of sanitary landfills and transfer stations.[17]



The CIL team visited one of the sanitary landfills outside of Santiago (24). The landfill has slope stabilization, waste compaction and cover, and leachate and landfill gas management, and would be characterized as "Full Control" of waste by the United Nations Waste Wise Cities Tool. The Consorcio

[17] Rojas C. A, Yabar H, Mizunoya T, Higano Y. The Potential Benefits of Introducing Informal Recyclers and Organic Waste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. Resources. 2018; 7(1):18. https://doi.org/10.3390/resources7010018

Santa Marta landfill receives about 31% of waste from the broader Santiago Metropolitan Area, which includes MSW from 15 municipal clients. The landfill accepts MSW and hospital waste, as well as other types of waste, for a total of about 110,000 tons/year. 90,000 tons are household waste. 90% of waste goes to a transfer station and then is transported by a larger truck to the landfill (this truck has the capacity of three smaller garbage collection vehicles). The landfill is estimated to have 5 – 6 years of capacity remaining.

Figure 24: Consorcio Santa Maria Landfill near Santiago

Recyclables collected are typically aggregated, cleaned, and laabled prior to sale for further processing (Figure 25). These businesses are often privately owned, and adapt to fluctuating markets, so final end points of recyclable materials are difficult to identify, although the CIL team did survey recyclers in community interviews on where various types of plastics were being sold. Information was sourced from recyclers knowledge, as well as online information about products produced with the recyclable material inputs (Table 6). The majority of sales to recyclers seemed to be occurring in Santiago. According to recyclers interviewed, PET typically has the highest resale value for plastics,

Table 6: Examples of sale of recyclable materials to companies and their final products.

Material	Sold To	Final Product
PET	ReciPET	Clamshells
	-	Trays for fruit, food
Clear flexible PET	Cambiaso	Superior Bolsas de Aseo
HDPE	Wenco	-
PP	Wenco	-
EPS	Idea-Tec	Paint
LDPE	-	Trash bags
Tetra Pak	-	Construction Materials
	Recupac	-
HDPE, LDPE, PP 'Eco-Bottles'	Revalora	Eco wood (plastic wood) & Outdoor furniture (benches)

Figure 25: Baled material ready for sale at a recycler.

The CIL team did observe some instances of Tetra Pak recycling (Figure 26), which is notable due to the wide usage in beverage products in Chilean grocery stores (See Product Design). Typically, aseptic coated paperboard packaging can be challenging to recycle due to the multi-material structure of the product.

Figure 26; Aggregated Tetra Pak in a recycling facility.

While household waste is almost universally ending up in landfills or recycling facilities, illegal dumping is still a problem in Santiago, especially for construction and demolition debris.

> **"Many cities don't have a system to deal with C&D waste, and if they do, people have to pay for it... If it's cheap, it takes a long time for them to pick it up."**
>
> – Government Official

> **"When people remodel homes for example, some may hire an individual with a truck to pick up the trash... That guy may dump it in the river or train tracks."**
>
> – Government Official

> **"People probably don't realize they are paying someone to throw the trash nearby."**
>
> – Government Official

> **"Most illegal dumping is coming from private construction companies... traceability is a challenge, to identify where it is generated and how to enforce that."**
>
> – Government Official

> **"In lower income areas, this [illegal dumping] generates more crime and a worse quality of life."**
>
> – Government Official

The CIL team visited the facilities of Revaloriza, which recently opened in March of 2022 (Figure 27). Revaloriza is the first plant to receive mixed C&D waste in South America (plants for recycling concrete specifically have existed previously). Construction companies can bring waste to Revaloriza mixed or sorted, although cost is higher for mixed waste. Contaminated plastics is a significant challenge, and some are too dirty to recycle. Sometimes plastics are sent as an alternative fuel to a cement kiln. When possible after sorting, PVC pipes and PET bottles (often present in the waste due to consumption on the jobsite) are taken to a nearby Punto Verde. EPS, when it is clean enough for recycling, is sent to Idea-Tec, a company that uses EPS in paint products. Asphalt is ground up for reincorporation, and tires are chipped up for incorporation into gym floors.

Figure 27; Alternative recycling projects for debris not typically accepted like C&D

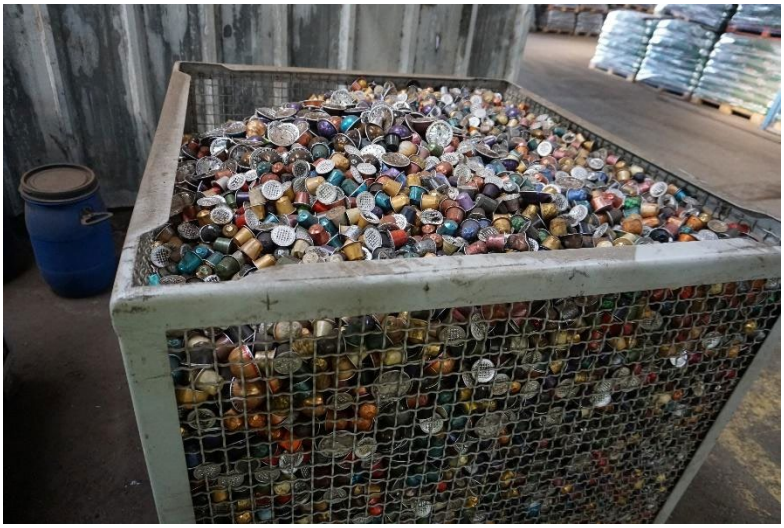
Over 40% of MSW in Santiago is organic, but of the organic waste produced only 10% is composted or vermicultured. [18] This presents an opportunity to increase the amount of organic waste that is collected for compost and therefore decrease the amount of waste that is taken to landfills.

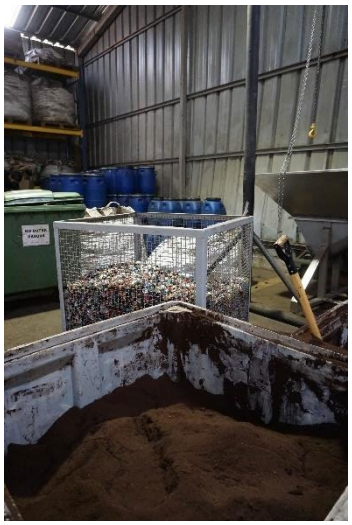
The CIL team visited Armony Sustentable, a composting plant in Santiago (Figure 28). Currently, the facility is primarily accepting waste from commercial streams where they can ensure consistent and uniform inputs. For example, the facility composts coffee grounds from Nespresso pods after extracting the aluminum to send to a recycler (Figure 29). The company has a unique composting formula for each corporate client. The consistency of input allows for a high-quality product; home waste is not as reliable to produce compost for agriculture.

[18] Rojas C. A, Yabar H, Mizunoya T, Higano Y. The Potential Benefits of Introducing Informal Recyclers and Organic Waste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. Resources. 2018; 7(1):18. https://doi.org/10.3390/resources7010018

Figure 28: Industrial composting plant in Santiago.

Figure 29: Composting coffee grounds from pods.



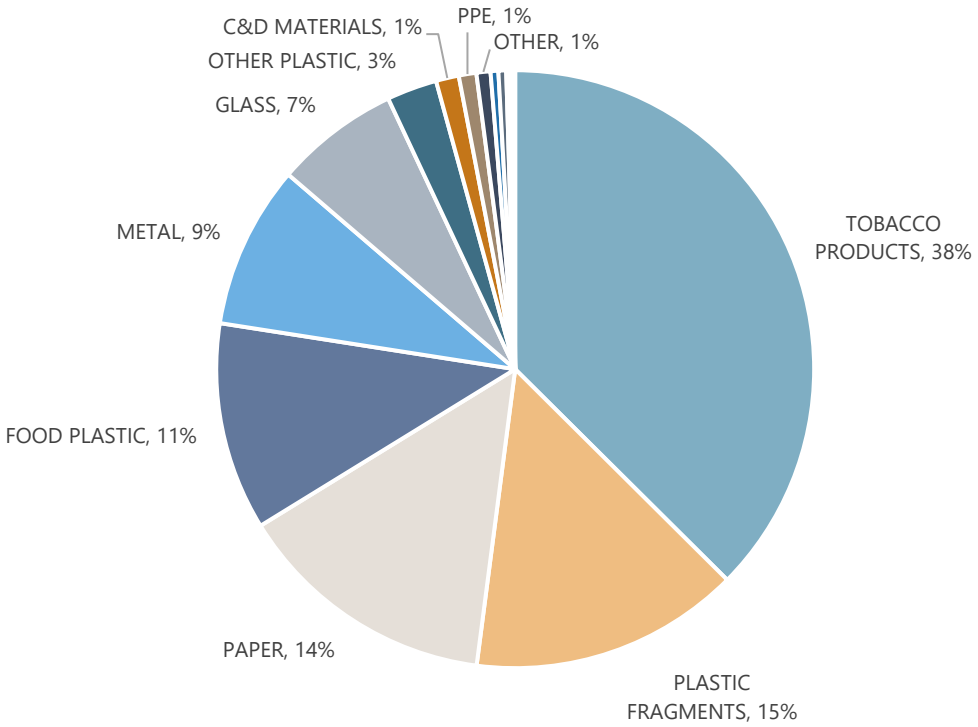


Among obstacles of capacity and financing to expand, polylactic acid (PLA) has recently emerged as a contaminant in feedstocks. PLA is biodegradable in industrial composting conditions; however, the facility reported that some traditional plastics are being labeled as PLA, and there is also confusion around which plastics are compostable. With the legislative push towards biobased and compostable plastics in to-go food ware, clearer label and standards for compostable products are critical to ensure appropriate disposal.

Leakage

In total, 10,011 items were logged in thirty transects (each 100m^2) characterizing ten different square kilometer areas. Transect locations were selected using a stratified random sampling method, in which transects were randomly selected in ten square kilometers which were distributed across three groups of population count (upper, middle, lower) based on LandScan ambient population data. Litter items were recorded using the open-source Marine Debris Tracker app. A full list of items available in the app and their associated material categories as well as a map of sample sites and their surveyed litter densities can be found in the Appendix.

Figure 30: Litter Material Breakdown for Santiago

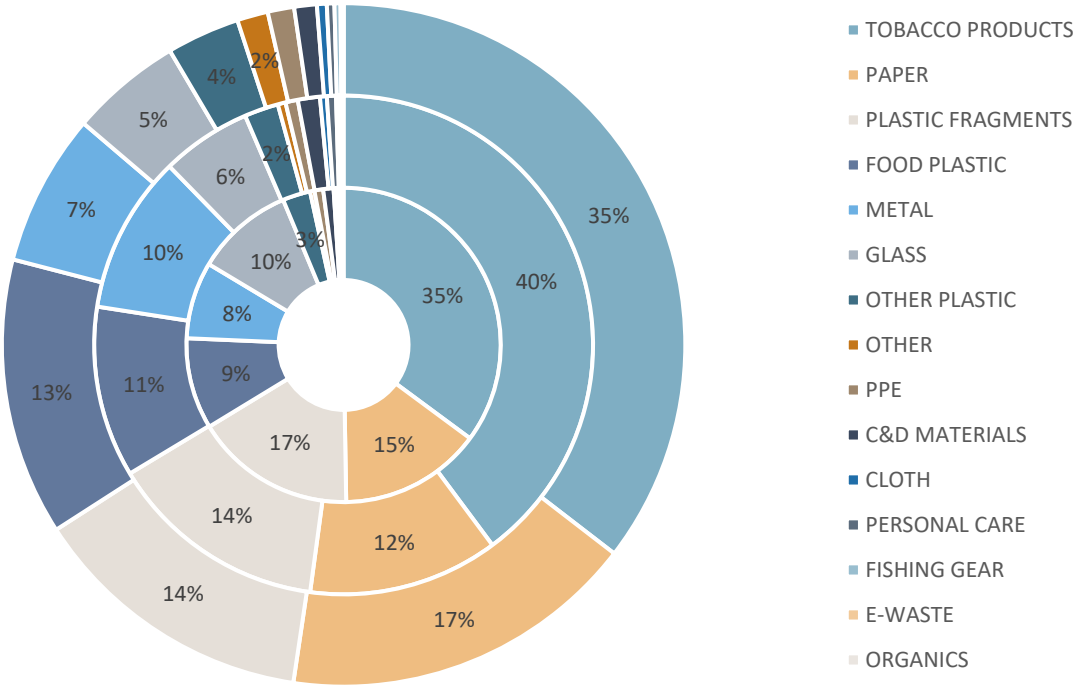


Across all transects, the largest percentage of litter by category was tobacco products, followed by plastic fragments (Figure 30). Tobacco products included cigarette butts as well as cigarette packaging. Plastic fragments included hard plastic, film plastic, foam plastic, and other plastic fragments. Together these two categories constituted over half of the litter items documented in the city. Other categories such as paper, food plastic, metal, and glass comprised between 7% and 14% of litter documented, respectively, while the remaining categories — including other plastic, PPE, C&D materials, PPE, personal care products, cloth, other, e-waste, organics, and fishing gear — each represented less than 5% of the litter items respectively. The total percentage of common plastic items (the sum of food plastic, other plastic, PPE, plastic fragments, and personal care items) was 30% of the total litter items documented (Figures 31 and 32).

Figure 31: Food plastic litter in Santiago

Figure 32: Film and foam plastic fragments in Santiago

Figure 33: Proportion of most common plastic items in low (inner), mid (middle), and high (outer) population count areas in Santiago



Interestingly in Santiago, the material breakdown of litter items is fairly consistent across high, mid, and low population count areas (Figure 33).

Litter densities were highest in the middle population tertile, while they were similar in high and low population sites (Table 7). On average, the litter density in Santiago was 3.34 items/m^2. The overall average litter density in San Antonio was 2.89 items/m2; for comparison, three cities sampled along the Mississippi River in the United States had average litter densities of 0.61 items/m2, 0.69 items/m2, and 0.28 items/m2 respectively. The litter densities in Santiago were more similar, although still somewhat elevated, to results from CAPs conducted in other large metropolitan and coastal cities globally. In a recent CAP conducted in Miami, the litter densities were found to be 2.46 items/m2 in high population count areas, 1.48 items/m2 in middle population count areas, and 3.79 items/m2 in lower population count areas as of 2021. Panama City, Panama, had litter densities of 1.87 items/m2 in high population count areas, 1.43 items/m2 in middle population count areas, and 3.04 items/m2 in lower population count areas as of 2021 (Urban Ocean). The densities are comparable to those found in Hanoi, Vietnam which ranged from 1.5 — 4.4 items/m2 across the three population tertiles there.

Table 7: Litter Density and Top Litter Items for Each Area of Population Count

Population Tertile	Top 5 Litter Items	Litter Density (count/m2)
Upper (10,385 – 20,862 persons/km^2)	1) Cigarettes, 2) Paper, 3) Hard Plastic Fragments, 4) Plastic Food Wrapper, 5) Metal Bottle Caps or Tabs	2.04
Middle (7,152 – 10,385 persons/km^2)	1) Cigarettes, 2) Paper, 3) Metal Bottle Caps or Tabs, 4) Plastic Food Wrapper, 5) Film Fragments	5.28
Lower (286 – 7,152 persons/km^2)	1) Cigarettes, 2) Paper, 3) Glass or Ceramic Fragments, 4) Hard Plastic Fragments, 5) Metal Bottle Caps or Tabs	2.34

The high proportion of cigarette butts as litter across all population tertiles is notable. Cigarette filters, in addition to leaching contaminants into water systems, are composed of cellulose acetate, a type of plastic, which may not be high in the public awareness. Previous studies have found that successful anti-cigarette litter campaigns should emphasize that these butts are toxic waste and are harmful when disposed of improperly.[19]

Street sweeping occurs seasonally in Santiago; vacuum trucks clean sidewalks to prevent dust from May to August, and inherently this practice will also capture some litter. Therefore, not all litter surveyed in this study may be entering the environment. However, these last-chance capture methods are not as effective as prevention and leakage is still occurring. In addition to more formal street sweeping practices, an interviewee informed that it is common to sweep outside one's home, which may lead to lower litter in residential areas.

> **"People sweep right in front of their own house, and it's a habit in certain places. It's common sense because people want to live in a clean environment."**
>
> – Government official

The CIL team observed occasional accumulation sites of litter, both single-use plastics on busy street areas, as well as bulkier waste observed near La Vega market (Figure 34). Additionally, several "informal" trash cans were observed, where a bucket, container, or other box was left out and became an accumulation site for waste. Areas with higher litter densities or regular accumulations might represent opportunities for targeted additional waste infrastructure or last-chance capture.

[19] Rath JM, Rubenstein RA, Curry LE, Shank SE, Cartwright JC. Cigarette litter: smokers' attitudes and behaviors. Int J Environ Res Public Health. 2012 Jun;9(6):2189-203. doi: 10.3390/ijerph9062189. Epub 2012 Jun 13. PMID: 22829798; PMCID: PMC3397372.

Figure 34: Waste accumulation noted in Santiago.

In November and December of 2021, a third national sampling of river litter in Chile was conducted. Similar to our leakage results, single use plastic was the most collected waste in rivers (32.2%). Average density of waste in the river was 1.6 items/m^2, lower than the average litter density the CIL team surveyed along city streets in Santiago. This may demonstrate that litter is more diffuse once it enters environmental reservoirs, and that capturing it nearer the source (for example, in the city) may provide more efficient outcomes.

Consistent with the discussion of illegal dumping presented in End of Cycle, 78% of collection sites in the study reported finding large accumulations of trash that had been left purposely.

Since the last survey of rivers in 2017, the study found a decrease in plastic bags due to Chile's bag ban being enacted[20]. In leakage data collected by the CIL team, only 45 plastic grocery bags were identified out of the over 10,000 litter items characterized in Santiago. representing less than 0.05% of the litter. This example highlights how effective policy can be in targeting problematic plastics and preventing environmental contamination.

[20] Ergas, Mauricio and Martin Thiel III Muestreo Nacional de Basura en los ríos de Chile. February 2022.

Opportunities

CIL found the following opportunities to expand and enhance circularity in Santiago based on the findings of this report. These opportunities are categorized based on the seven spokes of the CAP model. Stakeholder engagement with the partners of this project should take place to further expand, refine and prioritize these opportunities based on local context, impact, feasibility, and cost. It is important to note that the opportunities listed below are individualized based on the findings, but solutions cannot happen in a vacuum and are most impactful when strategically combined within a holistic system framework.

Input

- The relatively close proximity of manufacturing location for many common convenience items could present opportunities for engaging manufacturers in end-of-life packaging discussions, innovative product design, and alternative product delivery systems.
- Many parent companies were headquartered in Chile, potentially facilitating easier engagement and integration into Chile's EPR scheme.
- A few large parent companies – including PepsiCo, the Coca Cola Company, Mondelez, Arcor, and Nestle – represent a significant fraction of foreign parent companies selling common convenience products in Chile. Due to the high fraction of products coming from these companies, successful changes – for example, the expansion of uniform packaging – could produce scaled impact.

Community

- Current policy interventions have helped raise awareness on the issue of plastic pollution, which can be leveraged to create further change.
- Reuse practices have previously been successful in Chile, and this is a model that could continue to be expanded.
- Recyclers need fiscal, legal, and logistical support to increase their operations.
- Recycling education is an on-ongoing effort that can continue to reach more communities, although there is a need for clarity around roles and responsibilities between government and private business which may present additional opportunities for collaboration.
- Standardizing PLA labeling could lay the groundwork for successful composting programs, though composting collection and capacity would need to increase.

Product Design

- Many food wrappers are made of polypropylene, and existing clear labeling of these products could support an increase in PP recycling.
- The high proportion of multilayer film packaging could be targeted for redesign for recyclability in line with Chile's circular economy goals.
- The high fraction of paper-based products found in restaurant to-go items might suggest a higher willingness to switch to alternatives.

Use

- The successful transition to reusable bags in grocery stores could be expanded to other contexts both in terms of product and location. Street markets bags and produce bags used in large retail grocery stores might hold opportunities for adjacent expansion.
- Reuse and refill systems already have traction in beverage and household categories. Reuse systems could be implemented to reduce waste generation in other sectors.
- Refill systems can provide products to customers at a cheaper cost than traditional single-use plastics.

Collection

- Curbside collection is available only in limited cases and drop off centers may not be accessible equally to all residents, especially those that lack transportation.
- Access to recycling and recycling practices vary depending on drop off location, adding additional challenges to recycling education.
- Case studies have shown that integrating informal recycling workers into more formalized recycling systems can be successful.
- Private recycling collectors face financial and technical challenges to growth.
- Municipalities may be able leverage negotiations with PROs in the implementation of the new EPR system to improve collection capacity and offset their costs.

End of Cycle

- Most MSW waste is taken to a transfer station prior to a landfill, providing an opportunity to extract hazardous waste and potentially recyclables.
- A wide variety of companies recycling and upcycling plastics exists in Chile, providing local markets to sell recyclables collected.
- New models to recycle C&D waste could help target the prevalence of illegal dumping, with appropriate incentives or requirements.
- Industrial composting exists locally for corporate clients willing to pay for services; these local resources could support expanding municipal composting capacity. Clearer labeling and standards of compostable products could support these efforts.

Leakage

- Tobacco products (38%) and common plastic items (30%) comprised a majority of the litter, highlighting opportunities for targeted reduction. Increased community awareness of the composition and detrimental effects of improper disposal of cigarette butts could help reduce littering.
- Litter densities were higher in Santiago (average 3.34 items/m^2) than in environmental reservoirs, in a survey of Chilean rivers (average 1.6 items/m^2), implying an opportunity for more efficient last-chance capture by targeting litter closer to the source in the cities.
- The lack of plastic bags found in the litter highlights the effectiveness of policy in targeting problematic plastics like bags, which could (and is) being expanded to other unnecessary, avoidable, and problematic plastic products.

Glossary

C&D: construction and demolition

CAP: Circularity Assessment Protocol

CIL: Circularity Informatics Lab

EPR: Extended Producer Responsibility

EPS: Expanded polystyrene

FMCG: Fast moving consumer goods

GDP: Gross Domestic Product

HDPE: high density polyethylene

MSW: municipal solid waste

OC: Ocean Conservancy

PET: polyethylene terephthalate

PP: polypropylene

PRO: Producer Responsibility Organization

SUP: single-use plastic

UGA: University of Georgia

Appendix

Table A1: Full List of Debris Tracker Litter Items and Associated Material Categories

Material	Items
C&D Materials	Aggregate & Brick Bolts, Nails, and Screws Building Materials Lumber Other C&D
Cloth	Clothing Fabric Pieces Other Cloth
E-Waste	Batteries E-Waste Fragments Other E-Waste
Fishing Gear	Buoys and Floats Fishing Line Other Fishing Gear Plastic Net or Net Pieces Plastic Rope
Glass	Glass Bottle Glass or Ceramic Fragments Other Glass
Metal	Aluminum Foil Aluminum or Tin Cans Metal Bottle Caps or Tabs Metal Fragments Other Metal
Organic Waste	Food Waste Other Organic Waste
Other	Other Popsicle Stick
Other Plastic Products	Bulk Bags Flip Flops Other Plastic Plastic String, Tape, or Packing Straps Rubber Bands Tires

Paper	Coated Paperboard Corrugated Cardboard Multi-material Paper Box Noncoated Paper Food Wrapper Other Paper Paper Receipts
Personal Care Products	Blister Pack Cotton Buds Other Personal Care Product Personal Care Product Sachet Shampoo or Other HDPE Container Toothbrushes Toothpaste or Other Product Tube
Plastic Food Products	Foam or Plastic Cups or Lids Other Food-Related Plastic Other Plastic Bag Plastic Bottle Plastic Bottle Cap Plastic Food Wrapper Plastic Grocery Bag Plastic Utensils Straws Street Food Bowl Styrofoam Container
Plastic Fragments	Film Fragments Foam Fragments Hard Plastic Fragments Other Fragments
PPE	Associated PPE packaging Disinfectant Wipes Disposable Gloves Face mask packaging Face Masks Face Shield Hair nets Hospital shoe covers Other PPE
Tobacco Products	Cigarette Packaging Cigarettes Other Tobacco Product Tobacco Sachets

Figure A1: Litter densities in transects and sites surveyed in Santiago.

An interactive web map version of this map is available at: https://usg.maps.arcgis.com/apps/mapviewer/index.html?webmap=92d84e3251fa40f2a5a04c041ec718a7.