# Circularity Assessment Protocol

# San Antonio

University of Georgia

Circularity Informatics Lab

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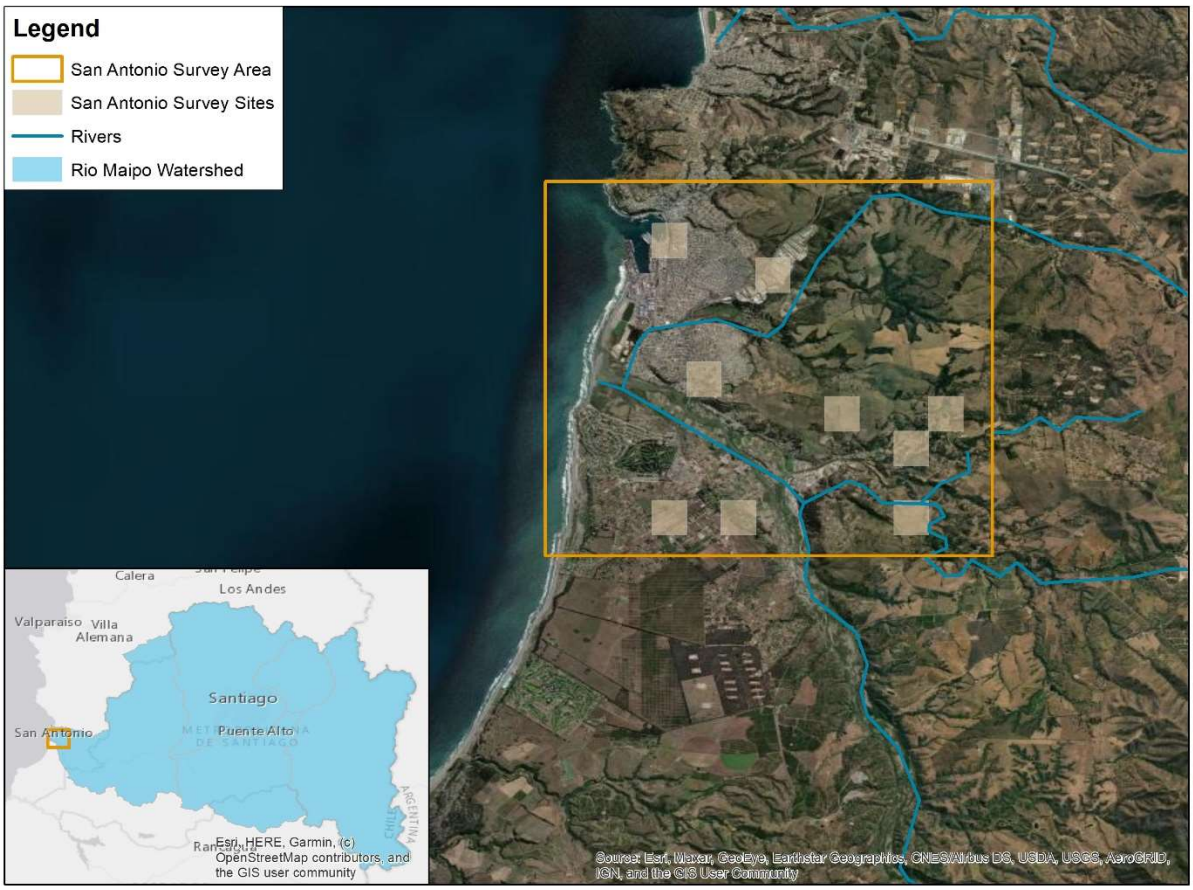
New Materials Institute
UNIVERSITY OF GEORGIA

## *Introduction*

The coastal region of Valparaiso, Chile, has a population of more than 1.7 million people. The port city of San Antonio lies at the headwaters of the Maipo River. The Maipo River, flowing through the Santiago region and into Valparaiso, is a key source of drinking water and water for agricultural uses in the region. While smaller in population at around 80,000 residents, San Antonio's primary industries of fishing, shipping, and coastal tourism, in addition to the wildlife habitats in the river mouth, make it particularly vulnerable to the effects of plastic pollution in both freshwater and marine environments (Figure 1). Plastic debris in the Valparaíso Region increases health hazards for humans and wildlife, requires substantial financial investments for cleanups, threatens growing industry.[1]

**Figure 1: Overview of survey area in San Antonio**




Over recent decades, Chile has seen rapid economic growth, resulting in the highest Gross Domestic Product (GDP) per capita among South American countries[2]. 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 sector. Industry employees

[1] Nelson Rangel-Buitrago, Manuel Contreras-López, Carolina Martínez, Allan Williams, "Can coastal scenery be managed? The Valparaíso region, Chile as a case study," Ocean & Coastal Management, Volume 163, 2018, Pages 383-400, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2018.07.016.

[2] World Bank. World Bank Open Data Development Indicators. https://data.worldbank.org/ Accessed on October 1, 2022.

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 single-use plastics, as well as becoming the first Latin American country to join the Plastics Pact Global Network.

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.[5]

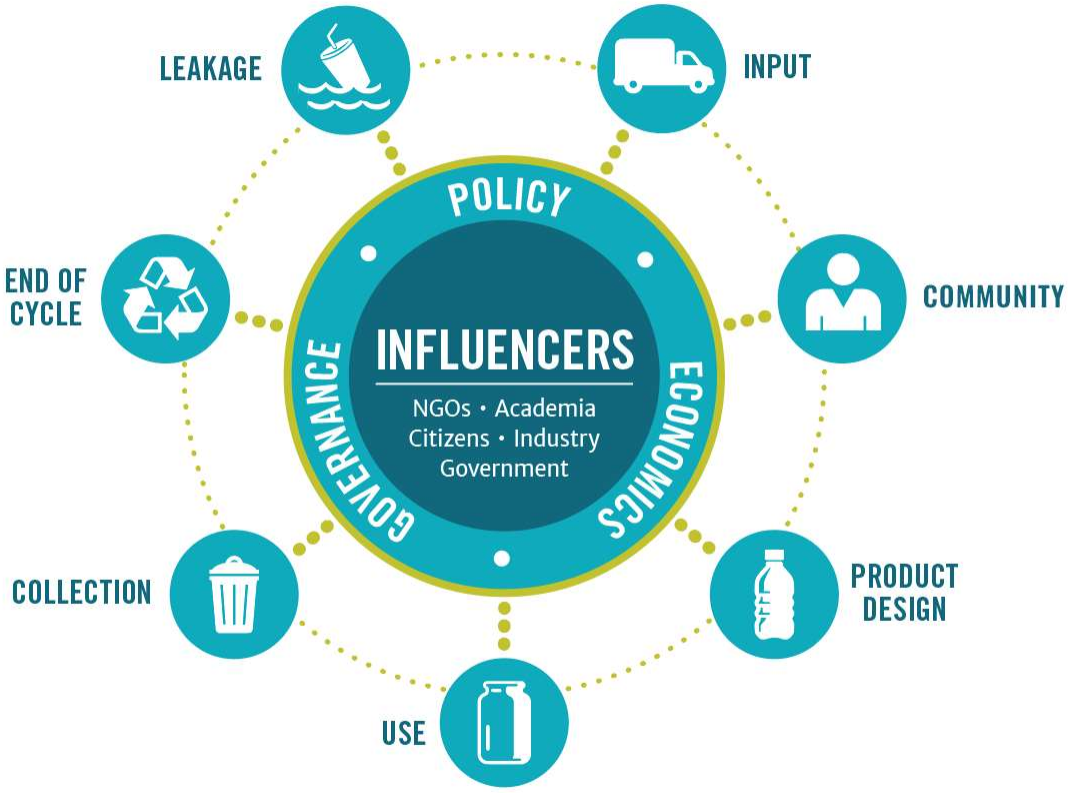
Also notably, the Chilean government recently approved Law 20920. The law establishes a framework for Extended Producer Responsibility (EPR) with the objective to "reduce the generation of waste and encourage its reuse, recycling and other types of recovery.[6]" Implementation of the law is in progress, making this an especially interesting time to study circularity in Chile.

The Circularity Informatics Lab (CIL) at the University of Georgia 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] Fundacion Cbile.New Plastics Economy: Chilean Plastics Pact. https://fch.cl/en/initiative/new-plastics-economy/
[6] 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 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 San Antonio.

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 below.

## Key Findings and Opportunities

**INPUT**

**Findings:** The majority of convenience items are manufactured in Chile. Most parent companies were international, with 25% of brands headquartered in the U.S, 12% in Argentina, and 15% in Switzerland, whereas 34% of parent companies were headquartered in Chile.

**Opportunities:**

- The relative 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 and recyclable packaging – could produce scaled 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 is acknowledged as the highest tier of waste prevention, and reuse programs have been successful in other parts of Chile. This is a model that could continue to be expanded in San Antonio.
- 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.

**PRODUCT DESIGN**

**Findings:** The majority (28%) of wrappers were made of labeled polypropylene (PP), followed by multilayer film (22%). Hard plastic (35%) and coated paper (27%) were the most common material types in restaurant to-go items.

**Opportunities:**

- Many food wrappers are made of 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 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 EcoCarga exist regionally 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, produce bags used in large retail grocery stores, and food delivery bags might hold opportunities for adjacent expansion.
- Reuse and refill systems already have traction in beverage and household categories in Valparaiso region and could be expanded geographically to San Antonio.
- Refill systems can provide products to customers at a cheaper cost than traditional single-use plastics, incentivizing engagement.

**COLLECTION**

**Findings:** Most household waste is collected door-to-door, and access to recycling is primarily provided through drop-off centers. Different drop off points accept different material types.

**Opportunities:**

- While recycling drop off centers are spread throughout the community, these centers may not be accessible equally to all residents, especially those that lack transportation. Because the local government in San Antonio controls these drop off centers, they may be able to specifically target disadvantaged neighborhoods to ensure more equitable access.
- New technology like bin sensors may increase efficiency of collection.
- Recycling practices and accepted materials vary depending on drop off location, adding additional challenges to recycling education.
- Pilot programs for integrating informal recycling workers into collection of recyclables could be expanded. Integrating informal recyclers is already a target in the local SWM plan.
- 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**

**Findings:** Household waste is typically taken to a transfer station and then to El Molle landfill. Systems for end of disposal of construction and demolition (C&D) debris is a significant gap that drives informal dumping, although illegal dumping of household waste is also occurring.

**Opportunities:**

- Most MSW waste is taken to a transfer station prior to a landfill, providing an opportunity to extract hazardous waste and potentially recyclables.
- Integrating the informal sector further upstream before last-chance capture at the landfill could help alleviate health and safety concerns at disposal sites.
- 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.
- Targeting small informal dumpsites off household waste could reduce leakage directly to the ocean. Existing collecting systems for household waste can be leveraged in combination with education.
- The composting program in San Antonio captures some organic waste and reduces the amount going to landfill. Expansion of this program to ensure appropriate composting conditions for compostable plastics like PLA may enable growth of compostable plastics in consumer product categories.

**Findings:** Tobacco products (36%), food plastic (22%), plastic fragments (13%), and paper (13%) were the main categories of litter found in surveys. Litter densities were 4.28 items/$m^2$ in the upper population areas, 3.24 items/$m^2$ in the middle population areas, and 1.14 items/$m^2$ in the lower population areas. Composition of litter was similar in a coastal transect and urban data collection, although some fishing gear was observed on the beach.

**LEAKAGE**

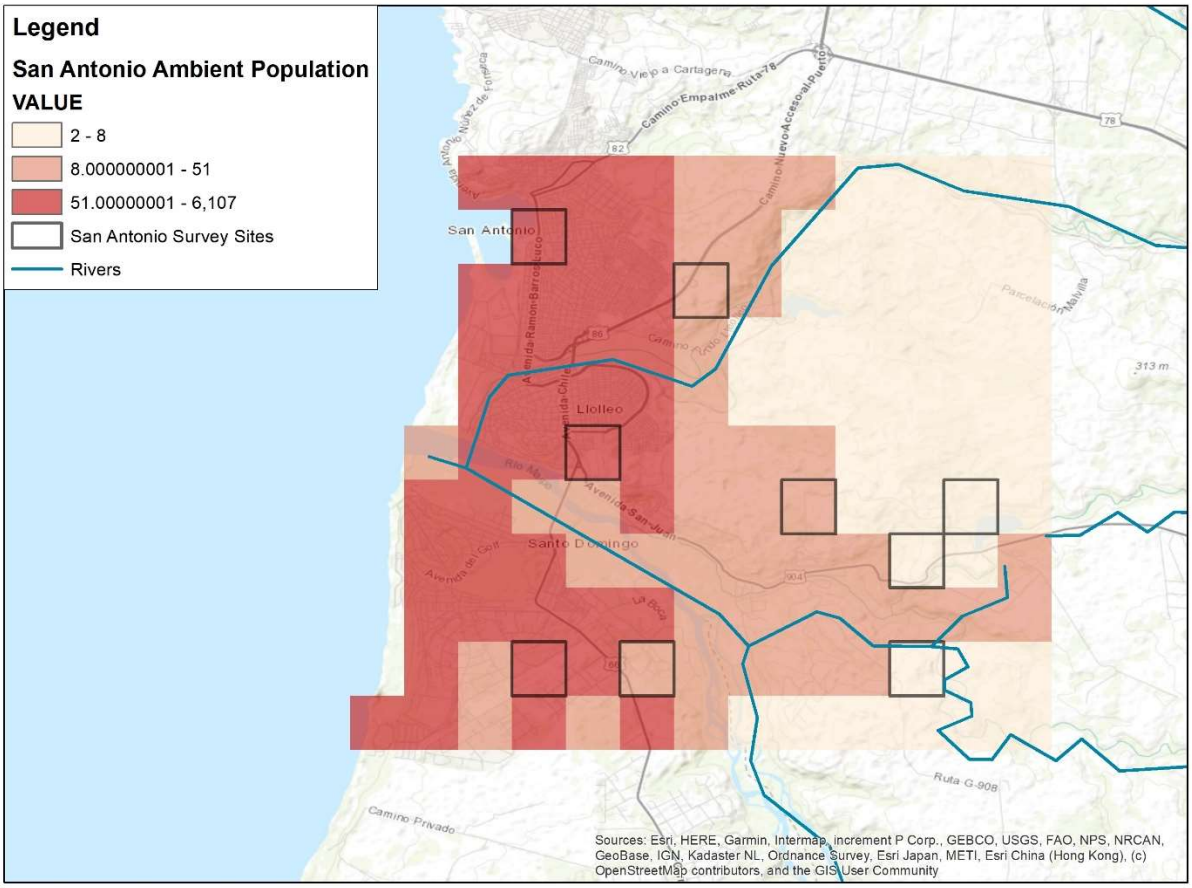
**Opportunities:**

- Tobacco products (36%) and common plastic items (40%) 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 San Antonio (average 2.89items/$m^2$) 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 commonalities between litter found in coastal ecosystems and in the urban areas of San Antonio suggests that reducing waste upstream may have a direct effect on plastic entering the ocean.
- 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 plastics.
- Storm drains present opportunities for last chance capture before leakage into the ocean.
- Successful projects in Chile have demonstrated the ability to reduce derelict fishing gear by paying fishermen for used nets.

## *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 San Antonio.**




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 total, 9 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 nine 1km2 transects in San Antonio, three each in the low, mid, and high 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, 63 unique brands of convenience products were collected and sampled, including 24 candies, 10 chips, 18 drinks, and 11 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 San Antonio**


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 ascertained 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).

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**: Benedictino, 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 San Antonio and manufacturer and parent company locations for common convenience items**

| | Distance Store to Parent Company (km) | | | Distance Store to Manufacturer (km) | | |
|---|---|---|---|---|---|---|
| | *Minimum* | *Maximum* | *Average* | *Minimum* | *Maximum* | *Average* |
| Beverages | 88 | 12,704 | 6,154 | 86 | 838 | 130 |
| Candy | 85 | 12,704 | 3,876 | 86 | 5,985 | 1,194 |
| Chips | 88 | 11,080 | 7,627 | 43 | 9,529 | 1,028 |
| Cookies | 85 | 12,704 | 7,098 | 66 | 9,529 | 943 |
| Tobacco Products | 10,731 | 12,937 | 12,386 | 10,665 | 10,731 | 10,682 |

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

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 beverages, cookies, chips. For candy, it is over three times as far. The relative proximity of manufacturing (typically less than 1,000 km) means decision-making about packaging design may be less geographically separated from the waste management consequences of those design decisions. 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.

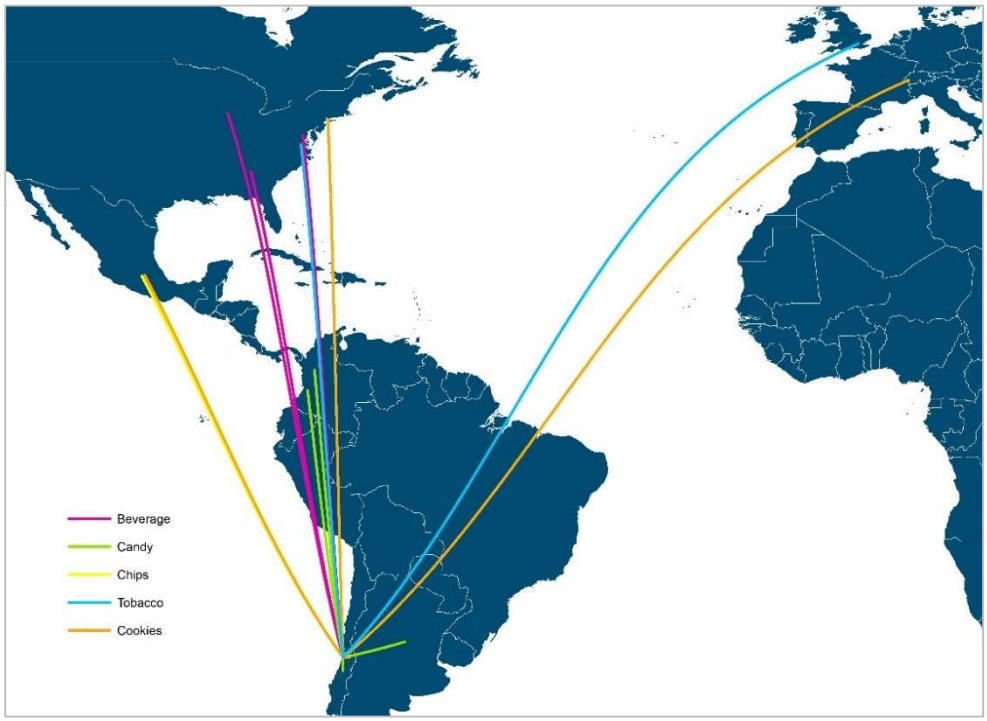
The products in San Antonio were more 'local' than those surveyed in Santiago CAP. Across all products sampled in San Antonio, 84% were manufactured in Chile, which was the most represented manufacturing location, followed by the United States (6%), Colombia (5%), and Argentina (3%). On average, manufacturers for common beverage, candy, chip, and cookie products were located within about 1,000km of Santiago. Tobacco products had the highest maximum and average distances to manufacturing locations (Figure 5).

Like the pattern for manufacturer locations, the largest fraction (34%) of top convenience item brands were owned by a parent company headquartered in Chile (Figure 6). In aggregate, the majority of parent companies (66%) were headquartered internationally. This included 25% of brands headquartered in the U.S, 15% in Switzerland, and 12% in Argentina, 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.

**Figure 5: Map displaying manufacturing locations for common convenience items in San Antonio**


**Figure 6: Map displaying parent company locations for common convenience items in San Antonio**



In the As You Sow corporate plastic pollution scorecard, companies were ranked on their sustainability efforts across six pillars of responsibility: packaging design, reusable packaging, recycled content, public data transparency, supporting recycling, and extended producer responsibility. Rankings for large parent companies selling products in Chile are show in Table 2.[7] The low scores of most companies on the scorecard reflect room for improvement in corporate sustainability efforts.

**Table 2: As You Sow Corporate Plastic Pollution Scorecard for common parent companies in Chile**

| Company | Overall Grade |
|---|---|
| The Coca-Cola Company | B |
| Nestle S.A. | C+ |
| Mondelez International, Inc. | C- |
| PepsiCo, Inc | D+ |
| Grupo Bimbo SAB de CV | F |

[7] Kelly McBee and Julia Hall. "As you Sow Corporate Plastic Pollution Scorecard 2021." https://static1.squarespace.com/static/59a706d4f5e2319b70240ef9/t/6154c623609b283fdc013b6c/1632945709916/AsYouSow2021_PlasticsScorecard_fin-v2_20210927.pdf

# *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.[8]

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 food ware 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.[9]

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) electrical and electronic equipment waste, 5) automotive batteries, and 6) portable batteries. Of particular

[8] Global Commitment 2021 Signatory Report. Ellen MacArthur Foundation. https://ellenmacarthurfoundation.org/global-commitment-2021/signatory-reports/gov/government-of-chile
[9] Fundacion Chile. New Plastics Economy: Chilean Plastics Pact. https://fch.cl/en/initiative/new-plastics-economy/

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.[10]

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 fourteen key stakeholders. Among those interviewed, five were government officials, six were from waste management or recycling companies, and three were from circular-economy businesses (Table 3). Circular economy business refers to those involved in regenerative business practices like reuse, refill, or composting.

[10] 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 3: Summary of Stakeholder Interview List**

| Stakeholder Group | Number of Interviews |
|---|---|
| Government Officials | 5 |
| Waste Management Company | 2 |
| 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 highly 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. In San Antonio, the city manages its own drop off locations and collection center, which may circumvent some of these challenges described by private recyclers.

**"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."**

–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."**

–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."**

–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."**
>
> –Waste Management 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."**
>
> –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."**
>
> –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."**
>
> –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."**
>
> –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."**
>
> –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. Polylactic acid (PLA), a type of industrially compostable plastic, 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

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**

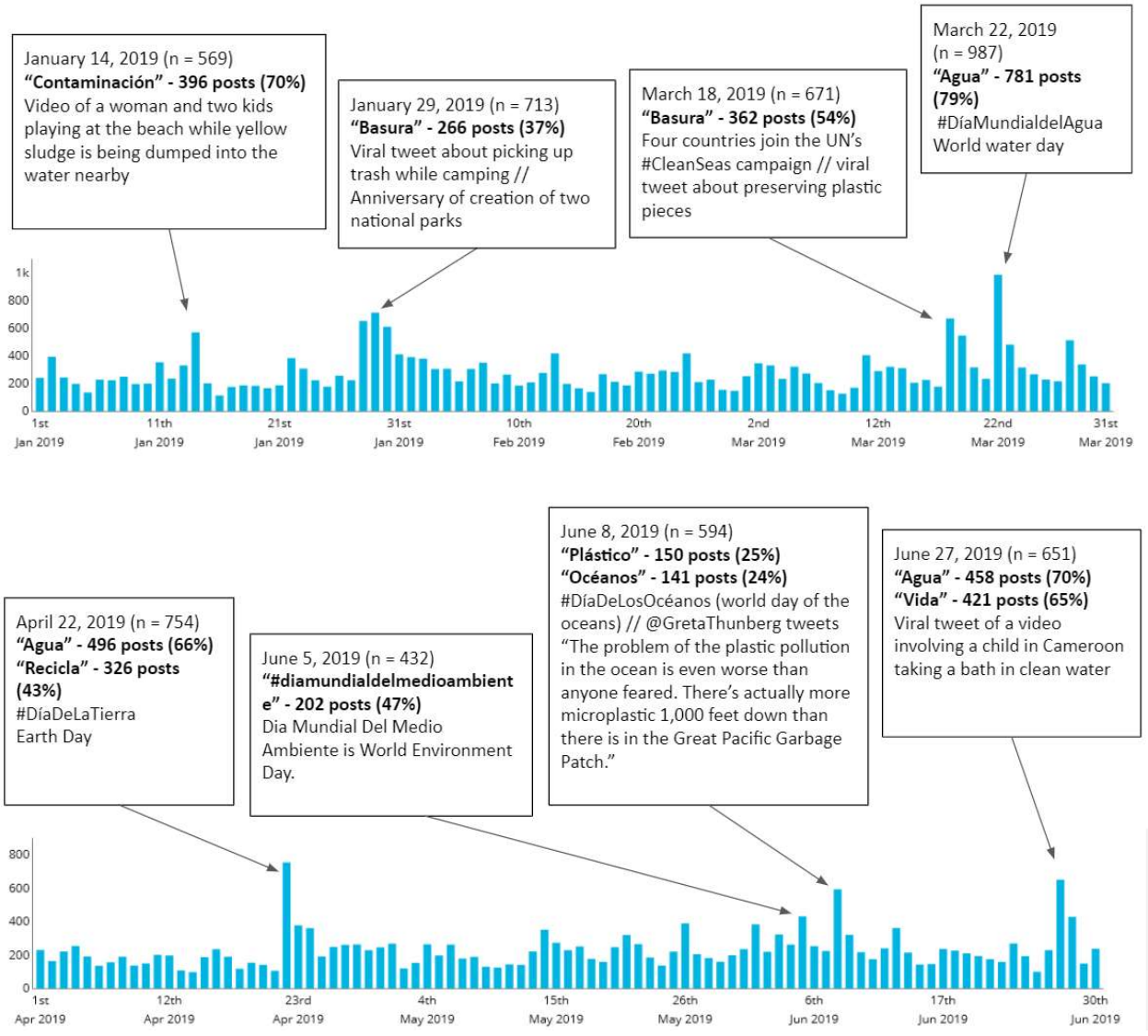
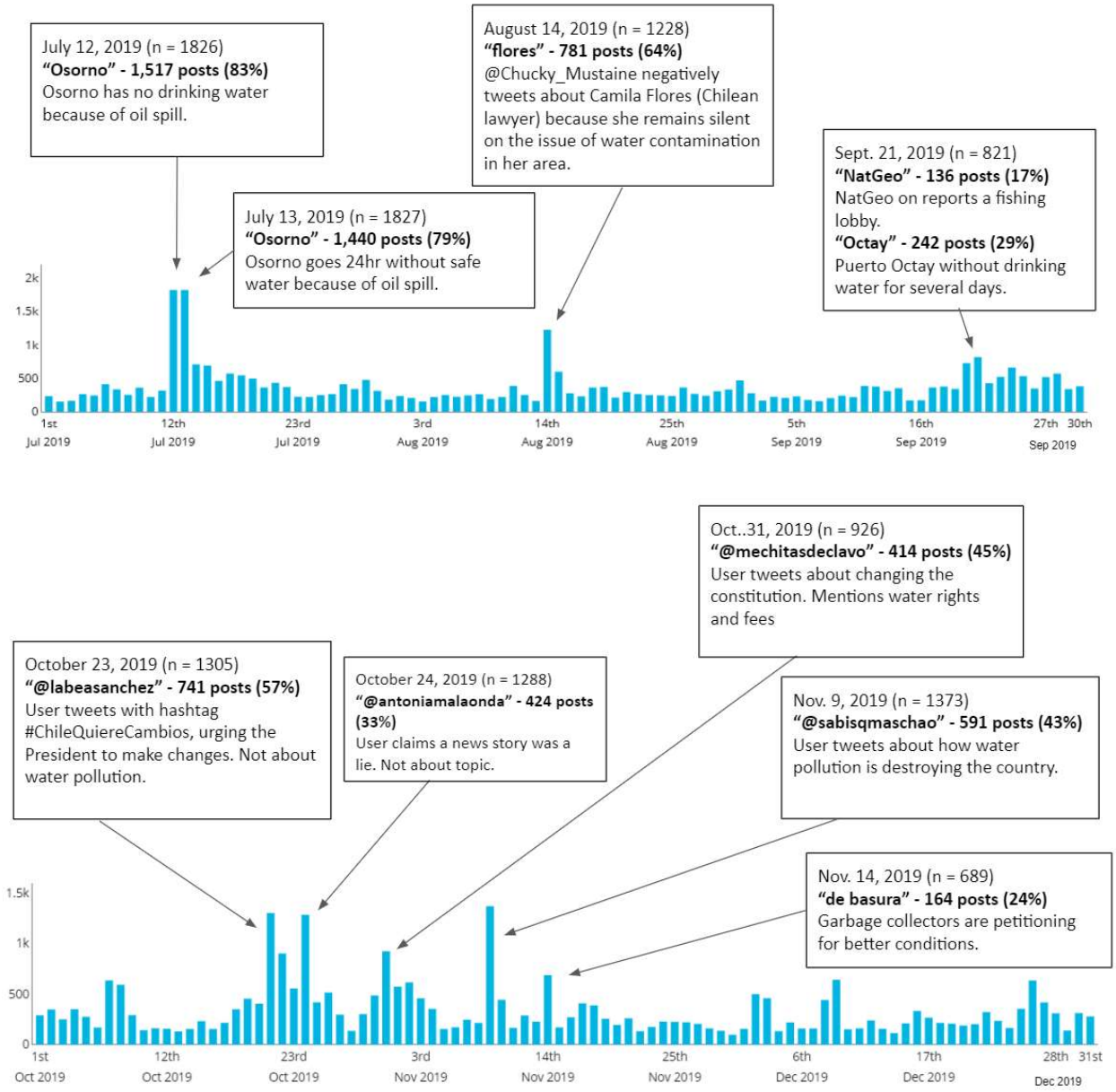


**Figure 9b: Spike Analysis of Twitter conversation related to plastic pollution, Jan. – Dec. 2019 (continued)**



## *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 nine 1km$^2$ transects areas, where they were present. The average weight of both the packaging and the product itself was collected for all samples (Table 4).

**Table 4: 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** | 18 | 28.2 | 538.5 |
| **Candy** | 24 | 1.2 | 37.2 |
| **Chips** | 10 | 7.3 | 80.8 |
| **Cookies** | 11 | 3.3 | 89.2 |

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 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.

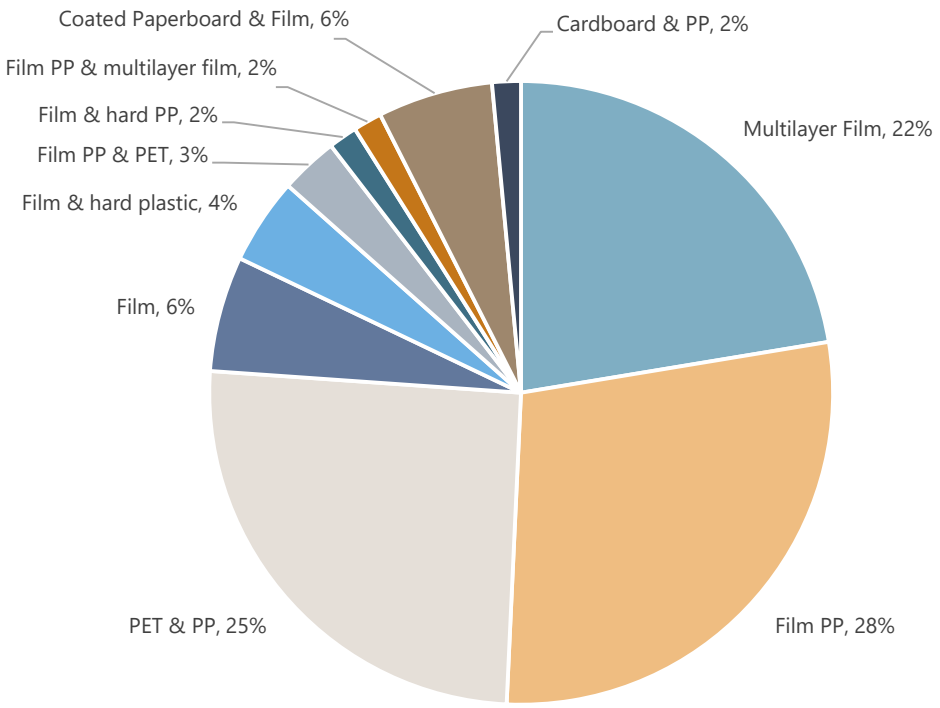
For beverages, the packaging and product weights were nearly identical to what has previously been surveyed in CAPs in US cities, due to standard size bottles. Candy is also similar in quantity and size to that found in the US. Compared to other international contexts however, while the ratio of product 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 San Antonio were around ten 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.

For each convenience item surveyed, the CIL team documented the polymer type. Like beverage sizes, material type of bottles was also PET as is typical in other sites; the majority of bottle caps were PP. Notably, many of the single-serve food wrappers in Chile were film polypropylene (PP) and the majority of these were labeled clearly and identifiable. Interestingly, in San Antonio, PP was the most common material type at 28%. Film PP combined with other materials, like cardboard, hard PP, and PET, comprised

an additional 7% of the samples. For most of these products, the wrapper was PP while the interior lining or tray was PET or cardboard; this was most prevalent in cookies and candies. 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.

Multilayer film was still a significant fraction (22%). This material 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 problematic material type due to the multi-faceted composition presenting challenges with recycling. 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.

**Figure 10: Material breakdown of top convenience items in San Antonio**




In addition to the common convenience items characterized above, the CIL team noted during in-store-surveys that coated paperboard (often TetraPak brand) was a common packaging type among grocery items in both San Antonio and 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 where they were present in each of the nine 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 51 items in 17 restaurants (Figure 12).

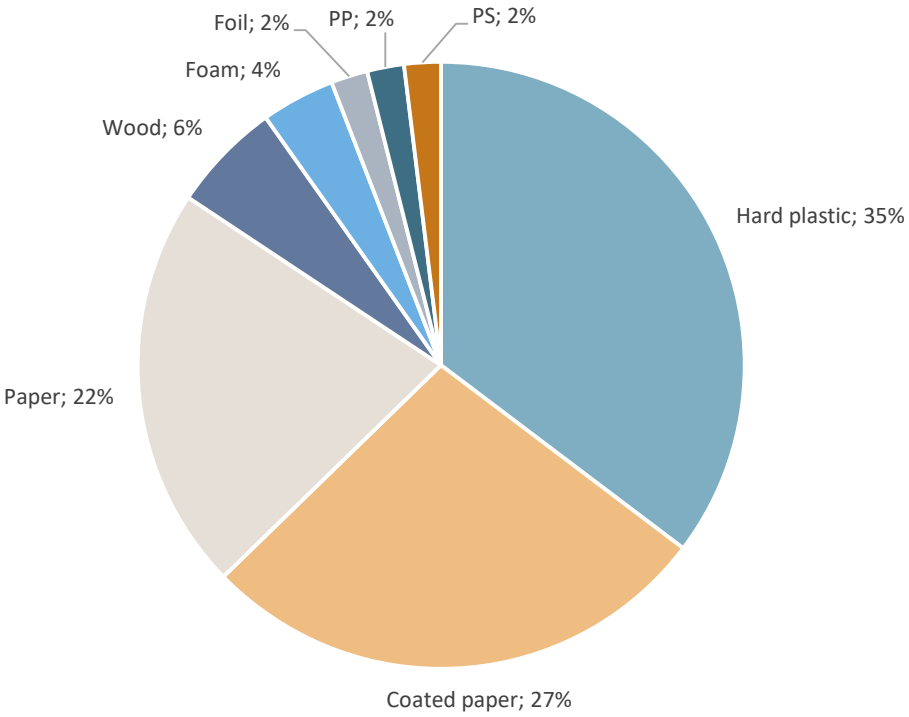
**Figure 12: Examples of common to-go materials in San Antonio, including hard plastic and paper**

**Table 5: Products and material types surveyed in restaurants and food vendors.**

| Product | Material Type | Number of Observations |
|---|---|---|
| **Bags** | Paper | 3 |
| | Coated Paper | 2 |
| **To-Go Containers** | Paper | 5 |
| | Hard Plastic | 4 |
| | Coated Paper | 3 |
| | Aluminum | 1 |
| | Foam | 1 |
| **Cups** | Coated Paper | 9 |
| | Hard Plastic | 3 |
| | Paper | 2 |
| | PP | 1 |
| | Foam | 1 |
| **Straws** | Hard Plastic | 2 |
| | Paper | 1 |
| **Utensils** | Wood | 3 |
| | Hard Plastic | 2 |
| **Lids** | Hard Plastic | 7 |
| | PS | 1 |

Bags, especially paper bags, seemed to be a popular alternative to to-go containers (Table 5). 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 San Antonio**




Of the to-go items we surveyed, the majority were hard plastic (35%), likely PET, PP, or occasionally HDPE. A significant fraction was coated paper (27%) or paper (22%). While sometimes difficult to distinguish visually, coated paper (often found in cups and containers) is paper with a plastic-type lining to prevent leakage. 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 in Santiago, 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.**

Loopholes in the policies, like ferrias and food delivery contexts, may be current sources of leakage but also present opportunities for expansion of reuse. Stakeholders interviewed spoke of the benefits of reuse, including building relationships with consumers, and how policy has helped shift consumer attitudes towards reuse, especially for bags. Price sensitivity is an important consideration, especially for smaller businesses.

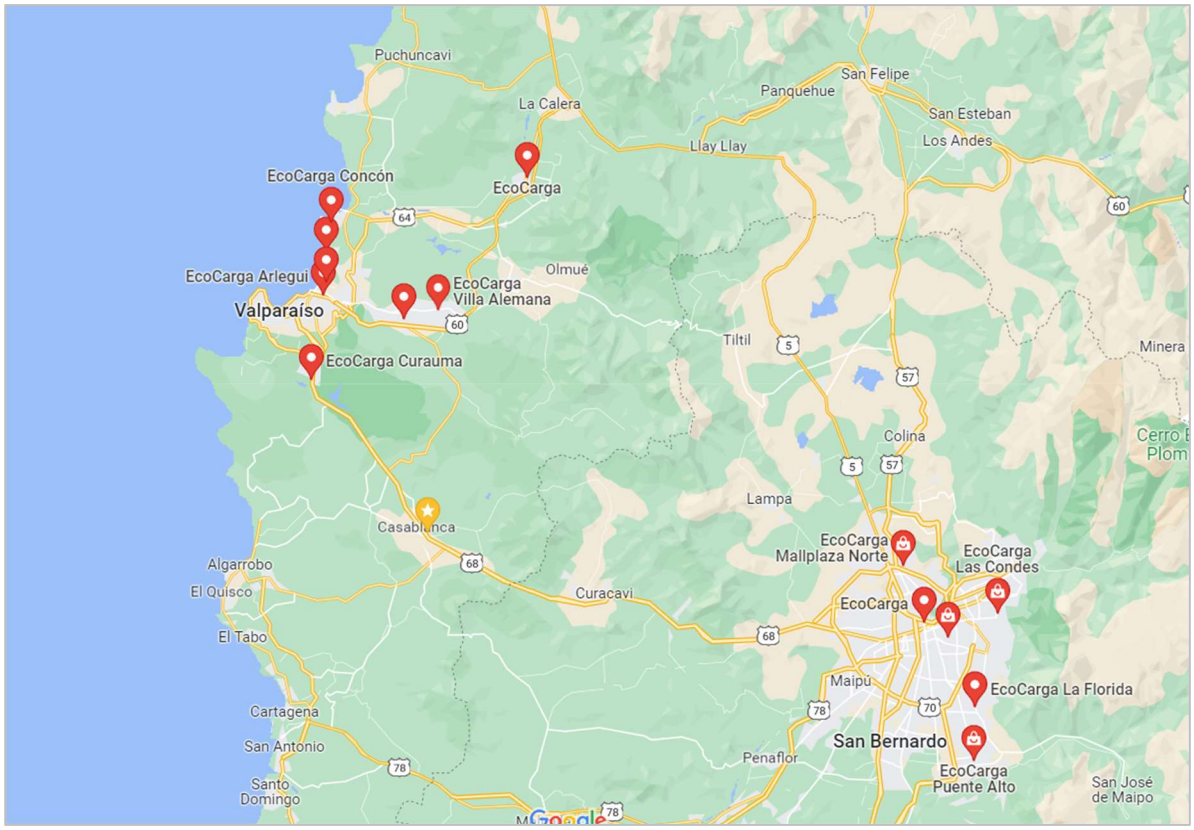
> **"Plastic bags are allowed for preventing food waste, so there are loopholes in the policy."**
>
> – Government official

> **"We are looking at reusable bags that you would return for the delivery market. For retailers, this could have economic benefits to start relationships with consumers… We are also working on a project to target ferrias to have reusable bags… Vendors are asking about the price mark up for this."**
>
> – Circular Economy Business

> **"The consumer trend is to acquire reusable bags, because of support from Chilean policy."**
>
> – Circular Economy Business

There are also stories of positive forms of plastic usage in the region, in the form of reuse. EcoCarga is a refill company that began in the Valparaiso region and is now active in both Valparaiso and the metropolitan region (Figure 15). 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.[11]

**Figure 15; Refill locations for EcoCarga in Valparaiso and Metropolitan regions.**




*Note: Images from https://ecocarga.com/pages/puntos-de-recarga, accessed February 16, 2023.

The CIL team surveyed available refill products in Santiago and found that refillable products were offered at a price savings to consumers (Table 6). 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

[11] EcoCarga Sustainability. https://ecocarga.com/pages/sustentabilidad

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. The current system in Santiago while still operating at a smaller scale, 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.

**Table 6: Cost comparison of refill and identical product in plastic packaging in Santiago**

| Product | Alternative | Cost of Alternative (CLP) | Cost of Product in Plastic (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% |

Both the potential cost savings for consumers as well as the geographic proximity of EcoCarga in nearby communities like Valparaiso and Vina del Mar highlight potential for expansion of refill in San Antonio.

In addition to start up efforts, 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]

**Figure 18: "Universal" returnable Coca Cola and Inka Cola bottles**


[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

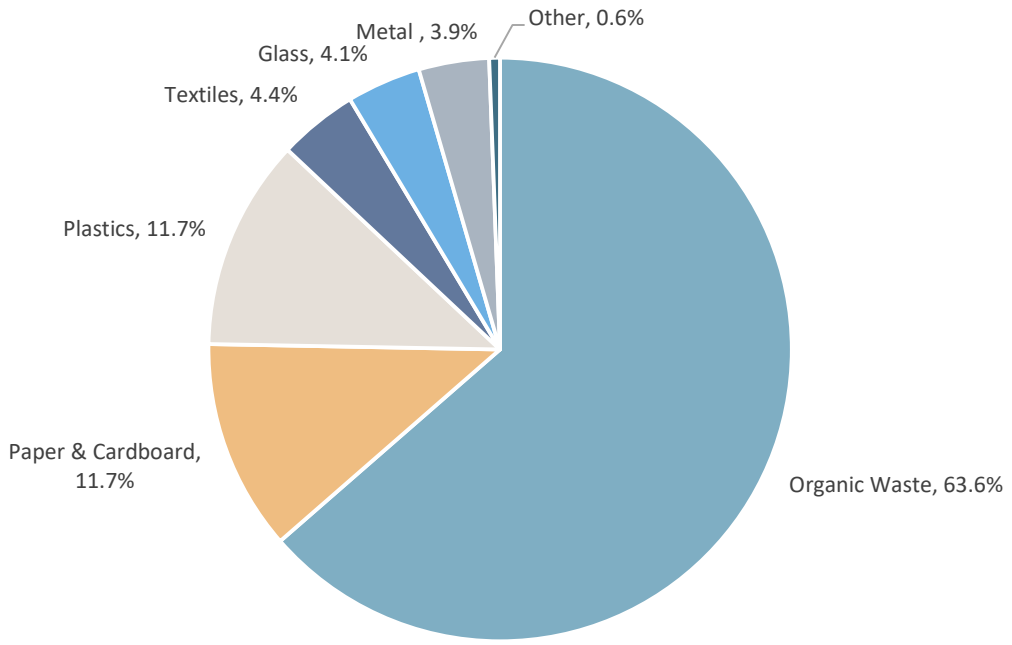
## *Collection*

It is estimated that about 584,000 tons of waste are generated annually in the Valparaiso region[13]. Like in other parts of Chile, each municipality within the region – including San Antonio – 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 in more remote areas of Chile.

The price households pay for collection varies by municipality, and is 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]

A large proportion (more than 60%) of municipal solid waste (MSW) collected in the Valparaiso region is organic, including kitchen and garden waste. The recyclable fraction – paper, cardboard, plastics, metal, and glass –comprises approximately 31% of the waste stream (Figure 19).[10]

**Figure 19: Approximate composition of MSW collected in San Antonio**




Note that the characterization above is based on 2001 study. While high levels of organic waste are typical in waste compositions in many parts of South America, it is likely the plastic fraction has increased

[13] Constantinos S. Psomopoulos and Nickolas J. Themeli. "A Guidebook for Sustainable Waste Management in Latin America." September 2014. IRRC - Waste to Energy.Vienna, Austria.
[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

in the twenty years since this waste characterization study. Localized data on waste characterization could help support municipal decision makers.

The Solid Waste Management Plan for San Antonio was enacted in 2020. The plan references the national Solid Waste Comprehensive Management Policy, and the historical focus in the Chile on waste disposal in sanitary landfills, rather than on prevention and minimization. The SWM plan for San Antonio prioritizes the reduction of MSW through composting, recycling, and source separation, although it notes the importance of national legislation (namely EPR implementation) to support these goals. The SWM plan also highlights the need to improve the public level of environmental education of the population, recognizing that this is a gradual process.[15]

**Figure 20: Trash cans, collection points, and recycling bins in Valparaiso region**




[15] "Plan de Gestión Estratégica de Residuos Sólidos, Comuna de San Antonio." Prepared by Francisco Valenzuela L, Director of Dirección de Medio Ambiente, Aseo y Ornato (DIMAO). January 2020.

Trash cans intended for public use, such as those in parks, 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 top left), are generally open grates. Escaped waste was observed below these disposal areas in some locations. Recycling collection points are often accompanied with signage on best practices for recycling.

Like waste collection systems, recycling practices vary by municipality within the region. Bins and educational signage may also vary site to site (Figure 20). 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]

Drop off sites may include one bell-shaped container for a single type of recyclable, where profits from recyclables are donated to charity (Figure 21) 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, depending on the municipality.

**Figure 21: Receptacle for a glass recycling campaign where profits are donated to children in need.**


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 (Figure 22). 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.

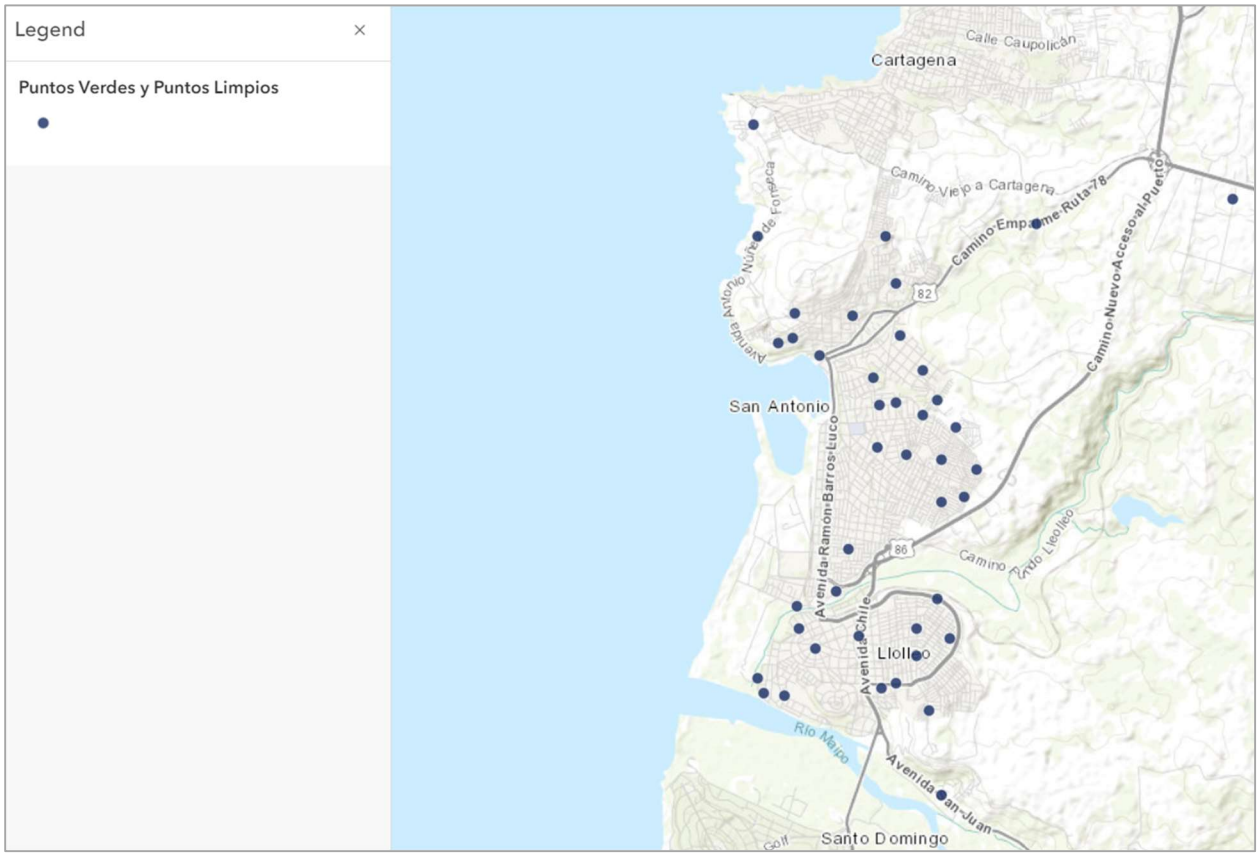
**Figure 22: Private recycler in the Valparaiso region**

In San Antonio, a collection center for recyclables was created in 2011 as part of the Comuna Limpia Plan Program. This corresponded with installing various recycling drop off points throughout the community, known as puntos verdes. Planned technological innovations to improve collection of recyclables includes the installation of fill sensors in the containers at puntos verdes.[16]

Locations for 46 recycling collection and drop off locations were shared with CIL, as shown in Figure 23 below. (The SWM plan refences 57 drop off points throughout the community). These puntos verdes and puntos limpios are distributed geographically throughout different neighborhoods in San Antonio. The municipality collects recyclables from the drop off points in their own collection vehicles.[15]

[16] "Plan de Gestión Estratégica de Residuos Sólidos, Comuna de San Antonio." Prepared by Francisco Valenzuela L, Director of Dirección de Medio Ambiente, Aseo y Ornato (DIMAO). January 2020.

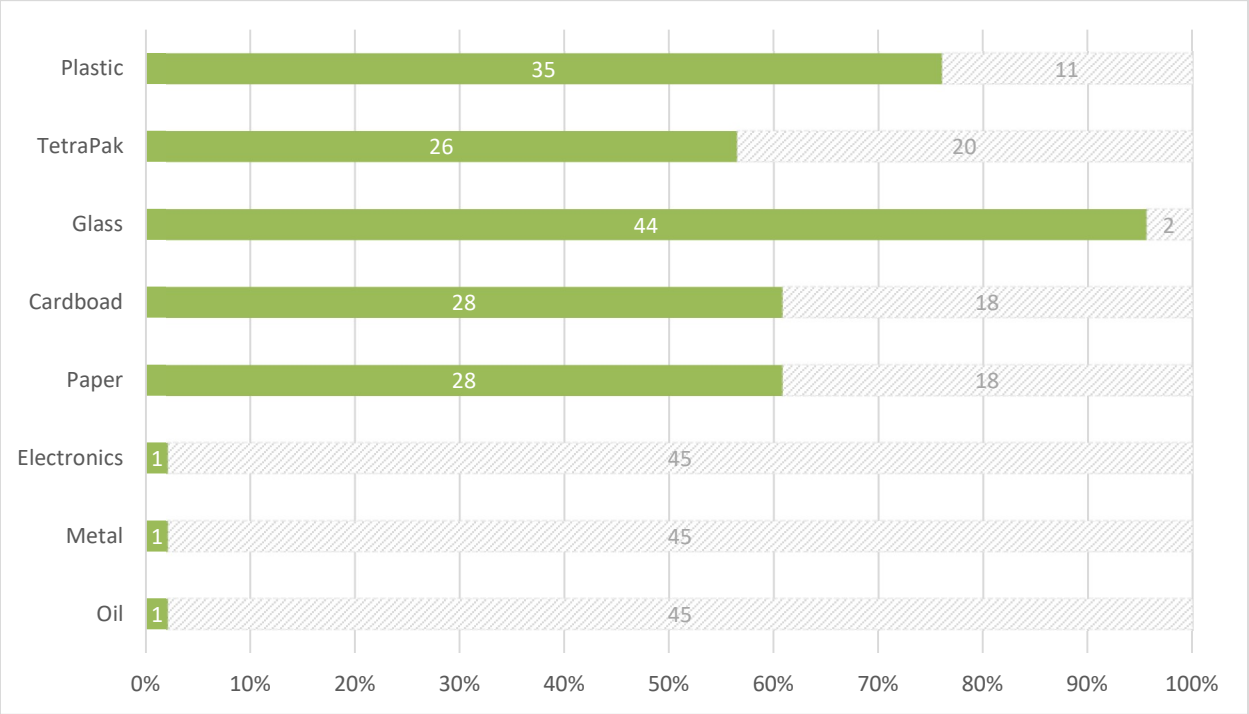
**Figure 23: Locations of puntos verdes and puntos limpios in San Antonio**




Access to the online version of the map is available at: https://www.arcgis.com/apps/mapviewer/index.html?webmap=eec5461ed38b433ea934e791f4b3b572.

Not all puntos verdes accept all material types (Figure 24). Based on data for forty-six recycling centers shared with CIL76% of recycling centers report accepting plastic and 57% accept aseptic packaging (TetraPak). The most universally accepted material type is glass, which 96% of recycling centers accept.

**Figure 24: Recycling centers that accept (green) and do not accept (gray) various material types**




Much of the waste separation in Chile 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.[17]

Like waste collection, integration of informal workers into formal systems has varied city by city, though most municipalities are choosing to integrate them. The challenge of integrating informal workers is more significant in the Valparaiso region that in Santiago. Incorporating informal or grassroots recyclers into San Antonio's current process is part of the municipality's ongoing vision for SWM; a current pilot project involves supporting these recyclers in efforts to collect materials from commercial sectors in San Antonio.[18]

> **"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

There remain unanswered questions about how integration of the informal sector will occur as the EPR law moves towards implementation.

[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

[18] "Plan de Gestión Estratégica de Residuos Sólidos, Comuna de San Antonio." Prepared by Francisco Valenzuela L, Director of Dirección de Medio Ambiente, Aseo y Ornato (DIMAO). January 2020.

**"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.

In addition to collecting recyclables, the municipality in San Antonio has one truck dedicated to this type of collection of organic waste, which collects organics once a week from more than 3,000 homes.[19]

[19] "Plan de Gestión Estratégica de Residuos Sólidos, Comuna de San Antonio." Prepared by Francisco Valenzuela L, Director of Dirección de Medio Ambiente, Aseo y Ornato (DIMAO). January 2020.

## *End of Cycle*

After collection, typically curbside from households, waste is typically taken to a transfer station (Figure 25), and from there to a landfill.

**Figure 25: Transfer station in Valparaiso region.**

Waste from San Antonio typically goes to El Molle, the main landfill in the region. The landfill has been in is owned by the municipality but under private management from Veolia. The CIL team visited El Molle landfill during field work in San Antonio (Figure 26).

El Molle landfill typically receives about 30,000 tons of waste per month, although it may receive up to 50,000 tons per month in the summer months when the coastal region has higher tourism activity. The majority of this is household waste from the Valparaiso region, especially from more populous communities like Vina del Mar and Valparaiso. The current cell being utilized in the landfill had a geomembrane lining and leachate control system. Older cells, filled prior to legislation around sanitary landfills, do not have these features. El Molle is projected to have capacity to continue to accept waste until 2028.

**Figure 26: El Molle landfill, the primary landfill in the Valparaiso region.**

An estimated 140 informal recyclers collect recyclables from the waste dumped at El Molle, presenting tension between landfill operators and recyclers, often due to safety concerns and uncertainty about the role of government in regulating activities.

> **"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."**
>
> –Waste Management Company

> **"Yesterday recyclers took over the landfill and wouldn't let people in… It's not our responsibility but it directly affects our processes. [Informal recyclers] are major stakeholders, even though they are the municipality's responsibility. To generate quick changes with them is difficult."**
>
> –Waste Management Company

The CIL team was informed that the landfill follows best practices, including slope stabilization and daily cover of the waste. However, when viewing the landfill face the CIL team was told the amount of uncovered waste pictured above was from 2-3 days. Large amounts of animal interactions with the waste were also observed. The lack of cover combined with animal interactions may be a source of leakage of waste from the landfill.

For recyclables that are not landfilled, they are typically aggregated, cleaned, and labeled prior to sale for further processing (Figure 27). In San Antonio, this occurs in the recycling collection center.

Many recycling businesses are 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 7). 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 7: 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 27: Baled material ready for sale at a recycler.**

The CIL team did observe instances of Tetra Pak recycling (Figure 28), 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 28: Aggregated Tetra Pak in a recycling facility.**

Despite systems for collecting waste and recyclables, illegal dumping is still a problem, especially for construction and demolition debris. Enforcement of laws against illegal dumping is particularly challenging.

> **"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 29). Revaloriza, located in the Valparaiso region, 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 29; Alternative recycling projects for debris not typically accepted like C&D**

In addition to C&D debris, illegal dumping of household waste is also occurring in San Antonio. While waste collection is available throughout the community, some households choose not to participate, illustrating the need for co-development of both infrastructure and education to solve these issues.

Local contacts shared that illegal dumping primarily is occurring in less populous areas in San Antonio and on private land and vacant lots where the government cannot intervene (Figure 30). Some of these areas are unfortunately in close proximity to the coast. Eliminating these micro-dumps from different sectors by working with the community is part of San Antonio's long term vision for waste management laid our in the 2020 SWM plan.[20]

**Figure 30: Coastal and vacant lot dumpsites in San Antonio**

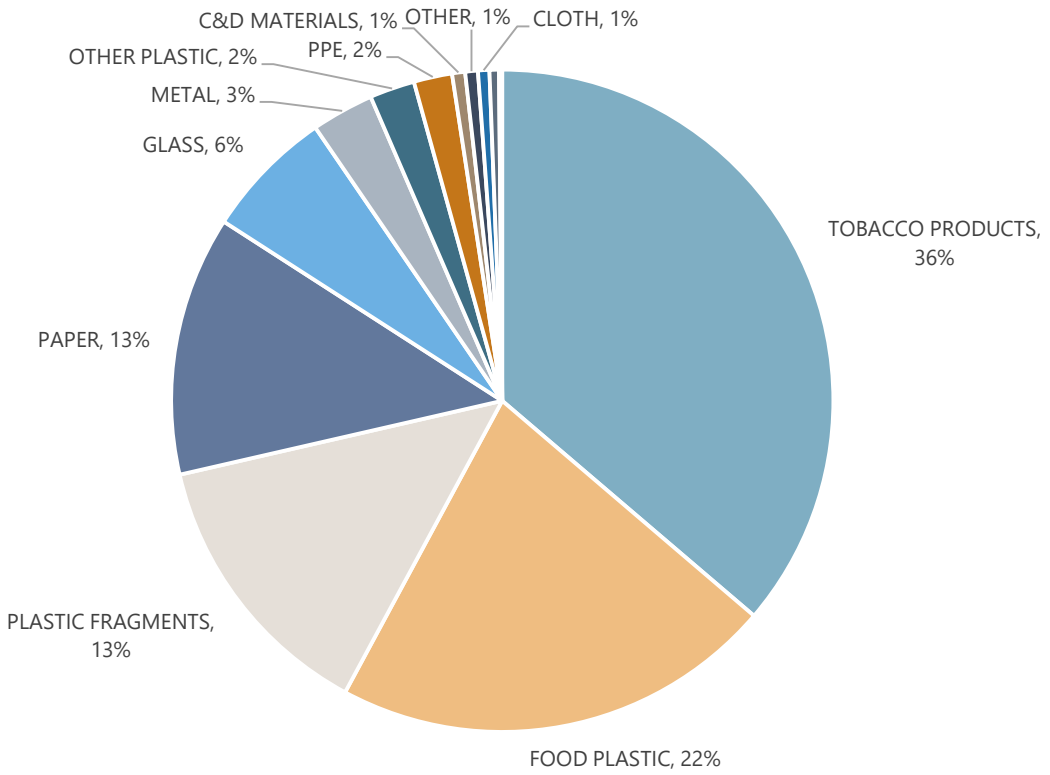
San Antonio currently does not have industrial composting that would be sufficient for compostable plastic alternatives like PLA, which is becoming increasingly common. There is composting of yard waste, organics, and leaf and limb debris in the city's collection center, which may help reduce the significant fraction of organic waste in the waste composition in the Valparaiso region. This waste comes from both household and commercial yard maintenance, as well as from industrial sources like the timber and agricultural industries.[19] Expansion of this program to ensure appropriate composting conditions for compostable plastics like PLA may enable growth of compostable plastics in consumer product categories. This material type is expanding in use, but infrastructure for management often lags behind. The CIL team found a similar situation in a CAP in Miami, where PLA was 6% of the to-go food ware (often purchased at significantly higher costs to food vendors), but no industrial composting exists.

[20] "Plan de Gestión Estratégica de Residuos Sólidos, Comuna de San Antonio." Prepared by Francisco Valenzuela L, Director of Dirección de Medio Ambiente, Aseo y Ornato (DIMAO). January 2020.

## *Leakage*

In total, 7,790 items were logged in twenty-seven transects (each 100m$^2$) characterizing nine 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 can be found in the Appendix.

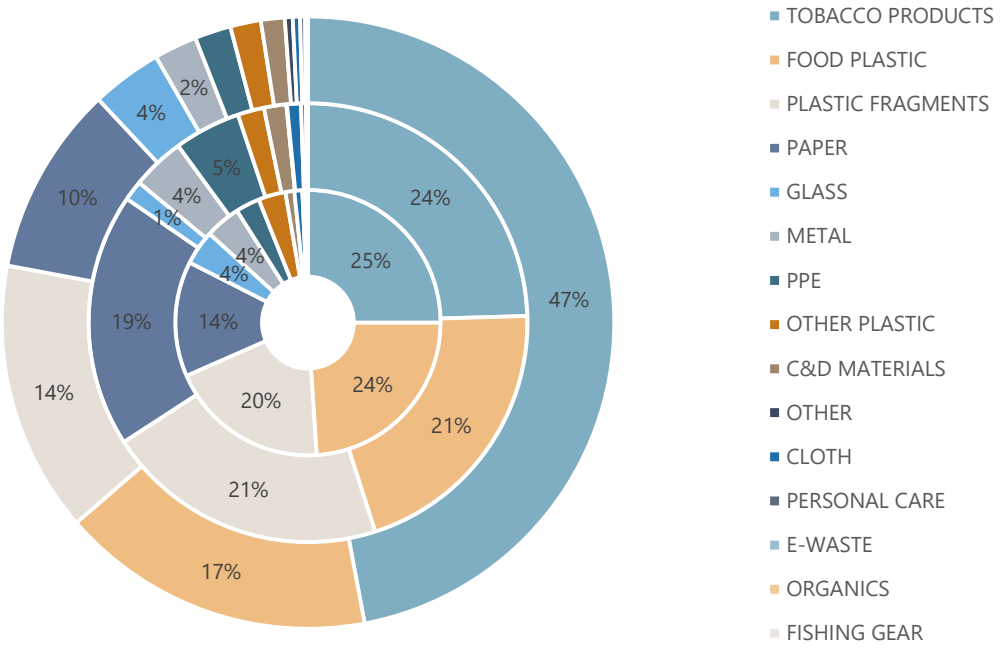
**Figure 31: Litter Material Breakdown for San Antonio**




Across all transects, the largest percentage of litter by category was tobacco products, followed by food plastic (Figure 31). Tobacco products included cigarette butts as well as cigarette packaging. Food plastic included foam or plastic cups or lids, plastic bottles, plastic bottle caps, plastic food wrappers, plastic grocery bags, other plastic bags, plastic utensils, straws, street food bowls, foam containers, and other food-related plastic. Together these two categories constituted over half of the litter items documented in the city (Figure 32). The categories plastic fragments, paper, and glass comprised between 6% and 13% of litter documented, respectively, while the remaining categories — including metal, other plastic, PPE, C&D materials, PPE, other, cloth, personal care products, e-waste, organics, and fishing gear — each represented less than 5% of the litter items. The total percentage of common plastic items (the sum of food plastic, other plastic, PPE, plastic fragments, and personal care items) was nearly 40% of the total litter items documented.

**Figure 32: Common plastic litter in San Antonio, including bottles, cups, and food wrappers**

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




When examining the litter densities based on the population count areas, there are distinctions for each (Figure 33). For example, tobacco products were the highest proportion of materials in the high population count areas, at 47%. Tobacco products were a smaller proportion in mid and low income areas, while food plastic represented a larger proportion in these population count areas at 21% and 24%, respectively. PPE was the highest proportion in the mid-population sites, at 5%; in other cities surveyed since the start of the COVID-19 pandemic, PPE typically comprises 1-2% of the litter.

Litter densities were highest in the upper population tertile, nearly four times higher than litter densities in the low population count areas (Table 8). The overall average litter density in San Antonio was 2.89 items/$m^2$ and the average litter density in Santiago was 3.34 items/$m^2$; for comparison, three cities sampled along the Mississippi River in the United States had average litter densities of 0.61 items/$m^2$, 0.69 items/$m^2$, and 0.28 items/$m^2$ respectively. The litter densities in San Antonio 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/$m^2$ in high population count areas, 1.48 items/$m^2$ in middle population count areas, and 3.79 items/$m^2$ in lower population count areas as of 2021. Panama City, Panama, had litter densities of 1.87 items/$m^2$ in high population count areas, 1.43 items/$m^2$ in middle population count areas, and 3.04 items/$m^2$ 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/$m^2$ across the three population tertiles there.

**Table 8: Litter Density and Top Litter Items for Each Area of Population Count**

| Population Tertile | Top 5 Litter Items | Litter Density (count/m2) |
|---|---|---|
| Upper (51 – 6,107 persons/km$^2$) | 1) Cigarettes, 2) Paper, 3) Film Fragments, 4) Plastic Food Wrappers, 5) Hard Plastic Fragments | 4.28 |
| Middle (8 – 51 persons/km$^2$) | 1) Cigarettes, 2) Paper, 3) Film Fragments, 4) Plastic Food Wrappers, 5) Plastic Bottle | 3.24 |
| Lower (2 – 8 persons/km$^2$) | 1) Cigarettes, 2) Plastic Food Wrapper, 3) Paper, 4) Film Fragments, 5) Hard Plastic Fragments | 1.14 |

Notably in San Antonio, litter densities were highest in the upper and middle tertiles of population count than in the lower population count areas. The low population areas randomly generated by our algorithm tended to be on the outskirts of town and were often agricultural and along roads that were unpaved and less frequently traveled.

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.[21]

As San Antonio is a coastal community, we surveyed one transect near the coast in an undeveloped area. The transect was adjacent to an informal dumping area. This transect had a litter density of 3.22 items/m$^2$; 24% of items logged were plastic, followed by 23% tobacco products, 22% paper, and 19% food plastic. Top items were 1) cigarettes, 2) paper, 3) film fragments, 4) plastic food wrappers, and 5) foam fragments.

Beach litter also had many overlaps with common items found in the city, including tobacco products and food plastics (Figure 34). Fishing net and rope, suggesting sea-based sources of marine debris, were also observed. Previous studies have also found that litter in sites like San Antonio derived primarily from direct anthropogenic activities, in addition to litter from distant sources.[22]

[21] 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.
[22] Nelson Rangel-Buitrago, Manuel Contreras-López, Carolina Martínez, Allan Williams, "Can coastal scenery be managed? The Valparaíso region, Chile as a case study," Ocean & Coastal Management, Volume 163, 2018, Pages 383-400, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2018.07.016.

**Figure 34: Beach litter observed in San Antonio**

There are success stories of preventing derelict fishing gear ending up marine debris through by back programs. The company Bureo, for example, collects fishing nets in six countries including Chile, to create skateboards, sunglasses, and other outdoor gear out of ocean-bound plastic. The company states they have collected over 3,000 metric tons of discarded fishing nets.[23]

While sea-based sources of debris may be more challenging to regulate locally, the prevalence of common consumer plastics in beach litter suggests that local reduction of leakage may have a very direct impact on ocean plastic pollution in the coastal San Antonio context.

In November and December of 2021, a national sampling of river litter in Chile was conducted for the third time. 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 of 2.89

[23] Bureo. https://bureo.co/. Accessed February 16, 2023.

items/$m^2$ that the CIL team surveyed in populated areas in San Antonio. 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. Leakage from urban stormwater systems into the ocean, for example, was observed to be occurring in San Antonio (Figure 35).

**Figure 35: A storm drain in San Antonio depositing anthropogenic litter into coastal waters**

Consistent with the discussion of illegal dumping presented in End of Cycle, 78% of collection sites in the river 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[24]. In leakage data collected by the CIL team, only 123 plastic grocery bags were identified out of the over 8,000 litter items characterized in San Antonio. representing 1.5% of the litter. This example highlights how effective policy can be in targeting problematic plastics and preventing environmental contamination.

[24] 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 relative 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 is acknowledged as the highest tier of waste prevention, and reuse programs have been successful in other parts of Chile. This is a model that could continue to be expanded in San Antonio.
- 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 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, produce bags used in large retail grocery stores, and food delivery bags might hold opportunities for adjacent expansion.
- Reuse and refill systems already have traction in beverage and household categories in Valparaiso region and could be expanded geographically to San Antonio.
- Refill systems can provide products to customers at a cheaper cost than traditional single-use plastics.

**Collection**

- Updated waste characterization data may be valuable for solid waste management planning for local officials.
- While recycling drop off centers are spread throughout the community, these centers may not be accessible equally to all residents, especially those that lack transportation. Because the local government in San Antonio controls these drop off centers, they may be able to specifically target disadvantaged neighborhoods to ensure more equitable access.
- Technology like bin sensors may increase efficiency of collection.
- Recycling practices and accepted materials vary depending on drop off location, adding additional challenges to recycling education.
- Pilot programs for integrating informal recycling workers into collection of recyclables could be expanded. Integrating informal recyclers is already a target in the local SWM plan.
- 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.
- Integrating the informal sector further upstream before last-chance capture at the landfill could help alleviate health and safety concerns at disposal sites.
- 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.
- Targeting small informal dumpsites off household waste could reduce leakage directly to the ocean. Existing collecting systems for household waste can be leveraged in combination with education.
- The composting program in San Antonio captures some organic waste and reduces the amount going to landfill. Expansion of this program to ensure appropriate composting conditions for compostable plastics like PLA may enable growth of compostable plastics in consumer product categories.

**Leakage**

- Tobacco products (36%) and common plastic items (40%) 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 San Antonio (average 2.89items/$m^2$) 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 commonalities between litter found in coastal ecosystems and in the urban areas of San Antonio suggests that reducing waste upstream may have a direct effect on plastic entering the ocean.
- 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.
- Storm drains present opportunities for last chance capture before leakage into the ocean.
- Successful projects in Chile have demonstrated the ability to reduce derelict fishing gear by paying fishers for used nets.

## *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

PLA: polylactic acid

PP: polypropylene

PRO: Producer Responsibility Organization

SUP: single-use plastic

UGA: University of Georgia

US: United States of America

# *Appendix*

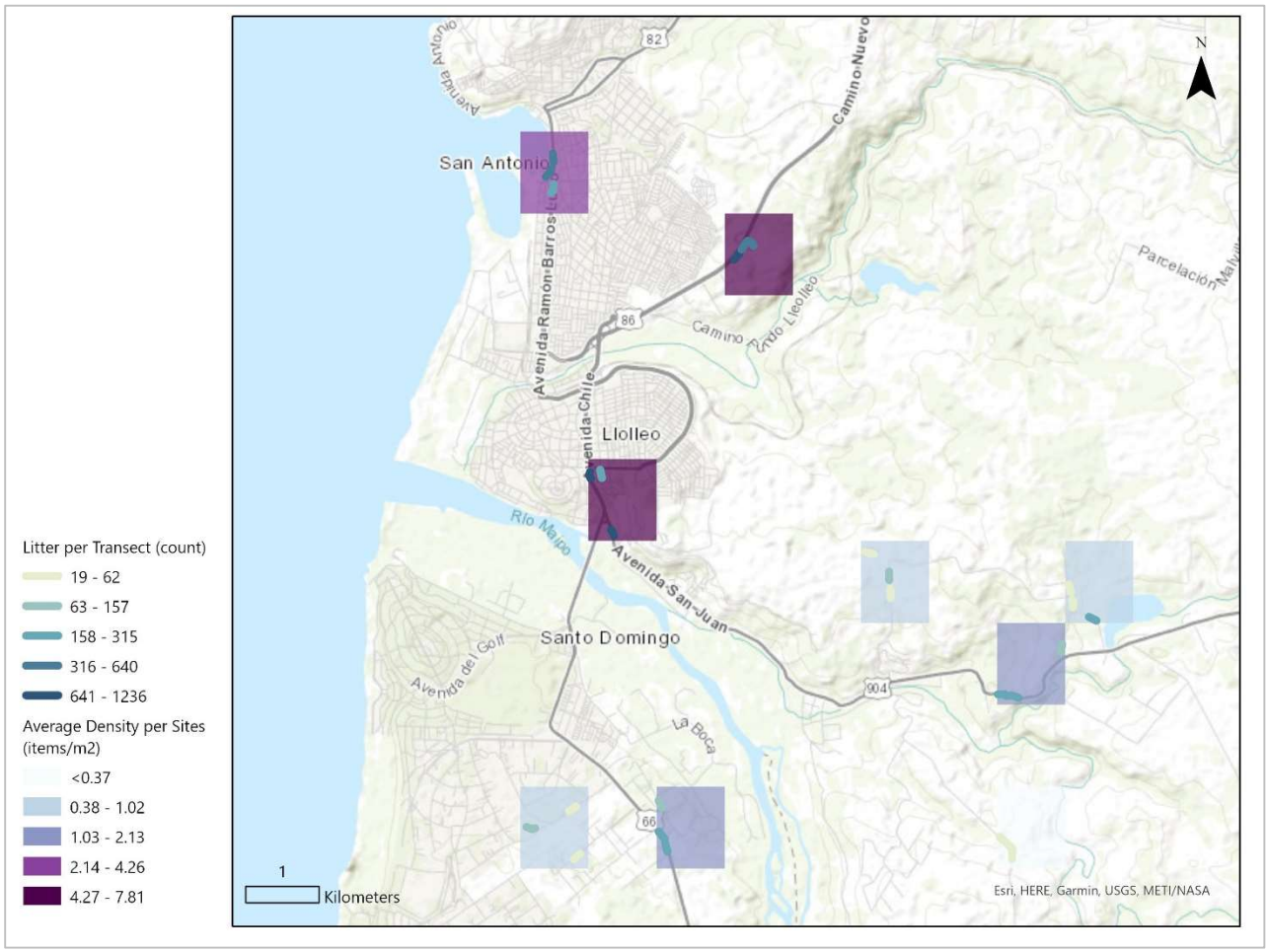
**Table A1: Full List of Debris Tracker Litter Items and Associated Material Categories**

| Material | Items |
|---|---|
| C&D Materials | Aggregate & Brick<br>Bolts, Nails, and Screws<br>Building Materials<br>Lumber<br>Other C&D |
| Cloth | Clothing<br>Fabric Pieces<br>Other Cloth |
| E-Waste | Batteries<br>E-Waste Fragments<br>Other E-Waste |
| Fishing Gear | Buoys and Floats<br>Fishing Line<br>Other Fishing Gear<br>Plastic Net or Net Pieces<br>Plastic Rope |
| Glass | Glass Bottle<br>Glass or Ceramic Fragments<br>Other Glass |
| Metal | Aluminum Foil<br>Aluminum or Tin Cans<br>Metal Bottle Caps or Tabs<br>Metal Fragments<br>Other Metal |

| | |
|---|---|
| Organic Waste | Food Waste<br>Other Organic Waste |
| Other | Other<br>Popsicle Stick |
| Other Plastic Products | Bulk Bags<br>Flip Flops<br>Other Plastic<br>Plastic String, Tape, or Packing Straps<br>Rubber Bands<br>Tires |
| Paper | Coated Paperboard<br>Corrugated Cardboard<br>Multi-material Paper Box<br>Noncoated Paper Food Wrapper<br>Other Paper<br>Paper<br>Receipts |
| Personal Care Products | Blister Pack<br>Cotton Buds<br>Other Personal Care Product<br>Personal Care Product Sachet<br>Shampoo or Other HDPE Container<br>Toothbrushes<br>Toothpaste or Other Product Tube |

| | |
|---|---|
| Plastic Food Products | Foam or Plastic Cups or Lids<br>Other Food-Related Plastic<br>Other Plastic Bag<br>Plastic Bottle<br>Plastic Bottle Cap<br>Plastic Food Wrapper<br>Plastic Grocery Bag<br>Plastic Utensils<br>Straws<br>Street Food Bowl<br>Styrofoam Container |
| Plastic Fragments | Film Fragments<br>Foam Fragments<br>Hard Plastic Fragments<br>Other Fragments |
| PPE | Associated PPE packaging<br>Disinfectant Wipes<br>Disposable Gloves<br>Face mask packaging<br>Face Masks<br>Face Shield<br>Hair nets<br>Hospital shoe covers<br>Other PPE |
| Tobacco Products | Cigarette Packaging<br>Cigarettes<br>Other Tobacco Product<br>Tobacco Sachets |

**Figure A1: Litter densities in transects and sites surveyed in San Antonio.**




An interactive web map version of this map is available at:

https://www.arcgis.com/apps/mapviewer/index.html?webmap=b55252fe93df4f25b537cb15efb39052