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Municipal Solid Waste Management from the Experience of São Leopoldo/Brazil and Zurich/Switzerland

Pamela L. Ghesla *, Luciana P. Gomes *, Marcelo O. Caetano, Luis A. S. Miranda and Léa B. Dai-Prá 

Civil Engineering Post-Graduation Program, UNISINOS University, Unisinos Avenue, 950, São Leopoldo RS 93022-750, Brazil; mocaetano@unisinos.br (M.O.C.); lalcides@unisinos.br (L.A.S.M.); bdai@edu.unisinos.br (L.B.D.-P.)

* Correspondence: plghesla@edu.unisinos.br (P.L.G.); lugomes@unisinos.br (L.P.G.); Tel.: +55-51-982-023-868 (P.L.G.); +55-51-999-767-772 (L.P.G.)

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Abstract: The challenge of developing country governments in municipal solid waste management (MSWM) is complex, often ineffective, and does not meet the required technical sustainability, which involves environmental, social, and financial aspects. The purpose of this research is to analyze two distinct waste management systems, in São Leopoldo (Brazil) and in Zurich (Switzerland), to develop a tool called “waste stream mapping” and also to compare the cities systems. The results show positively that the two municipalities have selective waste collection, however in São Leopoldo it was found that less volume was reinserted in the production chain, which considerably increases the volume of waste sent to sanitary landfill, which is the main method of disposal in Brazil. On the other hand, the Zurich management model is more expensive, especially compared to incineration, but its billing and power trading system ends up involving more of the population and paying for the operations, as Zurich generates more income than expenses. This study shows that each stage of waste management has its peculiarity and everything should be planned. The tool adapted from Value Stream Mapping has shown that it is useful to have a broad vision about the municipal solid waste management to be implemented.

Keywords: governments; municipal solid waste; management; stream mapping

1. Introduction

In recent years, a large number of research studies have been undertaken to determine influential factors affecting waste management systems in cities in developing countries [1]. However, even though the subject is frequently discussed, the problem of inappropriate management is still common in countries such as Brazil.

Municipal solid waste management is a service that represents a public health issue, since, if it is poorly done, it can result in the contamination of water, soil, and the presence of disease-transmitting vectors [2]. Because of these reasons, governments need attention in the choice of the best ways to serve it. In Brazil, according to the Federal Law No. 11445 [3], the collection, transportation, treatment, and final disposal of municipal solid waste are part of the public cleaning services, in addition to weeding and sweeping of public places. The National Solid Waste Policy of Brazil [4] was approved in 2010, determining the responsibilities of the generators and the public authority beyond other important challenges. However, the optimization of waste management is not happening. One of reasons, according to Mannarino, Ferreira, and Gandolla [5] is that the Brazilian regions are quite different with regard to their investment capacity.

In 2017, Brazil produced 78.4 million tonnes of municipal solid waste, 1% more than 2016, and collected waste was 71.6 million tonnes, evidencing that 6.9 million tonnes was disposed of in unknown places. From the total collected, 40.9% of waste was sent to inappropriate places, which do not have environment protection, it means 3352 Brazilian cities [6]. Although many cities still need to solve primary problems about municipal solid waste in Brazil—such as collecting, selective collecting, or final disposal—there are others, usually big cities, that started to search advanced technologies to waste management [5].

Un-Habitat [7] reported that waste management can be performed in different ways, and this variation occurs worldwide, with the accumulation of private attempts.

The authors add that the responsibility to choose the best sustainability strategies, to ensure the efficiency of costs and social operation, is one of the key challenges of a government.

This research has the goal of analyzing different waste management systems for later comparison and to develop a tool called “waste stream mapping”. The Waste Stream Map is a tool to study and compare management in different cities, verifying the entrances and exits, methods of collection, segregation, treatment, and disposal of materials. The cities chosen were São Leopoldo, in the south of Brazil and Zurich, Switzerland.

2. Materials and Methods

The choice of São Leopoldo and Zurich for this case study is justified by the cultural difference, date of foundation (or settlement), and the visibly distinct ways of waste management.

The survey (*) was divided into data collection: documentary and bibliographical research (reports, promotional materials, records), direct contacts, and elaboration of waste stream mappings for the two cities (Figure 1).

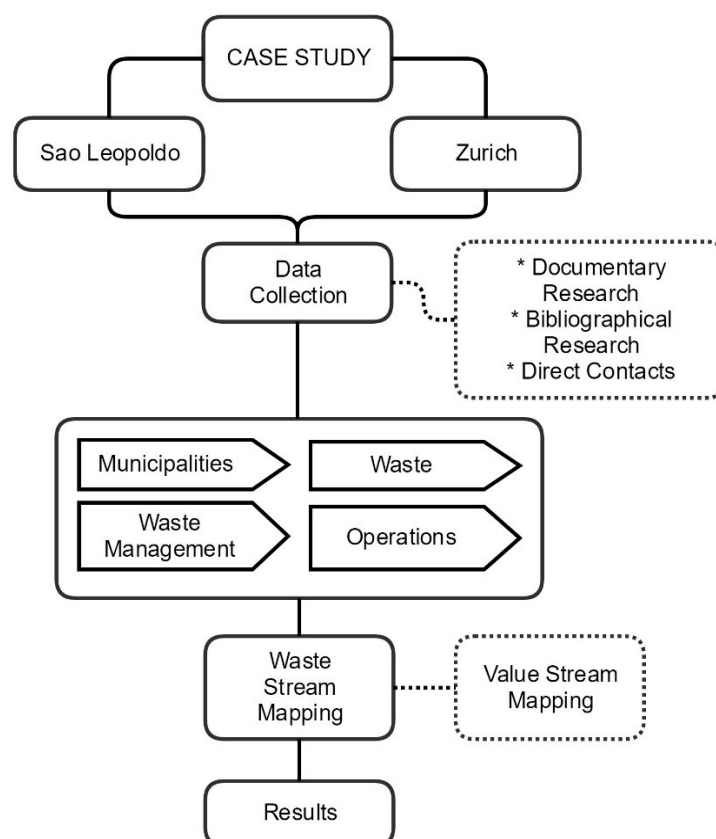


Figure 1. Methodological design.

Direct contacts have been conducted through personal interviews with those responsible for the waste management of each city and personal observation of the system. In São Leopoldo, interviews were conducted in 2011 and 2012 with the director of Municipal Public Cleaning Office (SELIMP) and in Zurich was made also in 2011 and 2012 with the Material Management Department director, of the Department of Recycling and Disposal (ERZ). Interview scripts were prepared to meet six indicators: global, operational, economic, social, quality, and political-institutional, following the proposals of Grimberg and Blauth [8], Macedo [9], Phillip Jr. and Aguiar [10].

The Waste Stream Mapping was adapted from the Value Stream Mapping, by Rother and Shook [11]. Different from other uses, this mapping is not focused just on value or time, the objective is to indicate in a single flowchart all waste management routines performed in the cities, allowing a wide analysis.

The results are presented as a report of cities and their municipal solid waste management. The two places are then compared, when their differences are analyzed. Finally, we present the conclusions of this work.

3. Results and Discussion

3.1. City of São Leopoldo

São Leopoldo is located in the state of Rio Grande do Sul, it has an area of 102.31 km² and according to the IBGE (Brazilian Institute of Geography and Statistics) [12], in 2010 its population was 211,663 inhabitants distributed in 24 districts of the city.

It is estimated through the mass of municipal solid waste collected, that São Leopoldo generates around 178 tonnes of waste per day, corresponding to 0.84 kilograms waste/inhabitant.day. Moura [13] held the characterization of municipal solid waste in São Leopoldo and the result indicated that 58.6% was putrescible waste, 13.3% was paper and cardboard, 12.3% was plastic, 4.3% was clothing and leather, 1.7% was glass, 1.5% was metal, 1.3% was milk packaging, 0.7% was wood, and 6% was considered waste, identified as: 0.7% of stones, soil, and ceramic, 0.3% of polystyrene, 0.3% of rubber, 0.2% of chemical contaminants, and 4.5% of biological contaminants, besides other mixed materials not identified.

Municipal solid waste management in São Leopoldo is held by the municipality, through the Municipal Public Cleaning Office (SELIMP), created in August 2010. SELIMP [14] has 51 employees operating directly on supporting of weeding, mowing, sweeping, and removal of debris. The other operational activities relating to solid waste are outsourced, under contract with a private company supervised by the municipal administration.

A “garbage fee” is levied annually, included in the IPTU (property tax) for all services provided by SELIMP. This value varies according to the area of the property; however, it was observed that even this does not contribute to the minimization of waste generation, since it does not refer to any kind of environmental education and awareness campaign, and also because the number of inhabitants per residence is variable, thus not compromising the relationship between waste rate and generation per capita. According to the municipality, the income associated with the garbage fee covers only 30% of these costs, with the remaining 70% paid with other public resources.

Waste Stream Mapping

The data collected in the interviews and observations were included in the Figure 2 flowchart which illustratively describes the steps in the management of municipal solid waste. The flowchart is based on value stream mapping.

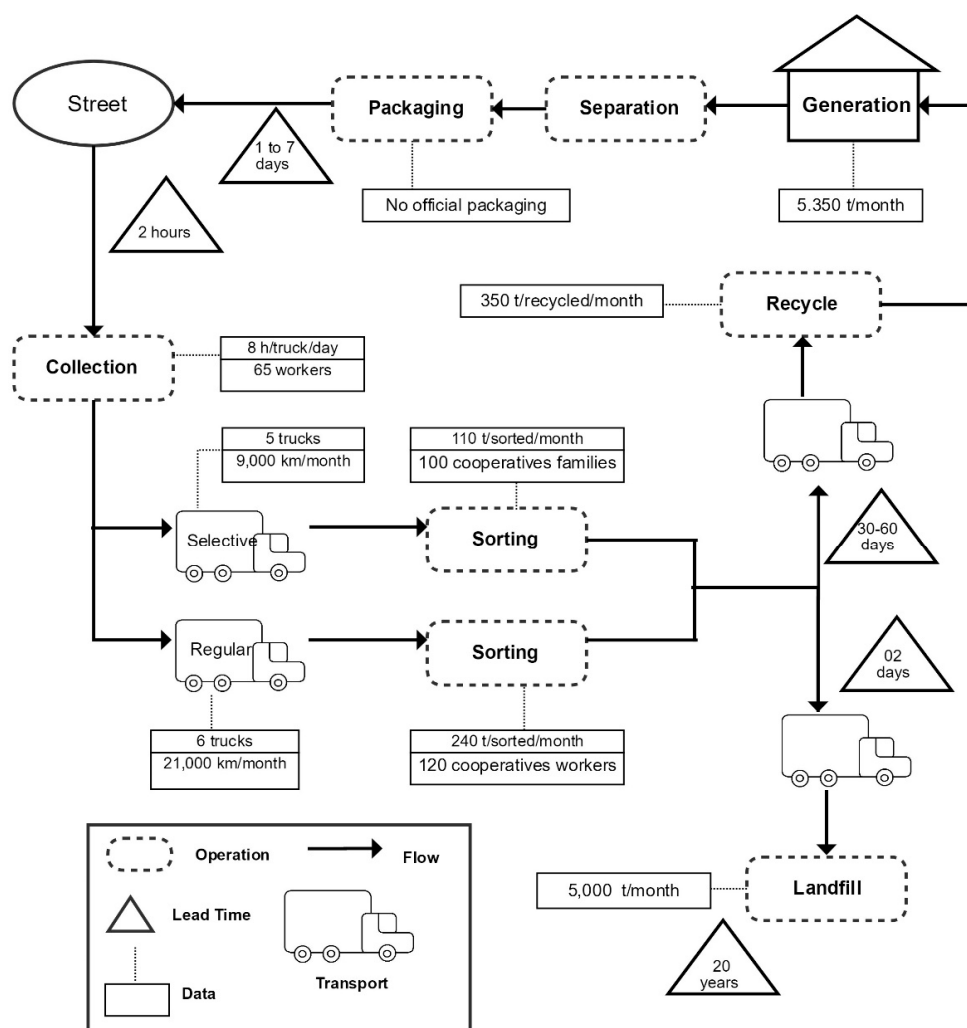


Figure 2. Waste stream mapping of São Leopoldo.

Packaging: According to the municipal regulation, the MSW must be properly packed and disposed on time and frequency set out in the official calendar of collection, in a period of less than 2 h [15]. There is no official packaging standard defined by the municipality; in general, the population has their waste in plastic bags or cardboard boxes.

It is very common the mixture of recyclable materials, as the packaging used are easy depredation, and often stay open, exposed to the action of rain and street animals. Materials such as paper and paperboard end up contacting wet waste, which means they can no longer be recycled or have their marketing value reduced. In cases of flooding, the bags end up moving through the streets, causing obstruction of the streams and pluvial system.

Collection and Transport: São Leopoldo's collection system, according to Table 1, is divided into recyclable collection (Collection A); collection of putrescible organic waste and non-recyclable (Collection B) and the collection held by the city's waste collectors (Collection C). This last collection is performed informally or by homeless people, that is, by people who are in an unfavorable economic situation, and use this alternative to improve their financial conditions, collecting the waste that have added value before the public collection trucks. With that, the economic issue of these people is partially resolved, but it worsened the problem of inappropriate disposal and in irregular areas, due to the lack of environmental education and because the sorting of waste is done in the homes of the collectors.

Table 1. Collection systems of São Leopoldo.

Collection A (Recyclable)	Collection B (Putrescible Organic and Non-Recyclable)	Collection C (Informal)
Sorting Recycling Landfill of residues	Sorting Recycling Landfill of residues	Sorting Recycling Inappropriate disposal

According to the municipality, the program of selective collection occurs once a week in all the districts, from 8:00 a.m. to 5:00 p.m., except the central district, where it occurs twice a week. All recyclable waste and non-putrescibles—such as paper, plastics, metals, glass, and cooking oil—are collected, with 65 people from the company outsourced working in this step.

Selective collection reaches other 100 points, among them schools and agencies, where the materials are separated for later collection by SELIMP truck. Companies that generate large amounts of waste are responsible for transporting them to the sorting center/sanitary landfill, when they should make the payment of a fee for disposal of the non-recyclable.

The costs associated with the collection of recyclables were not reported, only the rent of trucks in May 2011, which costs US\$24,365.38 (dollar exchange rate in August 2017 [16]). There is also the cost of collecting various waste of rubble, disposed irregularly, which was indicated by the interviewees as equal to US\$65,013.14.

Putrescible and non-recyclable waste is collected in the collection that occurs three times a week, on two shifts (7:00 a.m. to 3:00 p.m. and 7:00 p.m. to 3:00 a.m.). In the central district, daily collection is made due to the large quantity of waste generated, and it is estimated that this step costs the municipality approximately US\$33.30/tonne.

Currently there are six compactor trucks (four with 8 tonne capacity and two with 12 tonne), used in the collection of type B and five dump trucks (with 3 tonne capacity) for the selective collection, type A. The compactor trucks ride, on average, 21,000 km/month and the dumpers 9000 km/month.

The contractor reported that the main difficulties faced in São Leopoldo are relating to the education of the population regarding the separation of waste (with correct packaging), and compliance with the days and times of collection. In addition to these, there is also the difficulty of access for the collection trucks to some districts of the city, especially on rainy days. In central districts there is intense traffic of vehicles which also hampers the collection service.

Sorting: All the material coming from selective waste collection is forwarded to five sorting units, which receive the waste in a rotating system, i.e., all of them receive waste from all the districts. There is also a unit that separates the recyclable materials from collection type B, since many materials are mixed with that waste.

There is an agreement between municipal administration and waste collectors cooperative to provide, equipment, electricity, and water. They receive a quarterly allowance of US\$833.30 for other expenditure or allowance. There are around 100 families working and there is no weighing scale in all cooperatives, as a result, the accuracy of the values submitted for sorting is not exact, but, according to SELIMP, is approximately a total of 50 tonnes a day, as estimated by means of the weight of the waste collector trucks.

The sorting unit that operates on the sanitary landfill received, in April 2011, 3700 tonnes of waste. Of this total, only 241 tonnes were of recyclable waste commercialized (6.5%). The site was built to receive 90 tonnes a day, but currently receives 150 tonnes, which represents a large volume of waste sent to the landfill. The group of workers (23 people) sort 10 tonnes a day and the monthly income per person is around US\$176.30.

Sorting units of São Leopoldo perform a work at low cost for the public administration, ensuring savings regarding the cost with new landfills, as well as the reduction of social exclusion through employment and income generation; the actions related to waste management do not yet contemplate social and sociological issues and, for this reason, such actors still feel excluded and

marginalized. There is still an unsolved problem and estimation of quantitative control that needs to be faced by the municipality, which are informal collectors diverting recyclable waste before the public selective collection.

Treatment and Final Disposal: All sorted material is sold to about 20 companies or middlemen, which sell to industries that recycle the materials. The revenue gained from recycling is approximately US\$119,811.32, but this revenue could be greater if the sale was made directly to the purchasing industries, at least those close to São Leopoldo. The biodegradable waste could also be recycled if there was a composting plant in the town.

Putrescible waste and those that cannot be recycled because they have not been sorted on the cooperatives, are forwarded to a private sanitary landfill; the municipal administration paid in May (2011) US\$102,645.34 to dispose the waste at the landfill, namely, US\$26.86 per tonne.

3.2. City of Zurich

Zurich is located in the northeast of Switzerland and is the capital of the Canton of Zurich. Is the largest city in the country, with 91.88 km² and has 384,271 inhabitants (STADT ZÜRICH, 2010) [17].

The annual report of the local government, “Geschäftsbericht 2010” [18], estimated to generate approximately 120,000 tonnes of MSW in 2010. The value is very close to the previous years, the daily average generated per inhabitant is 0.86 kg or 314 kg per year.

The amount of materials sent for recycling outweighs the volume sent to incineration. Of 120,000 tonnes, 68 were sent for recycling, including paper and cardboard (22.00%), glass (9.52%), and pruning and garden waste (6.76%). This calculation do not include the value of the PET bottles. The remaining 52 tonnes were sent for incineration.

Municipal solid waste management of Zurich is held by the Department of Recycling and Disposal (ERZ), which is the largest department of the Department of Civil Engineering and Waste Management. This department is also responsible for receiving special waste from the city and the Canton of Zurich, and for the water and sewage treatment, urban cleaning, composting plant, energy management, and marketing of the heat generated by the incineration [19].

ERZ has approximately 900 employees, and 510 of these act in areas involving the management of waste. The only form of outsourcing of services is the collection and transportation of paper, cardboard and textiles (NGOs), glass, metals, PET, cooking oil (private companies). The companies themselves market the materials collected, without any payment by the municipality. The contracts are valid for one year, with the possibility of renewal.

The charging for services related to the management of municipal solid waste in Zurich is made in three ways. The first is part of the annual infrastructure tax, which also includes the service of wastewater treatment, and this collection is calculated by housing unit US\$89.07. The second, is a specific rate for trade, and the amount to be paid is US\$47.42, varying according to the number of employees of the establishment. The third form of charging refers to the bags sold to package the waste.

According to ERZ, the institution is non-profit, has the purpose of covering all the costs of waste management and still leave a reserve for the following year. The reserve obtained in the year 2011 was approximately US\$130 million.

Waste Stream Mapping of Zurich

Figure 3 shows the mapping carried out in Zurich based on all the information gathered.

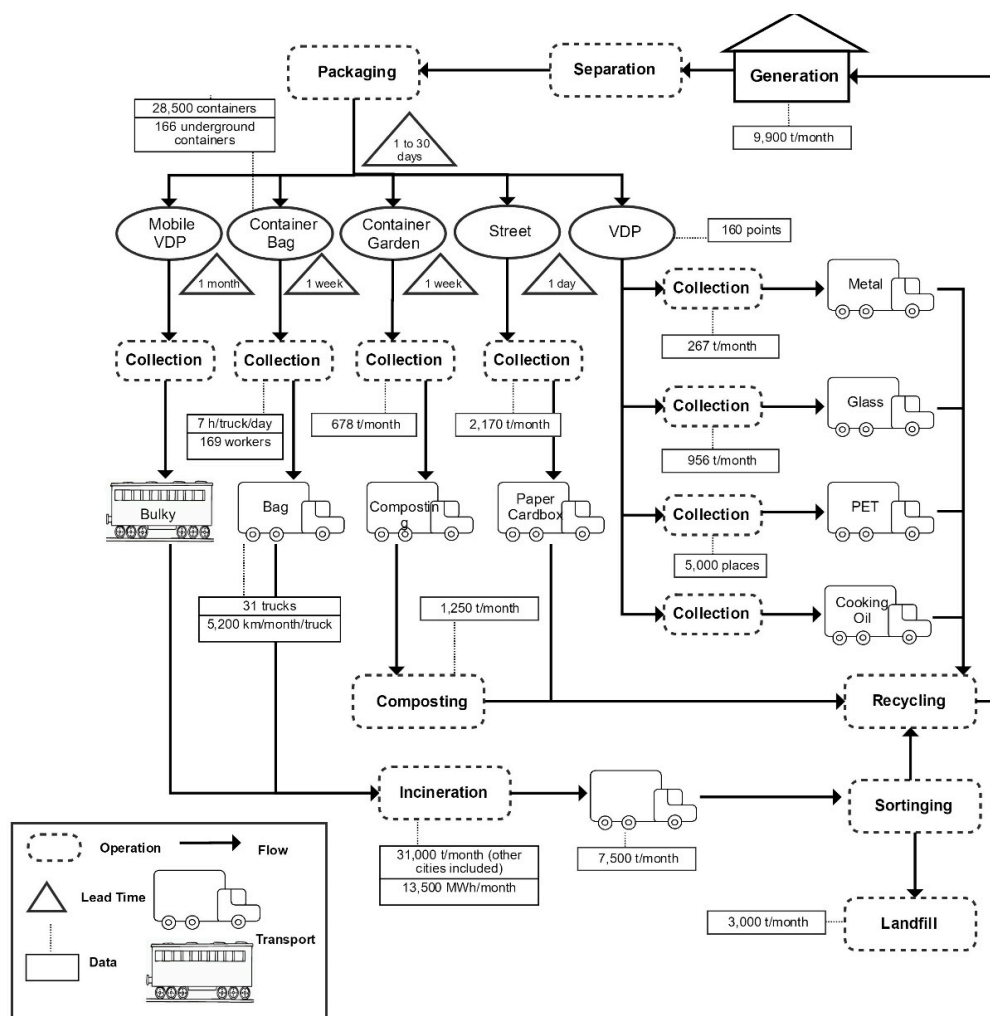


Figure 3. Waste stream mapping of Zurich.

Separation: Municipal solid waste separation is prior to packaging and the provision for collection, because it occurs directly in the source without the later step of sorting. It is the responsibility of the population to separate them according to their characteristics for the collection. The division of “paths” for the disposal of waste ends up influencing naturally the separation at source, because each category of waste must be packaged and sent in different ways.

Packaging: In 1993, a system called “Polluter-Payer” was deployed in Zurich, which requires (through municipal law) the population to acquire official packages from the municipality, called “Züri-Sacke”, to package their waste. The indication is that the Züri-Sacke should be used for: plastics, hygiene kits, packs of frozen products, incandescent bulbs, long life packaging, food remains (bones and meat) and other waste non-recyclable currently in the municipality.

The main objective is that the population dispose a minimum of materials capable of recycling, as these can be disposed for free, and that they should be more careful with the packaging at the time they purchase the products. The model also helps in sizing the volume generated, since in the vast majority of the time each family generate a bag a week. The price of each bag varies according to the size. Based on the values of the year 2011, a 17 L bag cost US\$0.87, a 35 L bag costs US\$1.75, a 60 L bag costs US\$3.20, and a 110 L bag costs US\$5.87; at the time of deployment of the system, the bags came to cost twice the value.

According to ERZ, since the implementation of the official bags, there was a 24% reduction in waste sent for incineration and a 32% increase in recycling. In addition, the number of collections in the city has been reduced. The person who does not comply with the law is subject to a penalty

of US\$257.73, but even so, daily are collected from 1.0 to 2.5 tonnes of waste in clandestine bags. This demonstrates that, even with the existing waste program, part of the population still does not participate appropriately.

Collection and Transport: The collection forms are determined according to the categories of waste generated, represented in Table 2. There are three types of collection: the first is made by a system of container for the “Züri-Sacke” and garden waste (Collection A); the second type is represented by the delivery of recyclable materials at the voluntary delivery points (Collection B) and the third form corresponds to the collection at door to door system of paper, cardboard, and textiles (Collection C).

Table 2. Collection system of Zurich.

Waste category	Collection A (Container)		Collection B (Voluntary Delivery Points)		Collection C (Door-to-Door)
	Pruning and garden waste	Official bags waste—“Züri-Sacke”	Recyclable waste	Residues	Paper, cardboard, textile
Processing	Recycling	Incineration	Recycling	Incineration	Recycling

The population may dispose their waste, conditioned in official bags, 24 h a day in plastic containers made available by the city (28,538 units scattered in the city). The containers have three dimensions and the average cost is US\$283.00. Annually approximately 140 units are destroyed, most of the time, burnt. Another type of container is “underground”, built at the bottom of the sidewalks and that store a higher quantity of bags; there are 166 units scattered in the city. The average cost of construction and installation is estimated at US\$46,000.00, being that the city contributes US\$3093.00, and the rest is afforded by the residents. In both cases (plastic containers and underground) collection occurs once a week in each district.

In the case of waste from pruning and garden, the system is similar to plastic containers, but these must be purchased by the population and the collection service is performed by the municipality. The ones interested must pay an annual fee of US\$61.23 for their waste (up to 100 m³) to be collected once a week.

In the municipal solid waste collection department of Zurich, there are 169 persons working, operating 31 trucks, from 7:00 a.m. till 11:30 a.m. and from 2:00 p.m. till 5:00 p.m. These daytime hours were established in function of the municipal law of silence, which does not allow noise after the lunch and at night. In the year 2010, 11,230,805 official bags of waste were collected.

The same vehicles used in the collections transport the waste to the incineration plants. Each truck travels 200 km/day, according to ERZ, being the annual expenditure estimated at US\$8,247,423.00.

The voluntary delivery points (VDP) are divided into three different systems. The VDP containers that are distributed in the streets (about 160 points) and receive the materials such as glass, metal, aluminum, and cooking oil; the VDP in freight trains (called “cargo-tram” or “E-tram” for electrical and electronic equipment), receiving the bulky and special waste, and the VDP on “recycling centers” (Recyclinghöfe). There are two VDP in recycling centers, one is located by the Hagenholz administration and incineration plant and the second next to the composting plant Werdhölzli.

In total, each residence in Zurich can dispose annually, free of charge, 400 kg of bulky waste in freight trains and recycling centers. To control this volume, annually, along with the official calendar, four coupons are delivered, from 1 to 100 kg each, to all residences. Wastes from construction and demolition, paper and cardboard, and pruning—or those who must be disposed in Züri-Sack—are not accepted.

Dispose of PET bottles also takes place through VDP (5000 points), but in Switzerland, the recycling of that material is part of a program in partnership with a private company (PET-recycling). Therefore, the posts not involving the ERZ are located in the commerce of the city—such as supermarkets, gas stations, and schools.

Treatment and Final Disposal: Recycling is divided into three groups: what is forwarded to the substitution of raw materials (such as paper, cardboard, glass, metals, plastic bottles, textiles),

compost (food and pruning and gardens residues) and the generation of thermal and electrical energy (incineration). Composting can be performed in condos, through homemade composters, or directly at the power plant of the ERZ-Werdhölzli, which receives the waste (except food) by monthly or per charge payment.

Zurich treats part of their municipal solid waste through incineration since 1904. The waste generated and that are forwarded for this treatment are those collected in the official bags of the city, the bulky waste, waste from industry and commerce (which are not special), wood, construction and demolition waste non-recyclable and the sludge from water and sewage treatment plants.

In the municipality there are two plants, being the main located next to ERZ in Hagenholz and the other in Josefstrasse. The two incinerated in 2010: a total of 371,417 tonnes of waste, being 98,696 tonnes from containers collection free of charge; 37,700 tonnes from nearby towns; 200,246 tonnes from private collections; and 34,775 tonnes from water and sewage treatment.

After the incineration of waste, around 90,000 tonnes of waste is generated, comprised of 79,000 tonnes of slag, 10,000 tonnes from the electrostatic filter, and 1000 tonnes from gas washing. The slag undergoes a kind of sorting, through which the waste of commercial value (such as aluminum) are sold for recycling. The remainder of the residue is forwarded to a landfill of inert materials, located in Lufingen (8 km from Zurich). About 120 tonnes are forwarded daily to the site, with cost of US\$74.00/tonne.

The electric energy generated by the incineration plants is distributed to the public energy network and the heat generated is sold (program “Zürich Wärme”) to 1500 places, being 41% to homes, 31% to service providers, and 28% to industries and commerce. According to ERZ, the heat generated (between 90 °C and 120 °C) is obtained by mixing of the components: 63% of waste, 14.5% of wood, 4% of heat collected on a system installed at the river of the city (Limmat River), 17% of natural gas, and 1.5% of oil.

3.3. Comparison between the Management of the Systems of São Leopoldo and Zurich

The difference of waste management between the cities of São Leopoldo and Zurich are related to financial issues, operational issues (packaging, sorting/separation, collection and treatment) and administrative issues. The waste stream mapping presented a visual flowchart about these differences, without any data it is possible to realize through the symbols that the Swiss system is more complex. It is also easy to compare the lead time between the steps, and it is important to determine how long waste is on streets or in residences.

Table 3 presents a comparison between the cities analyzed with some main information collected.

Table 3. Comparison between São Leopoldo and Zurich.

Characteristics	São Leopoldo	Zurich
Establishment	1824	5th Century
Inhabitants	214.087	384.271
Area	102.74 km ²	91.88 km ²
Inhab/area	2.084 inhab/km ²	4.182 inhab/km ²
GDP	US\$1.7 bi/2008	US\$52 bi/2008
Urban Waste	5350 tonnes/month	9900 tonnes/month
Waste/inhab	0.84 kg/inhab	0.86 kg/inhab
Responsible for the management	SELIMP	ERZ
Outsourcing of services	Yes (paid)	Yes (unpaid)
Contract's validity	20 years	1 year
Collaborators	220 (170 outsourced and 50 from the municipality)	510 (municipality)

Table 3. Cont.

Characteristics	São Leopoldo	Zurich
Directive plan for wastes	No	Yes
Packaging	Undefined packaging	Standard packing required
Collection	Door-to-door	Door-to-door voluntary delivery container system
Collection shift	Day and night	Day
Vehicles	Compactor trucks and dump trucks	Compactor trucks (mechanical collection) and Hoist
Recycled waste	350 tonnes/month	4643 tonnes/month (composting, paper, metal, glass)
Treatments	Sorting Recycling	Incineration Recycling Composting
Final disposal	Sanitary landfill	Inert landfill
Landfilled waste	5000 tonnes/month	3000 tonnes/month (included other cities)
Recovered energy	No	13,500 MWh/month
Waste social program	Yes	No
Commercialization of services	No	Yes
Sweeping of streets	Manual	Mechanical

With regard to the operational step of collection, it was observed that São Leopoldo, although performing door-to-door collection, has a smaller number of employees and trucks compared with Zurich. This is due to the fact that Zurich explores other activities, such as the commercialization of products and services.

In Brazil, the main methods of treatment considered are the pre-segregation of residues by residents and the recycling of materials such as paper (when in good condition), plastic, glass, and metals. As there are few environmental education programs, the pre-segregation of waste is not always correct, generating a lot of mixing between different materials and disabling recycling. For these reasons, in the country, about 60% of the MSW collected is destined to landfills; only 1.9% is screened; 0.2% composted and the remainder is destined for controlled landfills or dumps [20]. São Leopoldo does not have composting treatment, but already has a sorting center, which is one of the methods that assists in increasing the recycling percentage and decreasing the amount of landfilled waste.

Although the landfill is not the best option for final waste disposal or treatment, due to Brazil's aging and developing country status, it has been increasing the percentage of correct disposal over the years. In the past, it was common to dispose of waste in ditches or dumps without waterproofing, or any environmental care. Studies already performed show segregation at the source, sorting, recycling, and final disposal in landfill (with leachate treatment and gases), lacking only the composting of organic waste, as a scenario of lower environmental impact, compared to other environmentally incorrect methods, such as dumps [21–23].

Cities like Zurich which already have a waste management plan and have been educating the population for many years, because they already understand the importance of the correct treatment and disposal of waste, gain in the management of these materials. They have consolidated investments for the treatment of waste, as well as different ways of disposal, by the population. The fact that the municipality is not alone in charge of waste management also contributes to a correct disposal, since the population is paying treatment and final disposal of their waste, becoming responsible for them, leaving the residents with the responsibility to send waste to the right place. In the literature, there are several references to waste treatment systems by sorting, recycling, incineration, waste landfill, and organic composting, which generate great savings of resources. These treatments also generate

costs and environmental impacts, but according to studies, the gains in energy and benefits that the methods bring, they end up compensating, for example, the ecological footprint related to the impacts. [21]. LCA (life cycle assessment) studies for MSW management show that these processes (sorting, recycling, incineration, landfill, and composting), when used together, as in the case of Zurich, are considered a solution to promote sustainability and overcome the problem involving management of waste [24,25].

For effective waste management, it is necessary to know the stakeholders. In the case of São Leopoldo, there is the population (generators), the cooperatives of garbage collectors (social work for low-income people, who used to collect waste in dumps), and the city hall (public agency). The costs are minimized for the population (collection fee—IPTU—property tax) and mostly with the public agency (transportation, treatment, and disposal costs). In Zurich, the stakeholder group becomes larger, being also composed by the population and city hall, but instead of cooperatives of garbage collectors, the city works with the private sector, coming from outsourced companies that collect several wastes. The population comes in with a good portion, considering that they need to deliver some waste at strategic points, reducing collection costs. Most of the costs come from residents, who pay annual fees to receive collection, treatment, and final disposal services.

While São Leopoldo did a social work, removing people from misery (garbage collectors, in poor health), and giving jobs in cooperatives, Zurich works more with environmental education of the population, avoiding the mixing of waste, through separation differentiated packaging and environmental incentive in schools. As seen in the literature [26,27], businesses involving solid waste management in both developed and developing areas depend on stakeholders to promote the management of this area, since the greater the interest is, the greater the value capture that can be achieved, as can be seen in the financial comparison between the two cities.

As to the financial question (presented in Table 4), Zurich disclose and publish annually for the population the values related to the revenue and expenditure. This is an important tool of waste management because it allows for transparency of operations.

Table 4. Financial comparison between São Leopoldo and Zurich.

	São Leopoldo	Zurich
Revenues (US\$)	1,895,192.31	161,266,112.16
Expenditures (US\$)	4,128,205.13	130,113,601.24
Reserve for 2011/2012 (US\$)	Not determined	12,107,216.50 to 2011
Negative balance (US\$)	2,233,012.82	Zero

In São Leopoldo, the value of revenues has not been determined officially by the department. Therefore, the value was estimated on the basis of which is obtained by the sale of recyclable materials, in the five sorting units, adding the value received through the payment of IPTU (property tax) by population. This last value, according to SELIMP, currently corresponds to approximately 30% of the total amount of the costs involved with these services. For the calculation of the expenses, it was added the values related to payment to services of collection and final disposal in sanitary landfills, and the subsidized values for the sorting units. It should be included in the expenditure the values relating to salaries of 51 employees of the Secretariat and also the maintenance of equipment and other services, but these data were not made available by the Municipality of São Leopoldo. For Zurich, it is clear that, even though expenditures are much greater than São Leopoldo, gains are also greater. The city still had a reserve fund for the year 2011, like previous years. Given this, it is considered that, given the organization of the Swiss city; good financial management, with great contribution of the population and almost no public investment; and use of technologies that present a good cost benefit, this city presented a better financial situation than that of São Leopoldo. Observing this, it is clear that the participation of the population as the main financial manager of their waste contributes greatly

to the success of Zurich's management, while São Leopoldo is suffering from the dependence of the public agency, already so deficient in many areas, not only in this city, but in Brazil at large.

4. Conclusions

The waste stream mapping has been adapted from the known value stream mapping, allowing an overview of important information collected and their process differences. This tool can be optimized and used in studies in other cities, considering that each city has its own characteristics and the research must be adequate for it, aiming at the success of the results mainly about time and value information.

It was found that, in São Leopoldo, the environmental department does not have its own resources to keep the management, which is maintained, partially, by the revenue from IPTU (property tax for residences) and mostly by other areas of the municipality, with resources destined for the environmental area. This fact contributed to the imbalance between revenue and expenditure, not becoming clear the origin of the problems for the environmental department and for the population of the city.

São Leopoldo acts only in waste removal and subsequent disposal in sanitary landfill, without prioritizing non-generation/minimization and treatment of materials, especially with putrescible waste. Mostly because the city cannot afford most of the expenses, it gets hard to implement new technologies of treatment. It occurs also in the country and being the sanitary landfill one of the cheapest methods to disposal of the waste, the cities choose to be it. However, it also got better over the years, given the fact that disposal in dumps has been decreasing. In addition, it is possible to notice that there are conflicts between the SELIMP and contracted company, as each one has data and statistics that distinguish and differ among themselves. The lack of historical records allows important information to be lost which inhibit future planning based on real data. This is one of the points to be improve as soon as possible.

In Zurich the polluter-payer system, fees and commercialization of energy can sustain the waste management system of the city. It is interesting to note that in this case, the city is responsible for collecting, possessing own vehicles, equipment, and even offers private services, which helps in the monetary collection. On the other hand, the waste incineration generates high costs of implementation, maintenance, and environmental control of their units. Although this technology is expensive, incineration, when well-operated, overly minimize the quantity of waste disposed in sanitary landfills, a suitable method only for tailings disposal, and still gains on energy production. Composting also is a great method, that values the organic waste, transforming it into fertilizer, for example.

On the text above, it can be concluded that ERZ requires high standards of control to keep its waste management system working, especially because of the various types of collections held in the city. It can also be seen that the population has better social and economic conditions than in São Leopoldo, allowing greater freedom to the municipality for the selection of the management methods. As the population is educated, compliance with the rules will improve naturally.

Zurich develops environmental education works, selective collection and waste treatment alternatives for longer than São Leopoldo, being these activities essential for the adequate participation of the population. São Leopoldo have great chances of improvement along the years. It is a young city, but it already has the consciousness of the benefit of taking care of the environment. Zurich shows itself to be a well settled city, with years of experience, which is advanced in the environmental area precisely because it has had previous environmental problems and been able to solve them. Even so, it can be concluded that most people, both in Switzerland and in Brazil, participate in activities tied to the laws imposed by governments.

Through the analysis presented in this research, it is possible to reflex about how important and complex are the choices made to waste solid management to get systems that are economically viable, socially appropriate, and environmentally right.

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