Assessment of municipal waste management systems using performance indicators to analyze recycling capacity The case study of Corumbataí basin, São Paulo state, Brazil

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Abstract

The analysis of waste management practices is a multidimensional challenge faced by authorities, especially in developing countries, where actions are needed to reduce, reuse and increase recycling. Performance indicators are often used to assess the quality of municipal solid waste management systems. However, some studies suggest that different realities require different indicators to evaluate the quality of management systems. Moreover, effective data on the reality of municipalities are scarce, especially on the work carried out by the informal sector within the waste management systems. The purpose of this study was to investigate a set of indicators in order to examine the recycling modes and capacity of six municipalities in the interior of São Paulo estate in Brazil. Focus was placed on how the collection of the material for recycling is carried out. The analysis revealed that the municipalities have selective collection being carried out in urban areas, but in different ways and not always with the support of the public power. The reality found in this study points to a great participation of the informal collection in the recycling capacity of the cities surveyed.This study estimates approximately 8% of refuse are collected by the informal recycling of the total amount estimated for generation every year in the investigated cities. The average recycling rate in selected cities is 10.8%.

Keywords: *Municipal waste management; waste indicators; informal sector; recycling.*

1. Introduction

Management of solid waste is one of the most important functions in cities administration, it is a key service on which public health and the external image of the city depend[1,2]. As a result, waste management is a challenge for cities around the world, due to several factors such as growing generation, high management costs and lack of understanding of the diversity of factors affecting functions and interactions of the stages of waste management systems[3,4,5]. It is worldwide recognized that the integrated approach of waste leads the system to greater sustainability, for which the first step

consists of knowing all the elements that compose the system[6]. It has been reported by authors that one of the factors affecting waste treatment is the lack of access to information on waste management systems by the authorities[7,8]. Few studies report quantitative information on management systems, especially in low and middle income countries where informal services can reach high level of participation in recycling rates[9,10,11,12].

Appropriate waste management actions involve increasing recycling and reducing the amount of waste landfilled and incinerated[22]. Recycling occurs in different income countries as an importantwaste management strategy, also called the circular economy is applied by governments mainly in the European Union[23,24,25]. In low and middle income countries recycling occurs as a form of revenue for thousands of people[26,27]. In these countries, it is a matter of urgency to implement inclusive policies so that the role of the informal sector in clearing cities and recovering materials is recognized[1,15,28,29].

It is remarkable that municipalities with less than 30,000 inhabitants represent 80% of the municipalities in Brazil[30], therefore, solutions for these municipalities are important. These municipalities also present higher rates than the national averages for recovered mass and percentage of recovery of dry recyclables[30].

The aim of this study was to analyze and suggest indicators for city-level decision-making. The researchers purpose of this study was to investigate a set of indicators in order to examine the recycling modes and capacity of six municipalities in the interior of São Paulo estate in Brazil. Focus was placed on how the collection of the material for recycling is carried out.

In six municipalities (five with less than 30,000 inhabitants and one with 199,000) that make up the Corumbataí river basin in the state of São Paulo, Brazil. Data were collected with focus on recycling dynamics performed by formal and informal sectors. These dynamics represent important actions and should be taken into account when analyzing processes in waste management by the authorities in Brazil.

1.1. Overview of current knowledge

To reach the sustainability in waste management (i.e. treatment of waste in proper way and production of secondary raw materials and energy resources), following waste hierarchy should be applied:

1. Prevention,
2. Preparation for re-use,
3. Recycling,
4. Other recovery, e.g. energy recovery; and
5. Disposal[31].

Performance indicators are indispensable tools for decision-making processes and, when used correctly, can lead to innovative policies and new technologies[31,32]. The indicators offer an understanding of the conditions of systems and provide support for the decision making process. The actions related to waste management can be directed based on appropriate indicators to evaluate the real needs of the municipalities[33].

The most commonly used indicator to measure the environmental effectiveness of waste management systems is the recycling rate[34]. This is because it is complicated to measure waste reduction, so recycling is the option that can be measured[32]. However, other authors suggest that only the recycling rate is not sufficient to evaluate the sustainability of management systems, since this indicator does not assess the impacts caused by non-recyclable materials[35,34,32].

Therefore, to carry out an analysis that perceives reality effectively, several indicators are needed to evaluate the different aspects of the waste management system. Recycling fully participates in any sustainable waste management system and can be a waste recovery activity carried out by the formal or informal sector[36,37,13,5]. However, this work depends on source segregation, selective collection, sorting, mechanical processing and marketing[26].

In developing countries, waste recovery activities are often carried out by the informal sector[39,11,12,40]. That is, those activities that are not recognized by municipal waste management, so they are not accounted for the system. This is because, in developing countries, generators are not always recognized and often send their waste to recycling for revenue without be counted by the formal system[6,18,42]. Studies suggest that informal sector contributes to increasing recycling rates and decreasing the costs associated with waste management[43,6,1,26]. Informal sector is clearly a key ally in cities, if cities were to deal with such waste quantities the costs would be higher[1,44]. It has been reported by many authors the recycling activities performed by informal sector in China[45,8,5,38].

Studies about waste flows are important to support authorities on how to deal with different stakeholders in order to recover material and actors activities. Public acceptance and awareness of waste facilities are important for effective waste strategies. Garnett et al.[52] produced an empirical framework for negotiating the mode and level of public involvement in waste management decision-making, and suggest a need for greater inclusivity and awareness of stakeholders. Berg et al.[62] analyzed transformations occurred after changes in waste management legislation in Poland and have described that legal context of selective waste collection as one of the most effective ways to reduce the amount of waste sent to landfills. Aparcana[58] reviewed barriers and success factors for formalization of the informal waste sector, and concluded that the empowerment of informal workers is confirmed as a further key success factor for the formalization.

Ibáñez-Forés et al.[65] analyzed the evolution of the municipal solid-waste management system of João Pessoa (Brazil), which is one of the pioneering Brazilian cities to implement door-to-door selective collection programs; the authors concluded that the implementation of awareness-raising campaigns should priority in policies on solid waste. Davis and Garb[64] describes the informal work in the Israeli-Palestinian context and show how synergic solutions of partnership between formal and informal sectors can improve livelihoods of informal recyclers while reducing health risks and environmental impacts.

In this way, the study performed by UNEP[60], Global Waste Management Outlook, declares it is necessary to integrate the informal sector to work alongside the formal sector and thus incorporate it to the system. That is a challenge for authorities all over the world.

2. Materials and methods

This study was conducted in six municipalities in order to map waste flows and waste management practices. The methodology used for the development of this research involved a review of the literature on performance indicators for residues, definition of objectives, elaboration of research planning and questionnaires, implementation of field research and application of questionnaires directly with social actors, data collected in the field, analysis and evaluation of the data found, and finally, preparation of the final report. Data collection was carried out from July to December 2017 with the purpose of understanding the household solid waste streams of the municipalities investigated.

2.1. Study area

The municipalities make up the Corumbataí river basin in the interior of the state of São Paulo (Figure 1), which are five with less than 30,000 inhabitants (Analândia, Charqueada, Corumbataí, Ipeúna and Santa Gertrudes) and Rio Claro with 199,000 inhabitants. The total population of these municipalities is 256,819. Brazilian legislation provides that solutions for waste management must be taken from river basins, because this way the natural resources can be respected.

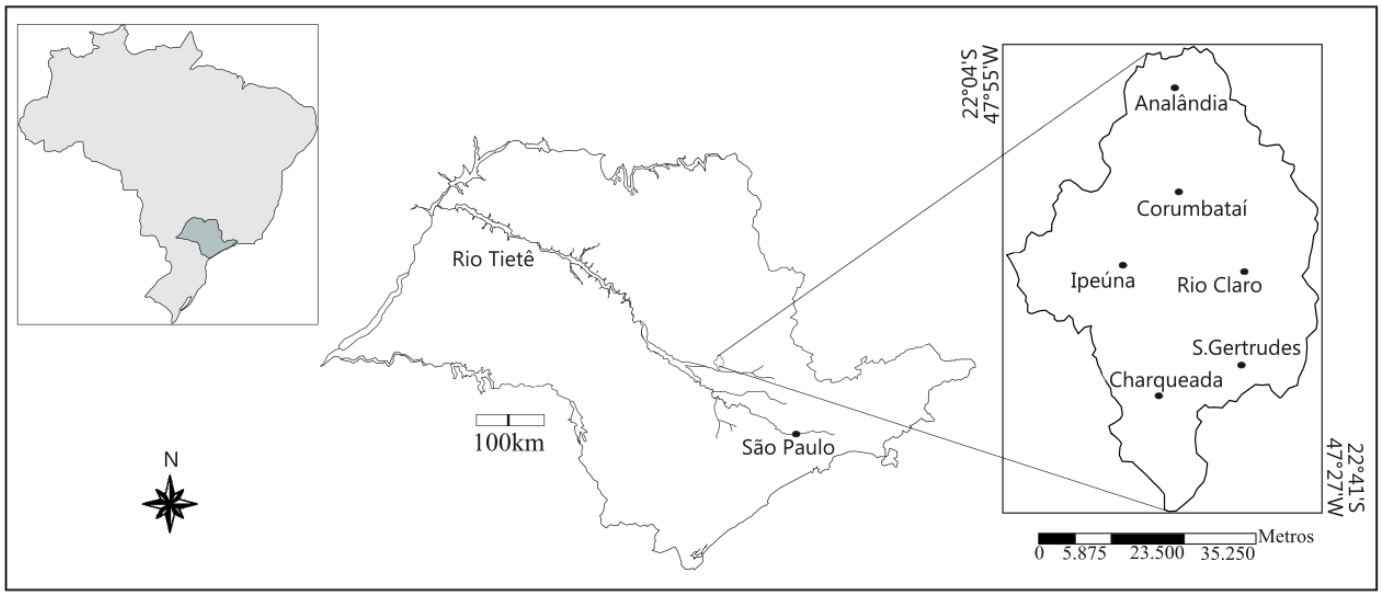

Figure 1: Location of study area. *Source: Own creation*

2.2. Construction of indicators

With the purpose of reveal the flows of the commercial and public solid waste management system of the six municipalities a set of performance indicators were selected. These were chosen in order to analyze all the different stages of the waste management system in the municipalities. With this, the chosen indicators contemplate quantitative and qualitative values of generation, of regular, selective and informal collections, as well as financial and administrative aspects of the practices adopted in the cities studied.

This step consisted in selecting and elaborating the set of indicators based on the survey of the main aspects related to the management of solid urban waste. For this, a bibliographic survey was carried out on the subject, followed by consultations with articles from periodicals, theses and dissertations whose themes involve indicators of solid waste management.

During this phase, a great number of indicators were found, applied in different ways, with several objectives[46,47,48,2]. In this work, we sought to group and select indicators related to the technological and financial issues of waste management in the studied municipalities. On the definition of solid waste, Wilson et al.[48] state that there are different ways around the world to define municipal solid waste. The values investigated in this study are on solid waste generated in households and businesses and do not include health service waste, construction waste or industrial waste.

2.3. Data collection

At the beginning of field work, a survey was carried out to recognize the organizations included in the household solid waste management system, especially those involved with regular, selective collections and informal collection routes conducted by private companies that buy and sell recyclable material. Three different structured questionnaires were developed, tested previously and modified to collect information with city hall employees, recyclable material cooperatives workers and recyclable trade establishments where informal collectors sell material. The organizations were visited and whenever possible, interviews were conducted directly with the actors. Also, data were obtained from public databases in Brazil. The primary data of this research were collected directly with the institutions that manage the various materials. At that stage, prefectures, cooperatives and establishments of commercialization of recyclable material were visited. The data collected refer to the amount of material accounted for by public bodies and published as values for generation and also declared values of collection by formal and informal street scavengers.

Secondary data was investigated to compose the set of performance indicators. Databases provided by the specialized public agencies were searched. Most of the data surveyed are available from the National System of Information on Sanitation - SNIS and the National System of Information on the Management of Solid Waste – SNIR [67], however, also the databases of the Brazilian Institute of Geography and Statistics - IBGE and the Environmental Sanitation Technology Company of the State of São Paulo. Also, values were consulted in the National Treasury Secretariat (STN) to compose the expenditure indicators.

Primary and secondary data refer to the years 2015, 2016 and 2017. Whenever possible, data from the same year were crossed and interviews were conducted directly with the responsible for the information investigated. Although effort was made to obtain all the information in the six municipalities investigated, not all prefectures provided all the information, this fact occurred both in the investigation of primary data and in the investigation of secondary data.

All set of indicators selected were calculated for each of the six municipalities studied, when data existed. The indicators were grouped by stage of the waste management system and over expenditure. At the end a process flow diagram was elaborated to map the results.

3. Results

The findings from the research provides a framework of waste flows, which allow for greater comprehension of waste management practices carried out in the investigated cities. Important outcomes show information for waste generation, selective collection, informal collection, recycling rate and expenditure indicators.

3.1. Waste generation

According to Sujauddin et al. [66], the generation of waste is influenced by the size of the families, the level of education of people and economic level, the last was also pointed out by other authors as being a factor that affects the generation of waste[49,42]. However, in Brazil, it was reported by the SNIS [67] in 2015, that the northern and northeastern regions, although they are regions with the lowest GDP per capita (18,358.59 and 15,002.31 R$ / hab. year) had the highest rates of generation per inhabitant (1.13 and 1.22 kg / inhab. day respectively). The same report points the possible causes such as greater control in waste landfills in the south and southeast (0.84 and 0.96 kg / hab. day respectively) or the diversion of recyclables by informal collection and, consequently, non-accounting inside the system.

On average, per capita waste generation was 0.8 kg / inhab. day (Table 1) in the investigated municipalities. Ipeúna presented higher generationthan the national average (1 kg / hab. day). The other cities presented generation lower than the national and regional averages (0.96 kg / hab. day), at this point it should be taken into consideration that there are recycling works being carried out in almost all the municipalities and the official values of per capita generation are calculated from the values of regular collection. These results can be due to informal work that collect recyclable material and divert it from regular collection.

Table 1: Population, GDP per capita and per capita generation rate

City	Total population[(1)]	Urban population[(1)]	GDP per capita[(2)] (R$/hab.year)	Generation per capita[(3)] (Kg/hab.year)	Regular collection in % on Inhabitants[(3)]	Rural collection in % on rural Inhabitants[(4)]
Corumbataí	4,054	2,191	24,506.35	0.90	54	20
Analândia	4,845	3,847	28,983.51	0.70	ad	0
Ipeúna	7,177	6,177	86,883.95	1,17	86	ND
Charqueada	16,772	15,216	15,988.52	0.70	91	ND
S. Gertrudes	25,637	25,364	64,130.83	0.78	95	0
Rio Claro	202,952	198,012	42,613.74	0.71	97	100

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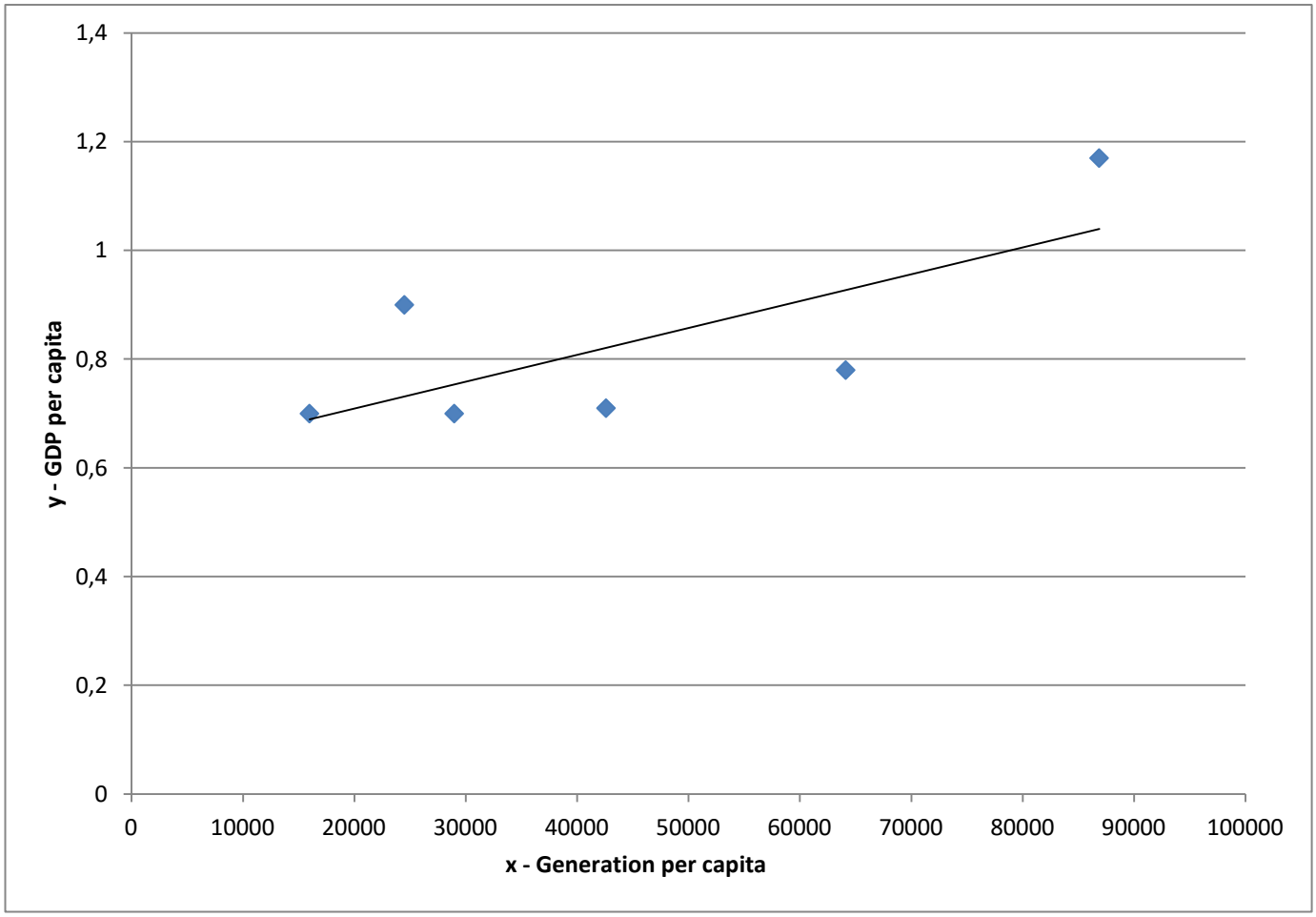
Fonte: (1) IBGE, 2017; (2) IBGE, 2014; (3) SINIS, 2015; (4) Dados de campo.
Source: Research data.



Graph 1: The relationship between GDP per capita and generation per capita *Source: Own creation*

Coverage data of regular collection show that not all the population has access to the regular collection service, especially the rural population. For example, Corumbataí has large part of its population living in the rural area and only part of that population has access to the regular collection service. Regular collection of rural area is a difficult situation faced specially by cities where rural population is large.

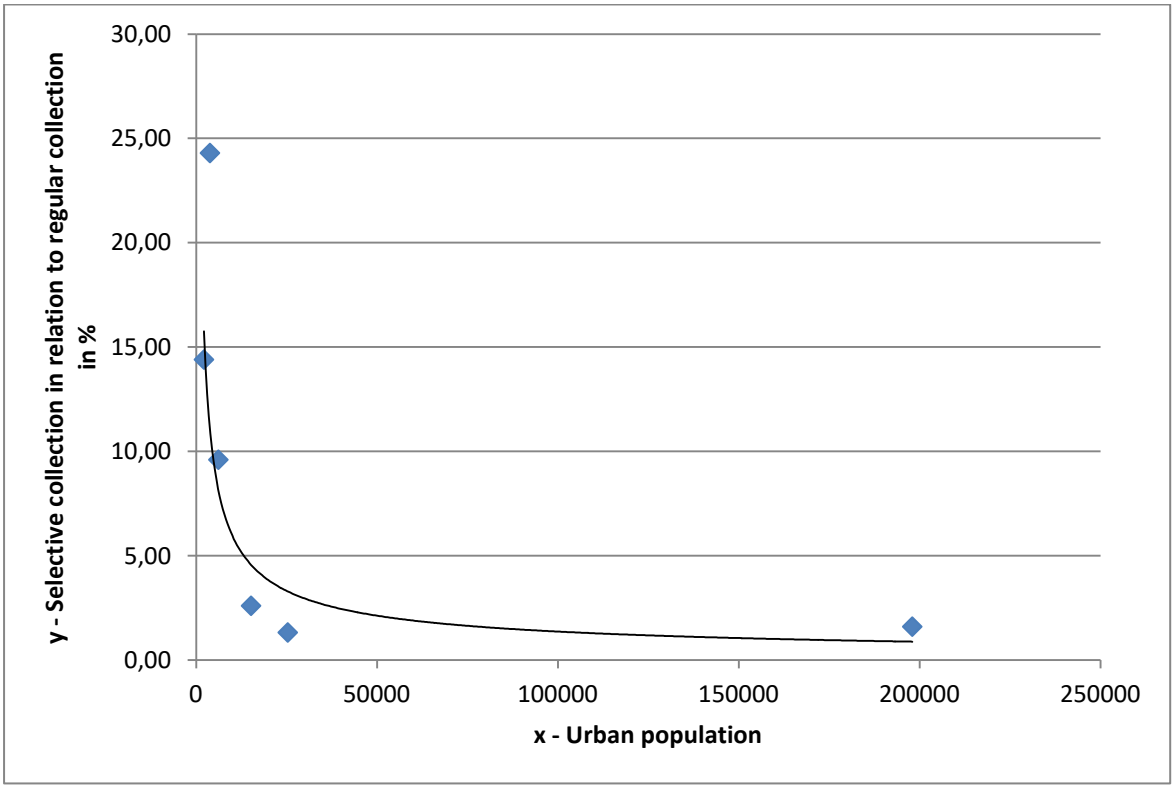
3.2. Selective collection of recyclables

For this study, it was defined selective collection as collection of recyclables offeredfrequently in urban zones, with or without public support. Table 2 shows field data for selective collection.

Table 2: Selective collection structure

City	Selective collection in relation to regular collection in %	Selective collection waste in %	Efficiency of workers (kg/person month)	Revenue per worker (R$/person. month)	Average revenue per recyclable (R$/kg)
Corumba- taí	14.4	12	1,222.20	738.88	0.60
Analândia	24.3	12	4,250.00	2,080.00	0.49
Ipeúna	9.6	3	2,550.00	1,765.00	0.69
Charquea-da	2.6	ND	ND	ND	ND
S. Gertrudes	1.32	17	890.08	1,397.91	0.80
Rio Claro	1.6	10	1,042.20	733.20	0.70

ND – No data provided on this aspect.
Source: Research data.



Graph 2: The relationship between urban population and selective collection in relation to regular collection in %. *Source: Own creation*

Informal collectors in Analândia and in Ipeúna offer urban selective collection. Many studies pointed informal sector as important part of SWM in low and middle-income countries[50,6,1,26]. In Analândia, a family company provides a service that covers the entire urban area and provides packaging for recyclable waste. This family company reaches the highest worker efficiency and revenue. In Ipeúna, informal collectors collect in their own vehicles and have a shed of the city hall to carry out the sorting of the material. In Charqueada, Santa Gertrudes and Rio Claro there are low-income collectors associations (cooperatives) that offer the service in the urban area with help from city hall. Analândia, Corumbataí and Ipeúna achieve considerable values of selective collection in relation to regular collection. Rio Claro, Charqueada and Santa Gertrudes presented selective collection incidence around the Brazilian average of 2.2% [30].

In Corumbataí, the city hall offers the service through a program started 20 years ago. The incidence of selective collection on regular collection signals to the success of the selective collection program of the city council of Corumbataí that obtains 14.42% of recycling on the total collected by the regular collection. The success of a waste management system depends on the segregation at source, which is the result of the active participation of the generators. However, in developing countries, generators are not always known and often refer their waste to recycling without being accounted for by the system[6,42].

3.3. Informal collection

This study focused in identify a waste stream that is not accounted for by the formal management system, in this case the material purchased by recycling depots from generators and from informal collectors that go through urban area looking for recyclable materials. The recycling depots are commercial establishments that deal with population in general to buy recyclable material. For this studied it was investigated the recyclable material bought from people or commercial establishments as supermarkets, stores, bakeries, restaurants, etc, not from industries. The numbers found in this survey were investigated directly with people who buy the recyclable material in small private companies. These companies buy the recyclable material from informal collectors, who run through the surrounding streets of these companies collecting material left for the regular and selective collections or directly with the generating households. Depots also buy material from larger generators that market their waste and, therefore, send waste for recycling in an informal way that is not accounted for by the waste management system. These entrepreneurs are usually a family small company with few employees. The work of these business is responsible for divert tons of material from landfill every year in five of the six studied cities. Table 3 shows the investigated infrastructure of informal recycling.

Table 2: Infrastructure for collecting recyclable material via recyclable deposits

City	Recycling depots	Inhabitants perdepot	Informal recyclable recovery (t/hab.)	Incidence of informal recyclable recovery (%)	Recovered material through depots in relation to regular collection (%)
Corumbataí	0	-	-	-	-
Analândia	1	3,847	17.00	100	21.0
Ipeúna	1	6,177	20.40	100	10.0
Charqueada	1	15,216	2.10	20	0.66
S. Gertrudes	3	8,455	45.50	83	6.76
Rio Claro	14	14,144	511.40	88	12.27

Source: Research data.

In Rio Claro, the largest municipality investigated, the incidence of recycling through recyclable deposits corresponds to 88.45% of recycling capacity. High values for the participation of informal sector in the recycling process of the municipalities studied can be explained by large generators sending their waste for commercialization via the establishments that were investigated once it represents a recipe for their business.

The same was pointed out by Scheinberg et al. [26], who investigated informal recycling in cities in middle- and low-income countries and found that this work is carried out by families and family micro-enterprises that seek to recycle discarded material, a form of income. Informal recyclers rely entirely on recycling revenue and do not receive financial or social recognition of their work to recover materials that would otherwise go to landfill with waste management costs[1].

3.4. Recycling rate

The recycling rate indicated in this study take into consideration informal collection. Corumbataí generate the highest recycling rate per urban inhabitant (Table 4), this city has a large rural population that doesn´t have selective collection. Rural areas are usually the most difficult for city councils to attend with regular and selective collection. Analândia generates second high recycling rate, also has a large rural population that doesn´t have access to selective collection, but where the informal small family company acts in the urban area numbers for recycling rate show similar results from Corumbataí. Actually selective collections of both municipalities are similar, in Corumbataí city council distributes packages for recyclable materials and in Analândia informal collectors also distribute packages for recyclable material. Small municipalities in Brazil (up to 30,000 inhabitants) had a higher recycling rate per inhabitant (23.9 kg/hab. year) than other population groups and the national average (8.0 kg/hab. year)[30]. This fact can be explained by the greater participation of the informal collection in larger municipalities or even greater participation of generators in selective collection programs, which are common in the Brazilian municipalities.

Table 4: Recycling indicators

City	Recycling rate formal + informal (kg/person year)	Selective collection (kg/hab. year)	Total recovered for recycling (t/year)
Corumbataí	60.25	60.25	132.0
Analândia	53.03	53.03	204.0
Ipeúna	39.63	39.63	244.8
Charqueada	6.68	6.55	124.8
S. Gertrudes	26.65	4.21	652.8
Rio Claro	35.56	4.04	6,937.2
Average	42.73	27.95	Total 8,295,6

Source: Research data.

Source segregation is a fundamental step in the operation of an integrated solid waste system[42]. Attitudes of population to separate recyclable materials are affected by active support and real investments of management system, besides the existence of committees of public participation[52], or the existence of taxes and systems of collection by the waste management system[26].

3.5. Expenditure indicators

Analândia did not present data for the expenditure indicators. The numbers presented were reported by prefectures about public cleaning expenses. The values account for expenditures on selective waste collection in municipalities that offer formal selective waste collection, such as Corumbataí, Charqueada, Santa Gertrudes and Rio Claro. However, municipalities did not provide data on specific expenses with selective waste collection. Corumbataí presented the highest expenditure per kilogram (Table 4) and per inhabitant, but the lowest percentage of expenses with regular collection. Ipeúna obtained the lowest values of expenses per kilogram, but Charqueada presented the lowest values for expenses per inhabitant.

In low and middle-income countries, data are rare and little is known about informal sector participation in recycling[26], however, studies by UN-Habitat [1] suggest that recycling via the sector in developing countries can reach 15 – 35% of the waste generated in cities. Wilson et al. [12], however, found informal participation from 20 – 50%. These values can vary greatly from city to city, because in each place the waste system behaves in a way. Organization of informal sector and promotion of micro-enterprises is a way to increase recycling rates and also to reduce material sent to landfills[43,6]. Informal sector, in low and middle-income countries, increases recycling rates at the level of high income countries. Informal recycling is supported by revenues from trading recyclable materials only, with no aid from waste managers. This fact strongly differs from high-income countries, where levels of recycling rate has come at high costs[12].

Table 5: Expenditure indicators

City	Regular collection cost (R$/kg)	MSWM costs in relation to the total city hall costs (%)	Despesas por habitante (R$/hab year)	Despesas com a coleta regular (%)
Corumbataí	0,84	2,80	241,51	29,21
Analândia	ND	ND	ND	ND
Ipeúna	0,31	3,12	134,19	46,40
Charquea- das	0,26	2,45	67,05	ND
Gertrudes	0,55	4,96	180,60	62,60
Rio Claro	0,35	2,55	90,04	41,90
Average	0,46	3,18	133,20	45,01

ND – No data provided on this aspect.
Source: Research data.

3.6. Process flow diagram

Process flow diagram (Figure 2) synthesizes information obtained in investigated municipalities. Data on waste management systems in municipalities in a country with continental dimensions, such as Brazil, are scarce and difficult to collect due to the high degree of complexity generated by several factors that act concomitantly. In Brazil, legislation favors the creation of inter-municipal consortia to increase efficiency of waste management. Six Investigated municipalities comprise a river basin and have the potential to unite in order to face the challenge of properly managing their waste. Informal sector presented itself with anassembled structure able to contribute to increase recycling rates and consequent decrease of the costs and still increase useful life of landfills.

This study estimates approximately 8% of refuse are collected by the informal recycling of the total amount estimated for generation every year in the investigated cities. This value represents the amount of material that are diverged from landfill by waste pickers and generators that sell material to recycling depots.

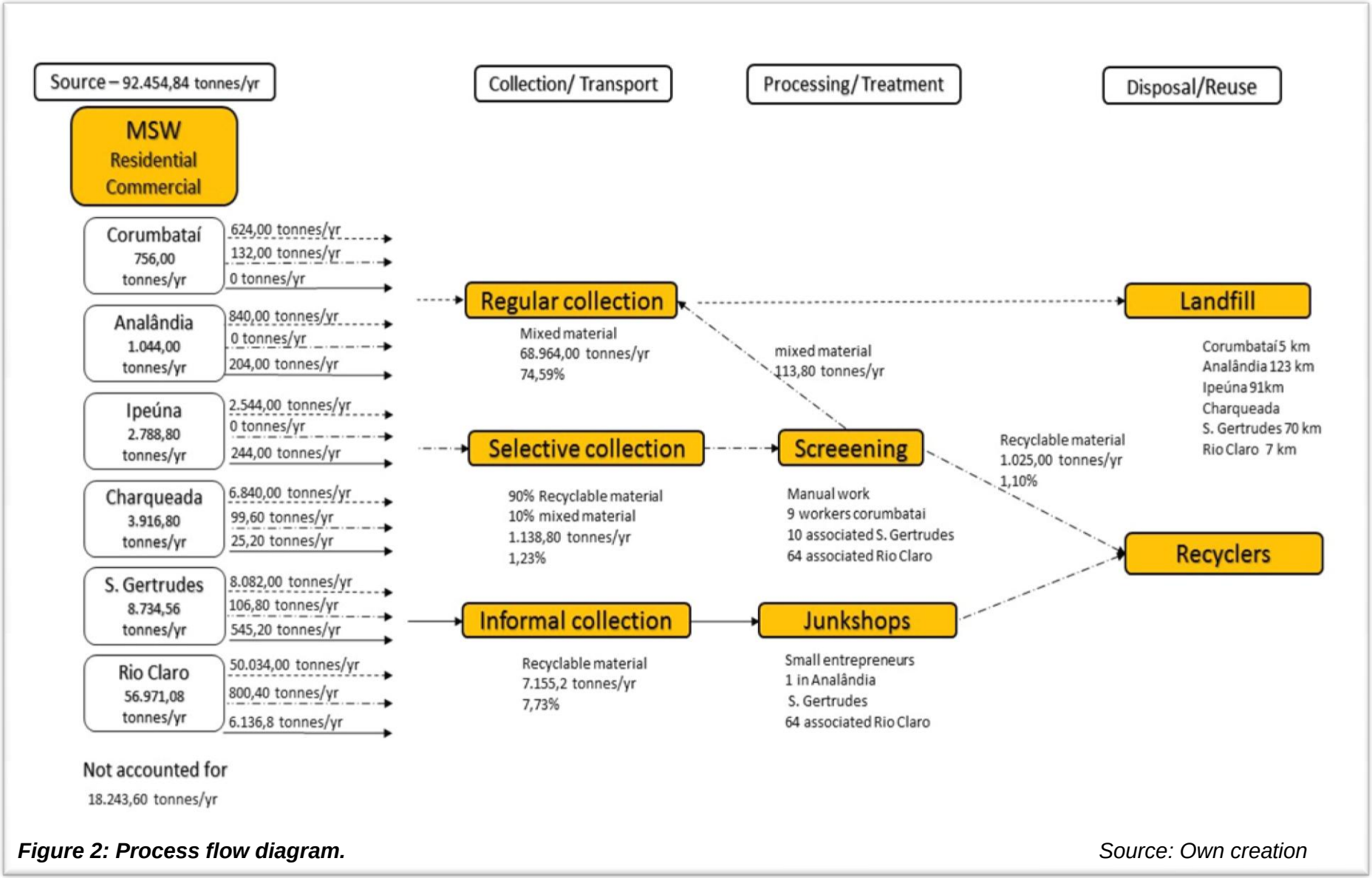


Figure 2: Process flow diagram. *Source: Own creation*

4. Discussion

Chung and Lo [7] highlight that municipal authorities are important actors once they formulate and implement local rules, decide waste management technologies and approaches. For that reason, they deserve more attention from researchers. In the studied cities local authorities must know that they have big infrastructure that supports many workers in different levels, also that these services are responsible for diverging tons of material from landfill. Greater effort is needed to enhance perceptions of complex issues and create a stronger foundation for decisions, in that way it is necessary to combine analysis and deliberation to improve social participation in waste management[53]. Source sorting and separation of waste is a fundamental step and determines the treatment and quality products of further steps[54,42,55].

Regular and selective collection don´t attend all rural population. Small cities studied with large rural population cannot attend all its population with simple regular collection. Corumbataí at the same time presents a successful selective collection program in urban area and part of inhabitants in rural areas do not have access even to regular collection. That is a challenge for low and middle income countries to offer regular collection service for all rural areas. Baran [63] investigated waste management practices in rural areas in Poland in the European context and identified some problems, including aversion of residents to waste sorting, helplessness of municipalities in battling illegal waste landfill sites, lack of infrastructure and ineffectiveness of educational campaigns. Zeng et al. [57] investigated rural household´s behaviors and perceptions of rural population in China and verified that most respondents are aware of the importance of source separation and are willing to participate to separation programs. The comparison of these studies suggest that different contexts demand different approaches, in one hand high income countries face more advanced issues, while in the other hand, low and middle income countries face simple question as to offer regular collection for all the population. In the studied cities, all urban areas are attended by selective collection. Informal sector offers organized selective collection service in two of the six investigated cities. The others cities presented high participation of informal collection through recyclable trading depots (junkshops). Informal sector is responsible for most of recycling in low and middle income countries, by definition this sector is left out of formal statistics[26].

Selective collection is efficient where the service is offered systematically with the distribution of recyclable packages to households and direct contact with generators is real. This fact reflects the action of the service with people through years of working on improve awareness of population about the organization of the selective collection. Many authors emphasize the education and optimize understanding about recycling methods as a form to improve source segregation and population participation[52,56,54,57].

The informal sector has large infrastructure and offers regular and reliable service to households end commercial establishments in at least three of six studied cities. Jaligot et al. [21] found that in the informal value chain-enterprises operating down-stream generate more revenue and are less vulnerable to market fluctuations, than the workers of upstream that deals with less quantities of material. In this context, authorities together with public and private sectors are frequently confronted with the dilemma of finding workable situations to encompass all the stake-holders involved[59]. Additionally, informal recyclers are exposed to a wide variety of hazards, due especially to poor working conditions and the lack of recognition for their profession by the system so the conditions can´t be improved[39,36,60]. In Brazil, the legislation already allows the formation of cooperatives for waste workers, that is an important initiative for integrating informal workers into the formal sector[61]. Not with standing, not all the scavengers get to be inside a cooperative and still go through the cities´ streets collecting recyclable material and selling it in recycling depots, this study sought to bring light to the work of informal workers and generators who sell selective material to recycling.

Specific charge policies can improve the performance of generators separation behavior[62]. It is important to highlight that improving efficiency in waste selective collection may lead to decrease the access to waste by scavengers[36,27]. Thereby municipalities must work on inclusive programs so that these people can at least be recognized by the system, these programs are related to integrate the recyclers that are willing to join the formal system, such as professional training, tax deduction, information, equipment and, about everything recognition[5]. Waste workers as scavengers and small

family companies offer an important service for society and are not seen by formal system. The small fact of understanding it can provide better conditions for all the stakeholders involved.

The average recycling rate in selected cities is 10.8%. When aligning with recycling rates in European countries in the group of states favoring landfilling, it reaches 18.9% and achieves on average 44.4% [23]. Waste management strategy is one of the most important environmental policy strategies and it can be expected that the recycling rate will converge in the future between developing and developed countries.

5. Conclusion

The data collected in this study indicate significant contribution of informal sector in recycling activities of municipal solid waste. Despite some uncertainties in these assessments, it can be concluded, that informal paths collect a significant share of recyclables in the studied cities. This fact indicates that authorities can find a whole system with great infrastructure for recycling enhancement in the studied cities if take into consideration informal work when stablish waste management.

For this reason, more research is required to describe real participation of informal workers. Studies, which enable the impact of informal services to be assessed and predict the potential for introducing new inclusive policies, are necessary. To understand how informal workers really contribute to waste management in the studied municipalities and other cities in Brazil can reduce costs and support decision makers.

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Fernanda Giffoni Fernandes Luz, Ladislav Rozenský, Zdeněk Vrba, Justin Michael Hansen, Jan Lípa, Josef Dolista, Martin Vítek, Marcus César Avezum Alves de Castro: Assessment of municipal waste management systems using performance indicators to analyze recycling capacity. The case study of Corumbataí basin, São Paulo state, Brazil

Hodnocení systémů nakládání s komunálním odpadem pomocí indikátorů výkonnosti k analýze recyklační kapacity. Případová studie povodí Corumbataí ve státě São Paulo v Brazílii

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Souhrn

Analýza postupů nakládání s odpady je vícerozměrná výzva, které čelí orgány, zejména v rozvojových zemích, kde jsou zapotřebí opatření ke snížení množství odpadu, jeho opětovnému využití a zvýšení míry recyklace. Ukazatele výkonnosti se často používají k hodnocení kvality systémů nakládání s tuhým komunálním odpadem. Některé studie však naznačují, že různé případy vyžadují pro hodnocení kvality systémů řízení rozdílné ukazatele. Využitelných reálných údajů a dat od obcí je navíc nedostatek, zejména pokud jde o práci prováděnou neformálním sektorem, v rámci systémů nakládání s odpady.

Účelem této studie bylo analyzovat soubor indikátorů pro zkoumání recyklační kapacity šesti obcí ve vnitrozemí brazilského státu São Paulo. Důraz byl kladen na to, jak probíhá sběr materiálu k recyklaci. Analýza odhalila, že obce mají sice selektivní sběr prováděný v městských oblastech, který je prováděn různými způsoby, ale ne vždy s podporou veřejné moci. Provedená reálná studie ukazuje na velkou roli neformálního sběru na recyklační kapacitě zkoumaných měst. Tato studie odhaduje, že přibližně 8 % odpadu se shromažďuje neformální recyklací celkového množství odhadovaného na generaci a každý rok ve zkoumaných městech. Průměrná míra recyklace ve vybraných městech je 10,8 %.

Klíčová slova: *Nakládání s komunálním odpadem; ukazatele odpadu; neformální sektor; recyklace.*