Chapter 4 Territory and sustainability from municipal waste management programs: Piracicaba case, Sao Paulo, Brasil

Capítulo 4 Territorio y sustentabilidad desde los programas de manejo de residuos municipales: Caso Piracicaba, Sao Paulo, Brasil

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Abstract

The generation of solid waste is one of the greatest challenges of contemporaneity, specifically in Brazil, there was an increase from 67 million to 79 million tons per year, between 2010 and 2019. That said, in 2010 Law 12.305 / 2010, called National Solid Waste Policy (PNRS), which established, in order of priority, the non-generation, reduction, reuse, recycling, treatment and environmentally correct final disposal of waste, the Municipal Plan for Integrated Solid Waste Management (PMGIRS) in which describes the actions related to the management of urban solid waste and the strategies to protect human health and the environment. Given the importance of the PMGIRS for environmental management in the urban environment, the study of its applicability is justified, in which this article will address the city of Piracicaba, located in the interior of the State of São Paulo. In which, the objective of the research is to diagnose the practices related to agroforestry residues; evaluate the current state of the objectives proposed by the Municipal Solid Waste Plan; construction of a SWOT matrix; prepare a prospective analysis of agroforestry waste services and also an action plan for municipal waste. For this, the methodology used was the formal, exploratory, ex post facto, cross-sectional study in time, carried out from the prospection of articles, theses and dissertations in the Web of Science, SciELO and Digital Library of the main Brazilian universities . It can be concluded the concern of the municipality for the proper disposal of pesticide containers, in which the Cañeros Cooperative (COPLACANA) has a prominent role in practically all stages of reverse logistics in compliance with current legislation, however , the document did not comply with the guidelines for organic agroforestry waste, especially with regard to its reuse of energy and fertilizers.

Integrated Municipal Solid Waste Management Program, Municipality of Piracicaba, Sao Paulo; Agroforestry waste

Resumen

La generación de residuos sólidos es uno de los mayores desafíos de la contemporaneidad específicamente en Brasil, se registró un aumento de 67 millones a 79 millones de toneladas por año, entre 2010 y 2019. Dicho esto, en 2010 la Ley 12.305/2010, denominada Política Nacional de Residuos Sólidos (PNRS), que estableció, en orden de prioridad, la no generación, reducción, reutilización, reciclaje, tratamiento y disposición final ambientalmente correcta de residuos, el Plan Municipal de Gestión Integrada de Residuos Sólidos (PMGIRS) en el cual, se describen las acciones relacionadas con la gestión de residuos sólidos urbanos y las estrategias para proteger la salud humana y el medio ambiente. Dada la importancia del PMGIRS para la gestión ambiental en el medio urbano, se justifica el estudio de su aplicabilidad, en el que este artículo abordará la ciudad de Piracicaba, ubicada en el interior del Estado de São Paulo. En el cual, el objetivo de la investigación es diagnosticar las prácticas relacionadas con los residuos agroforestales; evaluar el estado actual de los objetivos propuestos por el Plan Municipal de Residuos Sólidos; construcción de una matriz FODA; elaborar un análisis prospectivo de servicios en residuos agroforestales y también un plan de acción para residuos municipales. Para ello, la metodología utilizada fue el estudio formal, exploratorio, ex post facto, transversal en el tiempo, realizado a partir de la prospección de artículos, tesis y disertaciones en la Web of Science, SciELO y Biblioteca Digital de las principales universidades de Brasil. Se puede concluir la preocupación del municipio por la adecuada disposición de los envases de plaguicidas, en la cual, la Cooperativa de Cañeros (COPLACANA) tiene un papel destacado en prácticamente todas las etapas de la logística inversa en cumplimiento de la legislación vigente, sin embargo, el documento no cumplió con los lineamientos para residuos orgánicos agroforestales, especialmente en lo que respecta a su reutilización de energía y fertilizantes.

Programa de Manejo Integrado de Residuos Sólidos Municipales, Municipio de Piracicaba, Sao Paulo; Residuos agroforestales

1. Introduction

Waste generation is inherent to modes of production throughout history, however, with the emergence and consolidation of the capitalist system and the development of mass consumption, waste generation has become one of the greatest environmental challenges today in various Latin American countries such as Mexico (Niño-Gutiérrez & Rosas-Acevedo, 2011), a particular case in waste management is the city of Acapulco (Niño-Gutiérrez & Rodríguez-Rodríguez, 2010).

Specifically with respect to Brazil, the industrialization process throughout the 20th century and its consequent economic development led to urban population growth from 10% in 1900 to 81% in 2000 (Brito, 2006). In this sense, population growth, the urbanization process, consumption growth and the inability of public administrators to manage the increase in waste generation and its respective socio-environmental impacts have increasingly highlighted the waste problem in Brazil. According to the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE, 2020), according to the Panorama of Solid Waste in Brazil 2020, between 2010 and 2019, the generation of urban solid waste in the country registered an increase from 67 million to 79 million tons per year. In turn, per capita generation increased from 348 kg/year to 379 kg/year. Much of the MSW collected goes to landfill disposal, which saw an increase of 10 million tons between 2010 and 2019, from 33 million to 43 million tons per year.

However, part of this amount of waste is still destined for inadequate disposal, as controlled landfills grew from 25 million to more than 29 million tons per year, confirming the socio-environmental seriousness of the situation. That said, in 2010 the National Solid Waste Policy (PNRS) was approved, which established, in order of priority, the non-generation, reduction, reuse, recycling, treatment and environmentally sound final disposal of waste, the latter being when all waste is exhausted possibilities of reuse, with the aim of mitigating environmental impacts and avoiding risks to human health (Law 12,305/2010; Souto & Povinelli, 2013). In addition, the PNRS in which brings a set of concepts, tools, guidelines and objectives for the management and handling of solid waste in the country. Among these tools we can mention the Municipal Plan for Integrated Solid Waste Management (PMGIRS) (Chaves, Siman & Sena, 2020).

The PMGIRS, according to Law 12.305/2010, is:

A document that outlines and describes the actions related to the management of urban solid waste, which exposes aspects related to the non-generation, reduction, reuse, recycling and environmentally sound final disposal of waste. The PMGIRS also contains the general strategy of those responsible for waste generation, to protect human health and the environment, as provided for in Law 12.305/2010 and Decree 7.404/2010 that regulates it. See articles 3, 18, 19, 21, 26, 26, 31, 33, 35 and 36. The preparation of the PMGIRS is a mandatory condition for municipalities to have access to financial resources from the Federal Government, which are intended to invest in services related to urban cleanup and solid waste management.

Thus, the PNRS, specifically in its art.19, describes the minimum content required of the PMGIRS, which must include all aspects of management, such as: actions, procedures, controls, human, financial and material resources; and also the management aspects, which include all activities involved from waste generation to final disposal (Law 12.305/2010). In this sense, given the challenge of the management and handling of urban solid waste in Brazil, as well as the legal requirement for the elaboration of the PMGIRS by the country's municipalities and the same as an instrument of change in the solid waste scenario in Brazil, an analysis of this document is warranted. In this sense, the PMGRIS of the municipality of Piracicaba, a city in the interior of the state of São Paulo, was chosen as the object of study, and given the complexity of the document, the analysis of agroforestry waste was outlined, in order to allow a detailed analysis of the management, management, processes and their adequacy to the minimum content required by the PNRS of this waste.

Understanding that its implementation is as important as its elaboration, a diagnosis of this process was carried out, based on the successes and failures observed in terms of the objectives related to agroforestry waste, proposed by the municipality's PMGIRS. The present work aims to evaluate the management practices adopted by residents with respect to agroforestry waste in the municipality of Piracicaba, based on the requirements of the Municipal Solid Waste Plan, which is included in the Municipal Basic Sanitation Plan of Piracicaba, Sao Paulo, Brazil. In this sense, the following specific objectives are proposed: (a) Diagnose practices related to agroforestry residues in the municipality of Piracicaba, SP; (b) Evaluate the current status of the objectives proposed by the Solid Waste Plan in the area under study; related to agroforestry residues; c) Construct a SWOT matrix, representing strengths, opportunities, weaknesses and threats based on the diagnosis made, as well as the construction of actions and goals for the municipality for the year 2033 and d) Prepare a prospective analysis of services in agroforestry residues, as well as an action plan for the aforementioned residues in the municipality under study.

2. Method and materials

The present work, was classified as applied, since it aims to evaluate the Municipal Program for Integrated Solid Waste Management, specifically in what refers to agroforestry-pastoral waste, mainly in what, refers to aspects related to its management and handling in the municipality of Piracicaba, a city in the interior of the State of São Paulo in the light of the National Solid Waste Policy, with emphasis on its article 19, where the minimum content required for the PMGIRS is presented.

In addition, the present work is considered a formal study, since it aims to construct a matrix of strengths, opportunities, weaknesses and threats (SWOT), based on the diagnosis made, as well as the construction of actions and goals for the municipality for the year 2033, as well as to elaborate a prospective analysis of services in agroforestry-pastoral waste and an action plan for such waste in the municipality of Piracicaba.

As for the object of the study, it is exploratory, since it addresses a subject still little treated by the literature, specifically with regard to the analysis of a specific waste such as agroforestry and livestock waste, as well as of the municipality of Piracicaba. Table 4.1 summarizes the methodological descriptors.

Table 4.1 Methodological descriptors.

Category	Type
Degree of crystallization of the research question	Formal study
Object of study	Exploratório
Power of the researcher to produce effects on the variables studied.	*A posteriori*
Time dimension	Transversal
Research environment	Web

Source: Own Elaboration (2021)

To achieve the objective, qualitative research was adopted, mainly through consultation of the Municipal Program for Integrated Solid Waste Management of the Municipality of Piracicaba, published in 2019. The website of the Brazilian Association of Public and Cleaning Companies was also consulted, as well as, the National Congress, especially with regard to Law Number 12,305, of August 2, 2010, which instituted the National Solid Waste Policy. In a complementary manner, a bibliographic review was carried out by consulting articles published in journals indexed in the Scientific Electronic Library Online, SciELO, Web of Sience, Francis Taylor, Emerald and Springer Nature, as well as in the digital library of dissertations of Fundação Getúlio Vargas, Universidade de São Paulo, Universidade Estadual de São Paulo, Universidade de Campinas, Federal University of Minas Gerais, University of Brasilia and the websites of the Secretariat of Environment of the Municipality of Piracicaba, Cooperative of Sugarcane Planters of the State of São Paulo (COPLACANA), Cooperative of Rural Producers-Association of Sugarcane Suppliers of Coopercitrus and Capivari (CANACAP), in addition to master plans of rural areas in other latitudes such as Mexico (Niño-Gutiérrez, 2021).

With the information collected from the literature review, as well as from primary documents, discourse analysis was applied, in which the objective is to question the meanings established in diverse natures of scientific production, which can be verbal and non-verbal, provided that since their materiality produces meanings for interpretation (Caregnato & Mutti, 2006). In this sense, the summary of objectives, literature base, methods of data collection and analysis can be seen in Table 4.2.

Table 4.2 Summary of objectives and their respective rationale

Object of the article	Literary background	Method of collection	Data analysis
Diagnose the practices related to agroforestry residues in the city of Piracicaba, SP. Evaluate the current situation of the objectives proposed by the Solid Waste Plan of Piracicaba, SP, related to agroforestry waste; Construct a SWOT matrix, representing strengths, opportunities, weaknesses and threats, based on the diagnosis made, as well as, the construction of actions and goals for the municipality for the year 2033; Construct a prospective analysis of agroforestry waste services and an Action Plan for the municipality of Piracicaba.	PM GIRS (2019); Ley 12.305/2010	Study of articles and documents	Inductive-deductive analysis

Source: Own Elaboration (2021)

3. Results

According to Antenor and Szigethy (2020), Brazil is one of the countries that generates the most solid waste in the world, where part of it ends up being thrown outdoors, as well as dumped in the sewage system and burned. The current situation is even more serious, considering the legal and technological advances in the management of solid waste in the country, which would allow the economically viable treatment of this waste, especially the most complex, in which civil construction, agricultural, hospitals, industrial, mining and radioactive substances, but also those from domestic activities, urban cleaning classified as urban solid waste.

ABRELPE (2019), highlights that Brazilian cities generated about 79 million tons of urban solid waste in 2018, in which collection reached about 92% of this total, corresponding to about 72 million tons, of which only 43.3 million tons, 59.5% of what was collected, was properly disposed of in landfills. Of the remaining 29.5 million tons of waste, about 40% of what was collected was improperly disposed of in landfills and about 6.3 million tons generated annually remain uncollected, even though the legislation determines the destination of the treatment and the technology for it.

Translation made with the free version of the translator www.DeepL.com/TranslatorAunque, according to ABRELPE (2020), the gravimetric composition of municipal solid waste is 45.3% organic matter; 16.8% plastics; 14.1% tailings; 10.4% paper and cardboard; 5.6% textiles; leather and rubber; 2.7% glass; 2.3% metals; 1.4% multilayer packaging and 1.4% other classification subject to reverse logistics. According to Gouveia (2012), one of the consequences of inadequate MSW disposal is the serious social and environmental impacts, in which, in addition to living with a situation of increasing pollution rates, it will bear an increase in health expenditure and expand waste recovery and recycling actions, which brings waste of economic, natural and human resources. For Antenor and Szigethy (2020), this situation persists given the costs and lack of integration in the management of urban solid waste, which have been pointed out by specialists as the reasons for these results, which remain practically the same as before PNRS.

Agribusiness is one of the strongest economic sectors in the country. According to the Brazilian Confederation of Agriculture and Livestock, the Gross Value of Agricultural Production (GVP) will be 9.8% higher in 2020 compared to the previous year. However, this superlative agricultural production also influences waste generation. The residues of agricultural activity are composed of crop residues, such as straw and zootechnical activity, as well as organic residues that can be treated for subsequent use as fertilizer, both of which are considered to carry low concentrations of pollutants. Their seasonal production is determined by the maturity of the agricultural crop or the supply of raw material, therefore, wastewater mixed with other residues may be present (Rossol, 2012).

With respect to wastewater, it can be the result of washing, blanching, cooking, pasteurization, cooling and washing of product processing equipment and facilities. Regarding solid waste, it is processing leftovers, discards and packaging waste and sludge from wastewater treatment systems. (Gouveia, 2012). In addition, waste can be classified into organic and inorganic. Organic waste is produced both in the agricultural sectors such as coffee, sugar cane, soybeans, cocoa, bananas, beans, rice, corn and cattle from waste generated in livestock and effluents and waste produced in agribusiness, such as slaughterhouses and dairy products (Lima, 2016).

As for inorganic solid waste, it covers packaging produced in the pesticide, fertilizer and veterinary pharmaceutical input segments (Lima, 2016). Specifically with regard to, pesticide packaging, in 2018 the Campo Limpio system processed 44,261 tons of empty pesticide packaging, which represented about 94% of the total of this type of merchandise sold in Brazil (Silva, 2020). The mass of these recovered materials decreased by about 0.6% compared to 2017. Of this total processed, 93% went to recycling and 7% to incineration. With the reuse of these materials, between 2002 and 2018 the Campo Limpio System helped reduce around 688,000 tons of carbon dioxide emissions. In view of the current situation, the PNRS, for Pinto (2017) classifies agroforestry residues as those generated in agricultural and forestry activities, including those related to inputs used in these activities. In this sense, it is necessary to properly manage these residues in the generating agricultural properties.

Founded in 1767, on the banks of the river that bears its name, Piracicaba (Figure 1) had, according to the Brazilian Institute of Geography and Statistics (IBGE), about 407 252 inhabitants in 2020. Located in the interior of the state of São Paulo with South Latitude 22º 42' 30"'; West Longitude 47º 38' 01"' and Altitude of 554 meters; in the macro-region of Campinas, 164 km northwest of the state capital, it occupies a total area of 1 376 913 km², of which 31 573. 3 km² of urban perimeter and the 1 345 339 km² of rural area and the municipalities Rio Claro, Iracemápolis, Limeira, Rio das Pedras, Saltinho, Laranjal Paulista, Santa Bárbara D'Oeste, Anhembi, Águas de São Pedro and Charqueada as neighboring cities (IBGE, 2021; PIRACICABA, 2019).

Figure 4.1 Location of the Municipality of Piracicaba/SP

Source: Own Elaboration (2021)

According to the Prudente de Morais Museum (2020), the city became one of the first cities in Brazil to industrialize with the opening of metal-mechanical industries linked to the sugar-energy sector, which expanded with the strengthening of this economic segment in the country, especially during the National Alcohol Program (Proálcool). In 2012, it was the second most relevant sector of the city's economy, contributing R$3 248 627 thousand to the Gross Domestic Product (GDP), with emphasis on the metallurgical, metal-mechanical, textile, food and fuel sectors (petrochemical and ethanol production). In view of its industrial strength, in 2012, the city's GDP was the 14th largest in the state of São Paulo and 52nd in Brazil.

In terms of the agricultural sector, orange cultivation stands out, with 2 500 hectares, 49 000 hectares of sugar cane and 1 720 hectares of corn. In the livestock sector; the city has almost two million head, highlighting the herd of 50 000 head of cattle and 4 million poultry (Piracicaba, 2019).

In addition, Piracicaba is home to important Brazilian universities such as the Federal Institute of Education, Science and Technology of São Paulo, the Luiz de Queiroz School of Agriculture of the University of São Paulo, the School of Dentistry of Piracicaba, of the State University of Campinas, Methodist University of Piracicaba and School of Engineering of Piracicaba (Prudente de Morais Museum, 2020).

The Organic Law of the Municipality of Piracicaba was enacted on August 1, 1990, in which, among its various articles, discusses the obligation of the municipal government to address the issue in a legal, impersonal, moral, public and, above all, efficient manner, solid waste in the city, as can be seen in Article No. 204:

It corresponds to the Municipality, with respect to the public services of basic sanitation: VII. To plan, design, execute, operate and maintain the cleaning of public spaces, the removal, treatment and disposal of domestic garbage and other waste of any nature; VIII. To regulate and supervise the generation, conditioning, storage, collection, transportation, treatment and final destination of waste of any nature; IX. Establish forms of cooperation with other municipalities in the region, with the State or other government entities for the planning, execution and operation of actions related to the production of drinking water, treatment of sanitary sewage, drainage of rainwater and treatment and disposal of solid waste, given the characteristics of a function of common interest that such actions perform in the region (Piracicaba, 1990).

In addition, in its collection of articles, in particular numbers 209, 210 and 211 deal with the obligation, both of the public authorities and of society, of the correct disposal of waste, as well as its prior treatment, if it is classified as hazardous or harmful to public health and the environment:

The dumping of solid waste in the open air in public and private areas and in bodies of water is prohibited. Waste not generated in the Municipality of Piracicaba may not, under any circumstances, be deposited or treated on Piracicaban soil. Art. 210: The Municipality may require, under the terms of the law, and in accordance with the technical parameters it establishes, that the generating sources carry out prior treatment of the garbage and/or other waste produced by them. Art. 211: Garbage and waste considered hazardous to public health and harmful to the environment must be compulsorily subjected to prior treatment at the generating source, in accordance with the regulations established by the Municipal Government (Piracicaba, 1990).

In addition, the legal framework, particularly Article 217, defends, in the form of a law, the right of all citizens to live in a clean and healthy environment in which the quality of life is promoted in accordance with the Federal Constitution of 1988, and in this sense, the proper disposal of solid waste is mandatory. Every person has the right to an ecologically balanced environment, a good of common use of the people and essential for a healthy quality of life, imposing on the Municipal Government and the community the duty to defend, preserve and reconstitute it for present and future generations, in accordance with Article 225 of the Federal Constitution, being the Municipality responsible for: IX. Establish the intermediate zone, of at least two hundred meters, destined to the green area, separating the residential zones from the industrial ones. to install, as well as deposits of solid and/or liquid residues (Piracicaba, 1990).

Finally, the Municipal Organic Law concludes in its Article No. 224, which highlights the importance of the proper disposal of solid waste to better preserve natural resources, especially in this article the municipality's water collectors:

Art. 224. The Municipality shall participate in the Integrated Water Resources Management System provided for in Article 205 of the State Constitution, alone or in consortium with other municipalities of the same basin or region, ensuring for this purpose, financial and institutional means, being responsible for: IX. Promote the adequate disposal of solid waste to avoid compromising water resources, in terms of quantity and quality (Piracicaba, 1990). It can be concluded that the Municipal Organic Law, enacted in 1990, is in line with the Federal Constitution of 1988, as well as with the PMGIRS, aiming to materialize what the law advocates both at the federal level and at the level of the municipality of Piracicaba.

In 2014, the first Municipal Solid Waste Integrated Management Program (PMGIRS) was prepared for the municipality of Piracicaba, based on the data update of the 2009 Piracicaba Urban Solid Waste Sanitation Plan, published in 2011 from Decree No 14,206/2011 (Piracicaba, 2019). After four years of its implementation, an analysis of the guidelines, actions and objectives proposed in the original PMGIRS was carried out, which allowed the progress and efficiency of the actions to be evaluated, with the objective of updating the plan and consolidating the municipal waste policy based on the municipal reality (Piracicaba, 2019). According to Law 12,305/2010, agrosilvopastoral waste is generated in agricultural and forestry activities, including those related to inputs used in these activities. In which the main residues are: waste; waste water; dead animals; cultural and forestry residues and pesticide containers. Specifically, regarding pesticide containers, according to Law 12,305 of August 2, 2010 in the National Solid Waste Policy, specifically in its first paragraph of Article 33 states:

Art. 33. Manufacturers, importers, distributors and traders of: I - pesticides, their residues and packaging, as well as other products whose packaging, after use, constitutes hazardous waste, observing the hazardous waste management standards provided by law or regulation, in standards established by the bodies of Sisnama, SNVS and Suaa, or in technical standards (Law 12.305 / 2010).

In addition, according to Law 12.305/2010, reverse logistics is defined as:

Economic and social development instrument characterized by a set of actions, procedures and means aimed at enabling the collection and return of solid waste to the business sector, for reuse, in its cycle or in other productive cycles, or other environmentally appropriate final destination. Therefore, its operation is carried out on the basis of sectoral agreements in which it is a legal contract signed between the government and importers, manufacturers, traders, distributors, consumers regarding the implementation of the co-responsibility of the life cycle of certain products, such as, in this particular case, pesticides.

The Sectoral Agreement for the Implementation of the Reverse Logistics System for Packaging in General was signed on 25/11/2015 and aims to ensure the environmentally sound final destination of packaging. In this sense, the main actors in the pesticide supply chain, such as manufacturers, importers, traders and distributors, are committed to work together to provide an environmentally sound product for agrochemical packaging. Therefore, for its operationalization, the sectoral agreement includes support to cooperatives and partnerships with the commercial network for the opening of voluntary collection points (Ministério, 2018).

According to the PMGIRS of the municipality of Piracicaba, the packaging of pesticides, after their application in agricultural activities, the collection, transport and final destination of the packaging are the responsibility of the company that markets the pesticide, in the case of Piracicaba, the Producers. Cooperativa de Caña de Azúcar de Piracicaba y región (COPLACANA), which promotes the proper disposal of the containers. According to data from the COPLACANA Collection Center, between January 2014 and June 2019, 1 493 277 tons were collected, pesticide packaging (Piracicaba, 2019).

COPLACANA, with the objective of increasing efficiency and effectiveness in the collection of empty pesticide containers, established partnerships, through agreements with the Cooperative of Rural Producers (COOPERCITRUS) (Limeira) and the Cooperative of Sugarcane Planters of the Capivari Region Limited (CANACAP) (Piracicaba, 2019). In this sense, the packages received by COPLACANA, from customers, associates and representatives, are counted, weighed and classified according to size and class (contaminated or decontaminated).

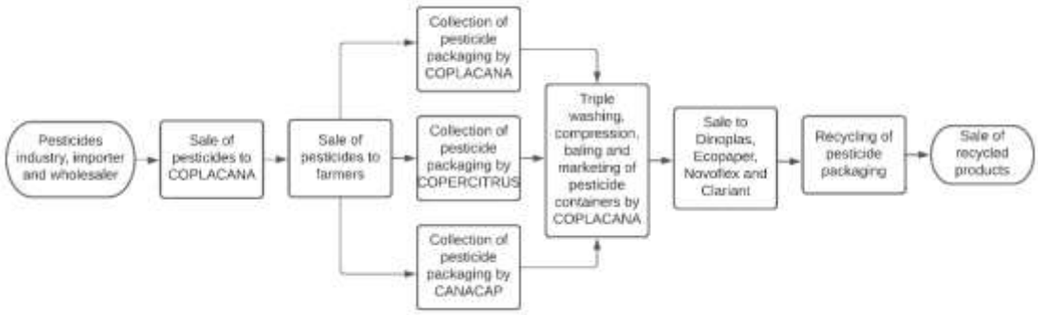
Subsequently, the material undergoes a triple washing, in accordance with Brazilian Regulatory Standard No. 13.968, in which the following steps are followed:

1. Emptying. The package is emptied and subsequently filled with clean water up to a quarter of its volume, the lid is replaced and tightly closed (INPEV, 2019);
2. Shaking. The package is shaken vigorously in all directions for 30 seconds to dissolve any product residue that has adhered to the internal surface of the package. The water from this first rinse is poured into the tank of the application equipment. The package remains over the tank opening for approximately another 30 seconds to allow all contents to drain. This rinsing procedure is repeated two more times (INPEV, 2019);

3. Disability. Finally, the package is rendered unusable, in which the bottom is punctured with sharp objects (INPEV, 2019).

Finally, the packages are compressed, packed and sold to recycling companies authorized by the National Institute for Processing Empty Containers (INPEV), where they are transformed into brooms, sewers, ducts, supermarket carts, and others, by companies Dinoplast (Louveira/SP), Ecopaper (Pindamonhangaba/SP), Novoflex (Várzea Paulista/SP) and Campo Limpo (Taubaté/SP). As for contaminated containers, they are incinerated at Clariant (Suzano/SP) and Essencis (Taboão da Serra/SP) (Piracicaba, 2019). Figure 4.2 illustrates the entire detailed procedure of the research.

Figure 4.2 Pesticide packaging flow diagram in the municipality of Piracicaba.



Source: Authors' Elaboration (2021)

Residues resulting from agroforestry activities cover a wide spectrum of biomass wastes, including manure, eggshells, chicken litter, wastewater, straw, fallen fruit and forest harvest residues. Each of these aforementioned elements will vary according to the volume of creation, planting, efficiency, management effectiveness and technologies used in the process. In this sense, the main indicators of agroforestry residues generated by the municipality of Piracicaba can be summarized in Table 4.3.

Table 4.3 Synthesis of agroforestry residues in the Municipality of Piracicaba in 2019.

Reproduction	Waste production	Quantity	
Poultry	Excrement	MS11 548t	MN24 644t
	Eggshell	69.4t	
	Broiler litter	MS 1 769.4t	MN 53 083.3t
	Dead birds	37 000 to 299000 birds	
Bovina	Manure	BL336 360t	BC4 565 728t
	Wastewater	20 835 000 a 33 336 000L	
	Dead animals	1 215 animals	
Piggery	Excrement	DL[5]20 898 000L	LDS[6]5 710.5t
	Dead animals	377 animals	
Sugar cane	Straw	637 000t	
Orange	Fallen fruit	11 767t	
Corn	Straw	19 917.6t	
Eucalyptus	Forest harvesting residues	290 500t	
Packaging of phytosanitary products	Packaging	300t	

Source: Piracicaba (2019)

[1] MS. Dry Matter
[2] MN. Natural Matter
[3] BL. Dairy Cattle
[4] BC. Cutting Bovine
[5] DL. Liquid Waste
[6] DS. Solid Waste

4. Discussion

In the analysis of the present PMGIRS, especially in the chapters referring to the diagnosis of agro-silvo-pastoral waste, the result of the implementation of the PMGIRS in the period 2014 to 2018 and the evolution of the plan indicators, the result of the implementation of the plan in the period 2014 to 2018, guidelines, goals and actions of the plan for the period 2019-2024, programs and actions for the participation of interested groups (cooperatives, associations, low-income people) and mechanisms for the formation of business sources, management of the plan: monitoring and evaluation of the plan and the municipality's waste indicators, waste management projections for the next 20 years and final considerations none were found related to the treatment of waste from the activities mentioned in Table V, except for pesticide containers. In addition, as can be seen, a significant volume of biomass waste generated can be considered, at this point there is a problem and also an opportunity. When not properly treated, this waste is a serious vector of environmental degradation, both for the soil and for the water catchment in the municipality and its surroundings. However, there are both legal frameworks and appropriate technologies for the reuse of such a volume of residual biomass, which can be converted into fertilizers, biogas and its use for electricity generation, fuel substitution and gas pipeline feed from the purification of biogas into biomethane.

Although this type of procedure is technically feasible, whether from digesters, motogenerators or cogenerators, the economic and financial viability of these projects varies according to the type of biomass, the economic scenario, the legal framework, public policies for the promotion of renewable energies and the efficiency of the biodigester and the motogenerator. Unfortunately, not only in the city of Piracicaba, but in Brazil as a whole, there are no policies that promote the energetic reuse of biomass residues, which means a triple loss: either because of the opportunity cost for agricultural producers, or because of the environmental impact of these residues on the surroundings and, finally, because of the non-creation of jobs, the latter being further enhanced by the economic, social, environmental and energy crisis that the country is going through, especially aggravated by the Sars-Cov-2 pandemic. Based on the analysis of the Municipal Program for Integrated Solid Waste Management of the Municipality of Piracicaba, as well as on the literature review, it is possible to formulate the SWOT matrix, which stands for strengths, weaknesses, threats and opportunities. For Sorensen, Engström and Engström (2004), SWOT analysis is an easy-to-use method, which allows obtaining a panoramic view of the environment and identifying areas for improvement and, in addition, aims to promote learning about the situation by reflecting on what can be done. Therefore, specifically for agroforestry-pastoral wastes, the SWOT matrix is shown in Table 4.4.

Table 4.4 SWOT matrix for agroforestry and livestock wastes

	Positive Factors	**Negative Factors**
Internal factors	**Strengths**	**Weaknesses**
	– Internal preparation and periodic evaluation of the PGRA; - Participation of a multidisciplinary team in the preparation and updating of the PMGIRS; - Control of waste generation and collection establishments; - Knowledge of current legislation on waste treatment. - Use of recycled and organic material; - Employees aware of their participation in the plan.	– Possible non-disposal of recyclable packaging waste for reverse logistics; – Possible non collection of waste for third parties; – Absence of guideline with justifications, goals, strategies, responsible parties, deadlines, indicators and results for agroforestry biomass waste; – Non-energy reuse of agroforestry biomass residues; – Non-compliance with PGRA guidelines by managers and employees. – PGRA guidelines by managers and employees.
External Factors	**Opportunities**	**Threats**
	– Encouragement of managers to promote generation reduction; – Increased visibility of cooperatives; – Investment in training and qualification of employees; – Investing in continuous improvement of the PGRA; – Reuse of organic waste to generate biogas for cogeneration (electricity and heat) and fuel substitution; – - Cogeneration of income.	– Contamination of water resources; – Soil contamination; – Risks to human health .

Source: Prepared by the authors (2021)

Based on the SWOT matrix prepared, as well as the PMGIRS and the literature review, a scenario analysis can be constructed, as well as actions and goals up to the year 2033. In view of what has been presented in this study, as well as what has been discussed with the literature review, actions and goals can be proposed for the year 2033, specifically for agroforestry residues, the subject of this disciplinary work. Even with the current financial and social crisis that Brazil is going through, agribusiness, in particular, is one of the least affected economic segments, since much of its production is exported to countries such as China, the United States, Japan and the European Union, in addition to Latin American countries (Niño-Gutiérrez, 2021) and how these nations are in the process of economic recovery from the crisis caused by the COVID-2019 pandemic.

In this sense, it can be assumed that there will be an increase in the demand for pesticides in the main agricultural units of the country, including the city of Piracicaba. Given that COPLACANA, together with partners COOPERCITROS and CANACAP, are responsible for the collection of agrochemical containers, the former being in charge of giving due treatment to such byproducts, as established by Law No. 12,305 of August 2, 2010 in accordance with NBR No. 13,968, it can be assumed the need to expand the structure from the reception of these packages to the triple washing process, as well as compartmentalization, packaging and commercialization.

In this sense the PMGIRS of the Municipality of Piracicaba in its chapter four, referring to the guidelines, goals and actions of the plan for the period 2019-2024, specifically in guideline 21 contemplates justifications, goals, strategies, responsible parties, deadlines, indicators and results, as can be observed:

Guideline 21. Develop and implement an agroforestry residue management program. Problem/Rationale: According to the PNRS and CONAMA resolution 458/2013, agroforestry waste is the result of activities linked to agriculture, animal production and forestry production. According to the draft version of the PNRS and the state solid waste plan, one of the main problems related to solid waste in rural areas is the packaging of inputs used in these activities, such as pesticides, fertilizers and veterinary products, and only pesticides are expressly cited in the law 12.305/2010 as mandatory the application of the reverse logistics system. The application of this guideline is intended to identify the agroforestry waste generated and propose actions for its correct management.

Define criteria and recommendations for the proper management of agroforestry and livestock waste. Approach: Actions: Incorporate members of the sector to the PMGIRS Review Commission and create specific WGs (suggestion: SEMA, CATI, EDA, NEA, ESALQ) for the elaboration of the program of actions for the destination of agroforestry and livestock wastes.

1.1 Carry out the diagnosis/inventory and elaborate the agroforestry and livestock waste program, quantifying and identifying the problems and needs for action.
1.2 Oversee the agrochemical container collection program.
1.3 Make ENP structures available in rural areas.
1.4 Implement an educational communication program. [RESPONSIBLE: PREFEITURA, COPLACANA, CATI, ESALQ and GENERADORES; PREFEITURA and ESTABLISHMENTS RESPONSIBLE FOR COLLECTION AND DESTINATION PREFEITURA. TIMEFRAME: 2019-024. RESULTS: Diagnosis of waste generated for disposal according to current environmental legislation; INDICATORS: Participation of the sector's representative in the PMGIRS Review Commission; Diagnosis of agroforestry and livestock waste (Piracicaba, 2021, p. 177).

Furthermore, with specific regard to residual biomass from agroforestry activities, an increase in its production can also be assumed, given the economic prospects of Brazilian agribusiness. However, unlike agrochemical containers, no reference to the energetic reuse of these residues was observed in the municipality's PMGIRS. However, in view of the emergence of environmental policies in central countries such as the United States with the Green New Deal and in the European Union with the European Green New Deal and the adoption by large transnational financial companies of the Environment, Social and Governance (ESG), the country should rethink its development model based on the promotion of renewable energies, especially biomass.

On this point, Piracicaba can become a pioneer by hosting one of the most traditional schools in the agricultural sector, such as ESALQ USP and also the Centro Tecnológico da Cana de Açúcar (CTC), as well as a government committed to environmental issues such as the Municipal Organic Law, enacted in 1990, which already covered the issue of solid waste, which only 20 years later became a national law, as well as the quality and democratic construction of the municipality's PMGIRS. In this sense, taking into account the previous analysis of the national agribusiness, and its correlation with the agroforestry activity in the city of Piracicaba, as well as the SWOT matrix and the PMGIRS,

Table 4.5 Prospective analysis of services in agroforestry residues

Indicator	**Current Scenario**	**Reference Scenario**	**Future Scenario**					
			Relationship to SDGs	Goals	Deadline/Quantification			
					Immediate	Short	Medium	Long
					2021-2023	2024-2026	2027-2029	2030-2033
Pesticide container collection coverage	100%	100%	2 Sustainable agriculture 12 Responsible production 14 aquatic life 15 terrestrial life	Maintain the collection at the current level and expand it in proportion to the increase in demand.	100%	100%	100%	100%
Proper handling of pesticide containers	100%	100%	2 Sustainable agriculture 12 Responsible production 14 aquatic life 15 terrestrial life	Maintain treatment at the current level and expand it proportionally to the increase in demand.	100%	100%	100%	100%
Proper disposal of pesticide containers	100%	**100%**	2 Sustainable agriculture 12 Responsible production 14 aquatic life 15 terrestrial life	Maintain destination at this level and expand with other partners	100%	100%	100%	100%
Lack of guidelines for agroforestry biomass residues	No data	100%	2 sustainable agriculture 7 clean energy 12 Responsible production 14 aquatic life 15 terrestrial life	Development of a guideline for agroforestry biomass residues	100%	100%	100%	100%
Energy reuse of agroforestry biomass wastes	No data	100%	2 sustainable agriculture 7 clean energy 12 Responsible production 14 aquatic life 15 terrestrial life	Harnesses the energy value of agroforestry residues	5%	25%	50%	100%
Reutilización energética de los residuos de biomasa agroforestal	No data	100%	2 sustainable agriculture 7 clean energy 12 Responsible production 14 aquatic life 15 terrestrial life	Harnesses the fertilizer value of agroforestry residues	5%	50%	75%	100%

Source: Own Elaboration (2021)

This is complemented with Table 4.6

Table 4.6 Action plan for agroforestry residues in the municipality of Piracicaba

Indicator	Goal	Deadline	Shares	Deadline
Pesticide container collection coverage	Maintain this pesticide container collection coverage.	Continua	Expansion of collection points in line with the increase in consumption	Immediate
Proper handling/treatment proper handling of pesticide containers	Maintain the current treatment of pesticide container collection.	Continua	Employee training	Immediate
			Expansion of transportation channels	Short
			Expansion of triple wash instruments	Short
			Expansion of compression instruments	Short
			Expansion of pressing instruments	Short
Proper disposal of pesticide containers	Maintain the current pesticide container collection destination.	Continua	Expansion of sales channels with INPEV-certified companies and in line with the increase in consumption	Inmediate
Directrices para los residuos de biomasa agroforestal	To achieve the elaboration of the agroforestry biomass residues guide.	Continua	Develop a guide for agroforestry biomass residues.	Immediate
			Permanent updating of this guide	
Reutilización energética de los residuos de biomasa agroforestal	Achieve full energy use of agroforestry biomass residues.	Medium and Long	Technical training for farm owners	Short
			Investments in biodigesters, boilers, motogenerators and biogas scrubbers	Medium and Long
			Biomethane and electricity trading	Long
Reutilización de fertilizantes de residuos de biomasa agroforestal	Achieving full utilization of fertilizer residues agroforestry biomass	Medium	Technical training for farm owners	Short
			Investments in biodigesters	Medium and long
			Commercialization of biofertilizers	Long

Source: Own Elaboration (2021)

5. Conclusions

The Municipal Program for Integrated Solid Waste Management is a fundamental tool for the diagnosis, planning, implementation and control of waste at the municipal level, which responds to the social and environmental challenges to be overcome in the 20th century, especially in Brazil, a country marked by social inequality, technological backwardness and environmental disrespect.

In this sense, the PMGIRS of the city of Piracicaba, prepared and reviewed by a multidisciplinary team, the most important institutions of the city and the state of São Paulo as the Secretariat of Environment of the Municipality, as well as the Luiz de Queiros School of Agriculture of the University of São Paulo, comes both in line with the organic law of the municipality and the Federal Law No. 12.305/2010 and allows public managers maximum efficiency in the management of municipal solid waste, consequently contributing to social and economic development in line with environmental preservation. Specifically regarding agroforestry and livestock waste, the document stands out for the clarity, methodology, data and information used and conveyed to the reader in which the concern of the municipality is highlighted especially with the proper disposal of pesticide containers, in which the sugarcane growers cooperative - COPLACANA has a leading role in virtually all stages of reverse logistics in compliance with current legislation, especially NBR No. 13,968, Federal Law No. 12,305/2010 and the Sectoral Agreement of 25/11/2015. However, no guidelines are observed in the document for agroforestry-pastoral organic waste, especially regarding its reuse for energy and fertilizer.

In this sense, a SWOT Matrix was prepared, as well as a prospective analysis of services in agroforestry-pastoral waste and an action plan for such waste in order to contribute, humbly, to the improvement in its future editions and, therefore, fulfilling the objectives described in the methodology of this work.

The municipality of Piracicaba is advanced in the practices of disposal and collection of agroforestry and livestock waste, having reverse logistics covering the entire urban area of the municipality. It is important to highlight the importance of a complete diagnosis of agroforestry residues, since it will serve as the basis for all proposals presented by the plan, such as programs, objectives and goals. It is necessary to know the local reality in order to effectively manage and administer agroforestry and livestock waste. Although the city of Piracicaba is well served by this service, it is still necessary to expand the inspection, either by the municipal, state and federal government, given the increase in pesticide consumption in the next decade.

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