http://dx.doi.org/10.23925/2179-3565.2023v14i3p84-98

RISUS - Journal on Innovation and Sustainability
volume 14, número 3 - 2023
ISSN: 2179-3565
Editor Científico: Arnoldo José de Hoyos Guevara
Editor Assistente: Vitória C. Dib
Avaliação: Melhores práticas editoriais da ANPAD

SOCIAL INNOVATION IN WASTE MANAGEMENT IN RESIDENTIAL BUILDINGS: PROPOSAL OF A CENTER WITH MULTI-SELECTIVE SEPARATION IN BRAZIL

Inovação social na gestão de resíduos em edifícios residenciais: proposta de um centro com separação multi-seletiva no Brasil

Lilian Aligleri, Camila Santos Doubek Lopes, Caio Victor Lourenço Rodrigues, Cláudio Pereira de Sampaio
Universidade Estadual de Londrina
Email: lilian.aligleri@uel.br, camiladoubek@uel.br, caio.rodrigues@uel.br, claudiopereira@uel.br

ABSTRACT

A large number of Brazilian municipalities still need to develop models and arrangements that enhance the disposal and proper destination of materials, especially in homes at large residential buildings that increasingly occupy the metropolises and the urban landscape. Thus, from the theoretical perspective of social innovation, this paper presents a proposal for structuring multi-selective waste collection for residential condominiums that include the design of a multi-selective waste segregation system in the form of a Center, an environmental education program to stimulate new behaviors and separation habits of residents, and the structuring of new channels for the disposal of sorted materials. The construction of the model took place collaboratively, in a multi-stakeholder approach, including researchers from various areas of knowledge, cooperatives of waste pickers, and representatives of business associations constituted to fulfill the reverse logistics of materials, managers, and residents of residential condominiums. The social innovation presented proposes new dynamics and structures to improve logistics efficiency and the recovery of the economic value of the material, as well as the ability for the action of society and the socio-productive inclusion of waste pickers.

Keywords: selective collection model, social innovation, waste management, condominiums, multi-selective separation

ACEITO EM: 10/08/2023
PUBLICADO: 20/09/2023

RISUS - Journal on Innovation and Sustainability
volume 14, número 3 - 2023
ISSN: 2179-3565
Editor Científico: Arnoldo José de Hoyos Guevara
Editor Assistente: Vitória C. Dib
Avaliação: Melhores práticas editoriais da ANPAD

INOVAÇÃO SOCIAL NA GESTÃO DE RESÍDUOS EM EDIFÍCIOS RESIDENCIAIS: PROPOSTA DE UM CENTRO COM SEPARAÇÃO MULTI-SELETIVA NO BRASIL

Social innovation in waste management in residential buildings: proposal of a center with multi-selective separation in Brazil

Lilian Aligleri, Camila Santos Doubek Lopes, Caio Victor Lourenço Rodrigues, Cláudio Pereira de Sampaio
Universidade Estadual de Londrina
Email: lilian.aligleri@uel.br, camiladoubek@uel.br, caio.rodrigues@uel.br, claudiopereira@uel.br

RESUMO

Um grande número de municípios brasileiros ainda precisa construir modelos e arranjos que potencializam o descarte e a destinação adequada dos materiais, em especial, nas moradias em edifícios residenciais que ocupam cada vez mais as metrópoles e a paisagem urbana. Assim, a partir da perspectiva teórica da inovação social, este trabalho apresenta uma proposta de estruturação de coleta multisseletiva para condomínios residenciais que incluem a concepção de um sistema de segregação multisseletiva dos resíduos no formato de uma Central, um programa de educação ambiental para estimular novos comportamentos e hábitos de separação dos moradores e a estruturação de novos canais para destinação dos materiais triados. A construção do modelo se deu de forma colaborativa, numa abordagem de multistakeholders, abarcando pesquisadores de diversas áreas do conhecimento, cooperativas de catadores, representantes de associações empresariais constituídas para cumprir a logística reversa dos materiais, gestores e moradores de condomínios residenciais. A inovação social apresentada propõe novas dinâmicas e estruturas para melhorar a eficiência logística e a recuperação do valor econômico do material, assim como a capacidade de ação da sociedade e a inclusão socioprodutiva dos catadores.

Palavras-chave: modelo de coleta seletiva, inovação social, gestão de resíduos, condomínios residenciais, separação multisseletiva

INTRODUCTION

Two of the greatest sustainability challenges of modern society are the excessive generation and environmentally appropriate management of solid waste, especially in large and medium urban centers. In Brazil, the daily generation of municipal waste is 1,039 kg *per capita* [Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE), 2020], which represents a significant amount in large cities. The high mass of materials discarded daily in urban centers becomes a major and imminent challenge for public management, that has dealt with many difficult-to-degrade materials from multiple production chains. The short life cycle of the packages, aligned with the increase in the programmed obsolescence of the products (Latouche, 2014) and the unbridled consumerism (Bauman, 2008), corroborate to expand the problem. World Bank estimates signal a 93% growth in total waste mass by 2050, compared to 2016 (Kaza, Shrikanth, & Chaudhary, 2021).

This context is amplified in the houses in large residential buildings, which increasingly occupy the metropolises and the urban landscape. A vertical condominium occupies a small urban space, although it concentrates a large number of individuals. This phenomenon promotes an increase in population density and consequently the concentrated production of municipal solid waste, increasing the challenges of the management of those wastes. According to da Silva and Romero (2013), urban expansion without technical monitoring promotes several negative impacts on environmental quality, mainly due to the absence of environmental education programs, adequate management of post-consumer materials, and other pollutants generated.

Although the Brazilian Solid Waste Policy (PNRS), promulgated 11 years ago, has brought innovative principles and objectives for the management of household waste and the reintroduction of recyclable materials into new production chains, the conclusions of several studies converge on the stagnation of recycling rates, despite the great dissemination that has been made about the theme [ABRELPE, 2020; Applied Economic Research Institute (IPEA), 2017; Business Commitment for Recycling (CEMPRE), 2020]. According to IPEA (2017), between 30% and 40% of municipal solid waste generated in Brazil is considered reusable; however, only 13% of those go to new transformation flows. Although the selective collection is already present in most Brazilian municipalities, the activity still does not cover, in the vast majority of them, the entire urban area (ABRELPE, 2020).

Besides, we shall consider the effectiveness of the selective collection models adopted. Bringhenti (2004), who studied several Brazilian selective collection programs, concluded that the engagement of the population is due to the organization, adequacy of the infrastructure, and the existence of continuous actions of dissemination, mobilization, and information.

A large number of Brazilian municipalities still need to build models and arrangements that enhance the disposal and proper disposition of materials in urban centers, since several studies have pointed out strong deficiencies regarding methodologies and technologies (Gonçalves-Dias, Ghani, & Cipriato, 2015; Teodósio, Gonçalves-Dias, & Santos, 2016; Netto, Guimarães, & Leal Junior, 2017; Aligleri, Aligleri & Gois, 2020), besides great idiosyncrasies between different cities and regions of the country (ABRELPE, 2019; ABRELPE, 2020). Therefore, it is urgent to expand the quantity and quality of the actions carried out so far, as well as innovate in management policies and practices (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018), especially in large vertical residential condominiums with high demographic density. We emphasize that, in general, the literature on the management of solid waste in the environment of vertical condominiums depends on diagnostic studies. Few articles propose models to promote the modification of the situation.

From the theoretical perspective of social innovation and spatial density as a catalyst for alternatives (Maccallum, Moulaer, Hillier, & Vicari, 2009), this paper presents a proposal for structuring multi-selective collection for residential vertical condominiums. The projected conception is a model based on the current context of the challenges of mobilization, articulation, and social inclusion still existing in the implementation of selective collection and reverse logistics of packaging, instituted by the PNRS - Brazilian Federal Law n. 12305, of 2010.

Thus, the social innovation of multi-selective collection described in this article started from the perspective that it is essential to eliminate structural restrictions that inhibit the proper disposition, as well as to help consumers overcome limitations and motivate them to more sustainable consumption and disposal patterns (Thogersen, 2005).

In this study, the researchers depart from the recognition of reusable and recyclable solid waste as an economic good and with social value, generating work and income, and wrapped in great cultural, technological, economic, environmental, social, political, administrative, and public health complexity. Therefore, the context of urban solid waste is considered as a complex socio-technical system, which involves both technical and human aspects, and whose effectiveness and efficiency result, more than its isolated elements, from the way the interaction between them occurs (Ison, 2017). The proposal was conceived by several researchers from a public university within the Interdisciplinary Center for Waste Studies (NINTER.UEL).

Above all, the relevance of the study is based on the recent nature of the law, with arrangements and articulations still in the process of structuring. Besides, the proposal presented in this article is justified by meeting several research efforts desired by the Vienna Declaration, such as the relationship between service innovation and social innovation, value creation through social innovation, and improvements based on collaborative organizational formats (Vienna Declaration, 2011), in addition to supporting actions within vertical residential condominiums and municipal public policies. This article is structured as follows: first, it presents a brief review of the literature on social innovation; then, describes the methodology used; after, it presents the local context of household waste and the central model for condominiums; then, it portrays the model proposed from the dimensions of social innovation; finally, it presents the considerations.

1 THEORETICAL FRAMEWORK

The problem of municipal solid waste can be considered complex (Rittel & Webber, 1968) and therefore cannot be solved through isolated disciplinary approaches. The management of household waste in Brazil, although standardized by the PNRS, presents numerous and important weaknesses in the management system, especially the production chains involved in mandatory reverse logistics (Venâncio, 2020; Siqueira, 2018; Aligleri & Lopes, 2022). The legislation brought changes in the role and behavior of social agents (general population, companies, waste pickers, and municipalities), in addition to the need for local reorganization of waste processes and flows (Neves, 2020).

However, in most municipalities, many of the materials generated at home do not present well-structured processes for proper collection and disposal. Waste that should not be considered as tailings continues to be sent to landfills or irregular deposition areas, as indicated by several Brazilian studies (Nunes & Bastos, 2018, Aligleri & Lourenço, 2018). There is no technical capacity or political skill in the municipalities to structure the reverse chains beyond the cooperatives and recycling associations, in integration and direct action of productive organizations co-responsible for mandatory reverse logistics. The household waste sector lacks effective systems that favor integrative management of all actors involved (Nunes & Bastos, 2018; Besen, Freitas, & Jacobi, 2017; Teodósio, Gonçalves-Dias, & Santos, 2016; Demajorovic & Massote, 2017; Anjos, Bueno, Anjos, Pinheiro & Jardim, 2020) to the selective collection model reverts to a circular economy. Several scholars on the subject have warned that this lethargy compromises urban sustainability, which is one of the great dimensions of sustainable development (Besen, Jacobi, & Silva, 2021; Abramovay, Speranza, & Petitgand, 2013).

Therefore, the time is ripe to seek changes and innovations that improve the efficiency of management, enable the circular economy, and fight poverty. New propositions can serve as a driver to improve the quality of the environment and life of the population (Neves, 2020), especially in urban territories with great density and population agglomeration. However, complex social problems such as the collection, segregation, and proper disposal of household waste cannot be understood, much less solved, without involving the agents of the third, public, and private sectors. It is in intersectoral relationships that new ideas, values, roles, and formats of cooperation are found, generating new and better approaches to create social value (Phills Jr, Deiglmeier, & Miller, 2008; Murray, Caulier-Grice, & Mulgan; 2010).

In this way, it is relevant to bring innovation in the dynamics of communities and in the articulation between various levels of social agents with proposals built from networks (Moulaert, Martinelli, Swyngedouw, & Gonzalez, 2005), where sectors, systems, and concepts converge. This context is anchored in the discussions of social innovation, understood as a process of mobilization-participation that leads to improvements in social relations, governance structures, greater collectivity, and empowerment of individuals (Vienna Declaration, 2011).

Phills Jr, Deiglmeier, and Miller (2008, p. 39) describe social innovation as:

[...] A novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals. A social innovation can be a product, production process, or technology (much like innovation in general), but it can also be a principle, an idea, a piece of legislation, a social movement, an intervention, or some combination of them.

The Theoretical, Empirical and Policy Foundations for Building Social Innovation in Europe (TEPSIE) project, which is in line with the concept of Phills Jr, Deiglmeier, and Miller (2008), complements the definition by stating that social innovation should be based on product dimensions (meeting social needs), process (improving relationships and capabilities or using assets and resources in a new way), and empowerment (increasing society's ability for action). They still advocate the presence of five elements to define a practice as socially innovative: I) novelty: innovation should not necessarily be original, but must be new for those involved in its implementation; II) put into practice: social innovation is concerned with the implementation of an idea; III) effectiveness: should be more effective than existing solutions, i.e. provide cost improvements or impacts on quality of life; IV) to meet a social need: they are created to meet a social need positively or beneficially and, therefore, are contextual and; V) increase the capacity of action of a society: empower those involved to act in other situations, creating new roles and relationships.

In this perspective, the concept of creative destruction, as proposed by Schumpeter, applies to the concept of social innovation, especially in the destruction of routines, usual practices, resource flows, authority, and established social structures. Murray, Caulier-Grice, and Mulgan (2010), in their important work, corroborate in describing the different stages of appropriation of the term, organized by the authors in six moments – identification of opportunities and challenges, generation of ideas, prototyping, learning, and validation, escalation, and systemic change.

However, it is important to highlight that social innovation appears in the literature linked to various activities and areas of knowledge, is considered a multidisciplinary concept. Choi and Majumdar (2014) point out in their work the different theories of social innovation and make a compendium from seven literature streams, being: the sociological perspective, the perspective of the study of creativity, the perspective of entrepreneurship, the perspective of the economy of well-being, the perspective of practice, the perspective of community psychology, and the perspective of territorial development. From the seven different lenses of knowledge, the authors identify three major congruences in the propositions:

a) the term social innovation is not linked to new specific products or services, but to the very change that is manifested in the transformations of social structures, that is, social innovation is understood as social change and a renewal of social structures;

b) social innovations are means intentionally designed to achieve specific purposes and, therefore, do not manifest themselves as a material object, but mainly at the level of the intangible involving interaction and social practice, and;

c) it is used to describe practices that explicitly aim at creating social value and inducing positive social changes, such as improving human and environmental well-being.

From the study, Choi and Majumdar (2014) propose three dimensions to understand the aspects of social innovation, as shown in Figure 1. The authors argue that, for a proposition to be characterized as social innovation, all three dimensions shall be present.

Figure 1 - Dimensions of Social Innovation from Choi & Majumdar's Perspective

Source: adapted from Choi & Majumdar (2014)

The discussions and the model proposed by Choi and Majumdar (2014) reinforce the statement of Franz, Hochgerner, and Howaldt (2012) that the intentionality of social innovation is collective and distinguished from

the mere social change, in which changes simply happen. Murray, Caulier-Grice, and Mulgan (2010) also recall that social innovation does not refer to any specific sector of the economy but to innovation in creating social solutions that are good for a collective and improve society's ability for action. Thus, they can come from the public, the private, and the third sectors. It is in this sense that Mair and Gegenhuber (2021) defend the concept of open social innovation, that combines the spirit of collective action and co-creation, integrating, for example, the public sector and citizens at the beginning of the process of identifying challenges, interacting with ideas, developing, and prototyping solutions. They argue that such a construction format could create a sense of collective responsibility with change and enable collective learning about how to face challenges and the crises resulting from the innovative process.

2 METHODOLOGY

The model of structuring and waste management for condominiums proposed in this article was built within the interdisciplinary Waste Center of the State University of Londrina (NINTER.UEL) with the participation of researchers from various areas of knowledge, including administration, design, engineering, biology, and collective health.

We developed a model based on the premises of open social innovation (Mair & Gegenhuber, 2021), in which, to the concept of social innovation, is added the creation and participatory construction, in which several agents that make up the problem participate in the design of viable solutions. The construction of the model, carried out collaboratively by researchers, also involved, in different phases of the process, cooperative member waste pickers and managers, representatives of business associations constituted to fulfill the reverse logistics of materials, condominium managers, janitors, and residents of vertical condominiums.

The methodological nature of this research is applied because it proposes artifacts in the form of a model, a Waste Center, and communication pieces. Within the context of Design Science Research, one of the design methods adopted, the term "artifact" is broad and can be classified according to the level of tangibility involved. Thus, in increasing order of embedded knowledge, we have the following types of artifacts: a new construct, a new model, a new tool, a new method, and a new product/service/system (Santos, 2018). Concerning the objectives, it can be affirmed that this is exploratory research because it seeks to promote more information on the theme of the object of study, enabling its design. As for the technical procedures adopted, each stage of the project has a typology. Initially, bibliographic and documentary research was carried out using primary and secondary sources (Provanov & Freitas, 2013), especially scientific articles, research reports, official documents, and course completion work to support the construction of a diverse concept of waste collection with recyclability potential in vertical condominiums.

The **first artifact** was the development of a theoretical-methodological model for waste management in condominiums, which considered the use of the following sequence of processes: problem analysis, data collection, model construction, model verification, model validation, projection and conduction of simulation experiments, analysis of results, and final recommendations (Altiok & Melamed, 2007).

The modeling of the **second artifact** (the layout of the Waste Center), in turn, was performed through the Design Science Research approach, which includes the following steps (Santos, 2018): understanding of the problem, generation of alternatives, artifact development, evaluation, and conclusions.

For the **third artifact** – communication model – the modeling involved studying the means of diffusion of graphic pieces, visual language, graphic design, and terms appropriate to the reader, considering the standard of environmental awareness and the definition of graphic design and production using vector programs.

As categories of analysis to correlate the idealized proposition with the theoretical contribution of social innovation, we will use the three dimensions of social innovation conceived by Choi and Majumdar (2014): formalization, processes of change, and social results.

Although the proposal for a Center has already gone through the prototyping stage in the form of a pilot application, we emphasize that the results obtained from it will not be presented in this article.

3 RESULTS

Artifacts, and specifically those of a concrete nature, are always related to problem-solving in concrete and specific contexts. In this sense, the territories, with their distinct economic, cultural, political, and social characteristics, obviously require diverse solutions to complex problems (Neves, 2020), since local specificities bring a high degree of contingency, as well as unique challenges and opportunities (Moulaert et al., 2005; Maccallum, Moulaert, Hillier, & Vicari, 2009). Besides, social innovation is considered by many authors to be specific to a context that, in this study, refers to the selective collection of municipal solid waste in vertical condominiums located in large Brazilian cities.

Some of the waste generated at home, although not collected by recycling cooperatives in Brazil, has mandatory reverse logistics in the country such as batteries, lamps, electronics, medicines, and packaging of food, beverages, and post-consumer cleaning products. Studies developed in different realities have already pointed out that the distance from the waste collection station and the conditions for separation is significantly related to the participation rate of individuals (Li, Zhang, Nouvellet, Okoro, Xiao, & Harder, 2020; Stoeva & Stina, 2017; Miliute-Plepiene, Hage, Plepys, & Reipas, 2016; Barr, 2016). However, many municipalities have not yet regulated, at the local level, the responsibilities, goals, and integrated solutions that will be adopted by the production chains to comply with federal legislation.

In a large number of Brazilian municipalities, the management of household waste hides worrying evidence, such as the increase in the volume and variety of different types of solid waste generated; the cramped rate of waste recycled, in the face of the potential existing in the city; inefficiency in system management; the absence of a municipal waste management plan; the lack of a local public environmental education program for proper separation; the high degree of misinformation of the population on the issue; and the low level of political involvement and community participation. However, municipalities lacks new strategies and proposals for the management of different types of post-consumer household waste, involving the active participation of the population and partnerships with various social agents, which would increase the environmental and social benefits of the system, and reduce public spending on the management of waste produced in the cities (Besen, Jacobi, & Silva, 2021; Besen, Freitas, & Jacobi, 2017; Amaro, & Verdum, 2016).

Therefore, the potentialities brought by the legislation, the weaknesses envisioned in the current waste management process, and the academic studies consulted, that sought to know the waste management in Brazilian vertical residential condominiums (Bringhenti, Bassani, Laignier, Braga, & Günther, 2019; Pontes, Barrella, Giordano, & Ferreira, 2018), formed the body of knowledge that supported the structuring of the central elements of the proposal, which can be understood from 4 dimensions.

3.1 Dimension 1: multi-selective separation

Selective collection at the origin of generation, in individualized fractions, is seen as a precondition to promote high-quality recycling and high recovery rates of materials (Seyring et al., 2015). Most simply, waste can be classified into three categories: organic, recyclable, and tailings. According to data from National System of Information about Sanitation - SNIS (BRASIL, 2021), in 2020, only 1,664 Brazilian municipalities, out of 5,570, presented selective collection initiatives and reverse channels for the categories mentioned. Still, in a large number of them, the collection is fractionated into only two categories: tailings and recyclable.

Some examples of recyclable materials are plastics, paper, cardboard, metal, and Styrofoam. However, it is necessary to define the reverse channels for other typologies of urban waste, such as glass, lamps, cells and batteries, electronic devices, medicines and sharps, kitchen sponges, cooking oil, and textile materials. Within these, according to article 33 of the PNRS (BRASIL, 2010), it is mandatory to implement the reverse logistics of cells and batteries, fluorescent lamps, and electronic products. They are materials that require more refined recycling techniques and can also be dangerous in their handling.

Thus, in the proposal of the Waste Center, segregation takes place in 13 fractions, as shown in Figure 2. Organic, tailings, packaging (plastic, paper, metal, and styrofoam), electronics, cells and batteries, medicines,

sharps, and textiles are collected individually with specific locations. Glass, cardboard, cooking oil, lamps, and kitchen sponges are collected from a monomaterial perspective (Cimpan, Maul, Jansen, Pretz, & Wenzel, 2015).

Figure 2 - Fractions of multi-selective collection adopted for the proposal for a Waste Center

Source: the authors

In this context, the dissemination of the concept of separation and multi-selective collection becomes important since the improvement of the traditional system can promote a better quality of segregated material, increase its market value, stimulate new institutional arrangements for reverse logistics, and ensure the safety of workers involved in the recycling process.

3.2 Dimension 2: The Design of the Waste Center

The design (conception, project, or drawing) of an artifact is, by its nature, a synthesis activity. The artifact synthesizes the various aspects identified and analyzed in the stage of diagnosis of the problem, and should, as far as possible, respond satisfactorily to each of them. As a result of the diagnostic previously performed in a systemic manner, these aspects result in two elements that will guide the artifact development process: the requirements that the artifact shall meet and the attributes that the artifact shall present to meet these requirements. Concerning the Waste Center, the following requirements and attributes can be listed, as well as the solution given, according to Figure 3.

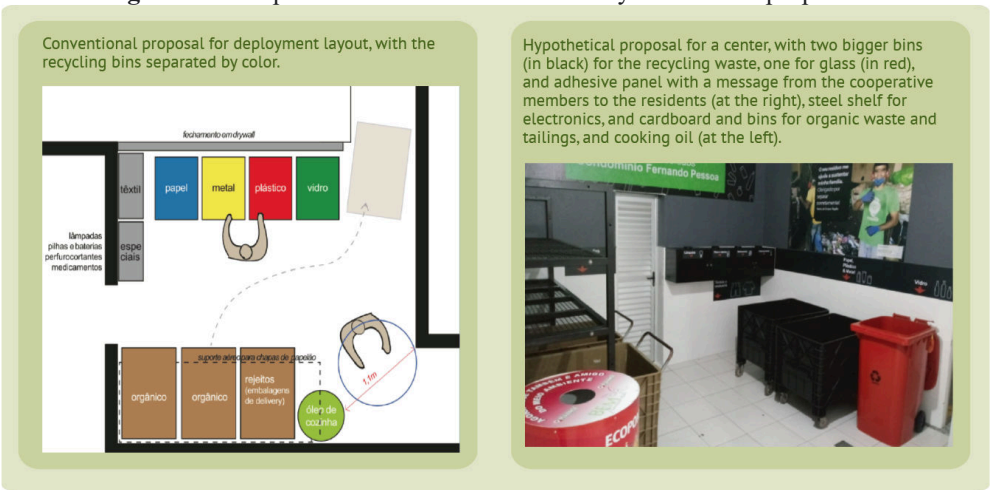
Figure 3 - Requirements, attributes, and solutions that are given for the Waste Center project

	Requirements	Attributes	Solution presented
Environmental	• Multi-selective separation into 13 categories: organic, recyclable (plastic, glass, metal, paper, and cardboard), tailings, glass, kitchen sponges, cooking oil, textile materials, medicines, lamps, cells and batteries, cardboard, and electronics.	• Bins adequate to each type of waste; • Limited access to children; • Use bins that are available in the market, whenever possible; • Mobility of the bins, allowing the reorganization of the layout, if needed.	• Plastic bins available in the market for organic waste, tailings, and recyclables, that are open, with wheels, and with a cover for the glass; • Metal shelf with railing for cardboard and electronics (metal shelf) due to the volume; • MDF box with an internal plastic bag for special residues (lamps, cells, batteries, medicines, sharps); • Bin for oil, provided by the company that collects this material.
Economic	• Cost-benefit relation considering the center's extended life cycle, not only the capital base invested.	• Bins and visual identification are made with durable and easy-to-clean materials.	• Solutions mentioned above; • Visual communication in high-durability vinyl adhesive digitally printed and applied directly on the wall.
Social	• Creation of an emotional bond between the residents of the condominium and the cooperative waste pickers; • Creation of new business, work, and income opportunities for waste pickers.	• The visual communication shall include a message that strengthens this bond; • Bins that are exclusive to new types of waste (textile, sponges) facilitate the disposal and collection of those materials.	• PVC adhesive plate with a message from a cooperative member, thanking for the correct separation of materials; • Bins for textiles and sponges, with exclusive identification.
Legal	• The dimensioning of the center shall respect minimum dimensions for spacial circulation, including wheelchairs, according to norm NBR 9050:2020; • The dimensioning of the center shall respect the minimum limits for ventilation opening for odors to escape and renewal of the air, according to the City's civil works code.	• The space shall have a minimum diameter of 1.5 m for wheelchair maneuvering; • The space shall provide extra space for openings for circulation corridors.	• The bins shall free the central space for circulation, with a free diameter greater than 1.5 m; • The circulation access points shall be maintained, considering the circulation of residents and collaborators for the removal of waste.
Funcional	• Possibility for adaptation to different types of layout and mobility of the components; • Simplified installation, maintenance, and cleaning, without the need for special tools; • Easy access by the user, mainly regarding the height and depth of the bins, the weight of the materials for removal, and the visibility and readability of information; • Easy identification of the different types of materials.	• The modular and ergonomic conception of the center, for the equipment, bins, and visual communication.	• The customized elements (shelf for electronics and cardboard) and MDF shelves and boxes are modular and collapsible; • The identification adhesives have modular measures of width and height; • The identification use text (names of materials) and image (pictograms) to support communication, in white lettering on black background, generating good contrast to facilitate reading, as well as indication arrows.
Aesthetic-formal	• The visual aspect of the center shall be light, pleasant, and elegant, and shall not look like a waste deposit; • The visual aspect of the center shall promote a feeling of pride and satisfaction for having this space in the condominium.	• Use of formal elements (shapes, colors, typography, and images) that reflect the aesthetic-formal requirements.	• The center shall be conceived with formal language and graphic-visual elements that the target public knows and apreciates (mall shops, kiosks, markets, and urban signs).

Source: the authors

As a result of this synthesis, images of the project and the Center already implemented are presented in Figure 4. It is worth mentioning the changes made between the design and the implementation to optimize the operation of the Center, such as the replacement of the four colored bins, initially provided as only two larger bins in the color black. This change is because, throughout the open innovation process adopted for the design of the Center, the waste pickers reported that one of the activities carried out by them is the separation of recyclable paper, metal, and plastic packaging, and the residents do not need to do this screening.

Figure 4 - Comparison between conventional layouts and the proposition



Source: the authors

3.3 Dimension 3: Reverse Channel Articulation

The reverse channel articulation is an indispensable condition for the effectiveness of multi-selective collection. Despite the mandatory reverse logistics of some waste, as mentioned above, sectoral agreements with manufacturers, distributors, and traders shall not only take place at the national level but also locally.

Despite the evolution observed since the creation of the PNRS, the reverse logistics of waste are still incipient. Some production chains have financed and created business associations for the establishment of reverse channels of their products, however, voluntary delivery points exist in small quantities, do not cover the entire national territory, and have low consumer participation (Demajorovic & Massote, 2017).

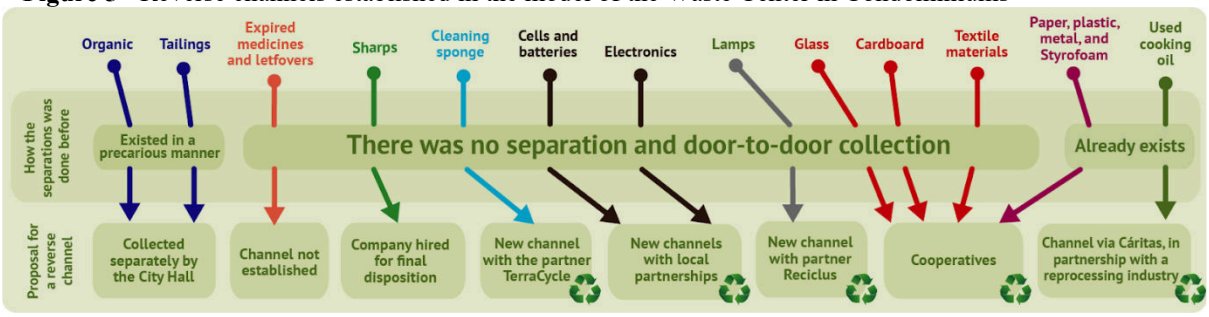
Through waste centers in multifamily vertical residential condominiums, multi-selective collection can stimulate new institutional arrangements for reverse logistics. However, the associations representing the productive sectors for reverse logistics must be partners and join the concept proposed in this work.

To date, some fragile reverse channels have been built from established partnerships, comprising organizations that operate at the local, regional, and national levels (Figure 5). Reciclus, an association that serves lamp manufacturers, has provided a bin and the reverse logistics of this material in the condominium. For the cooking oil used, they took advantage of the existing channel, the collection made in a specific bin distributed and managed by Cáritas Brazil, a religious association; the waste collected is destined by a specialized company and partnership of this organization. The kitchen sponges will be intended for TerraCycle, a company that is sponsored to provide solutions for waste that are difficult to recycle. Textile materials, glass, cardboard, and packaging will be destined for the cooperatives of recyclable materials contracted by the municipality. Cells, batteries, and electronics are sent to an entity with regional operations that has an environmental license for the specific operation of electronic waste.

Finally, the reverse channel for expired medicines and their leftovers has not yet been established. Despite the recent Brazilian Federal Decree No. 10388 of September 2020, the legal obligation, in the vast majority of municipalities, will take place from 2023. Thus, throughout the design process of the multi-selective segregation system, we encountered great difficulties in establishing partnerships with this sector to test new logistics channels.

This situation serves as a warning for municipalities to act in developing local agreements. Those policies bring benefits to the municipality itself, with savings in the management of solid waste.

Figure 5 - Reverse channels established in the model of the Waste Center in Condominiums



Source: the authors

3.4 Dimension 4: Environmental Awareness and Education

The environmental education approach developed to support the separation and disposal in the Center was constructed from an integrated process of sustainable consumption, use, and disposal, from a preventive perspective of waste generation. Several studies indicate that the success of selective collection is directly associated with investments in community environmental commotion and awareness (Bringhenti & Gunther, 2011; Rispo, Williams, & Shaw, 2015; Murase, Murayama, Nishikizawa, & Sato, 2017).

To the efficiency of communication for environmental education, we concluded that the most effective means to reach the target audience would be some prints to dispose of in elevators and murals, and posts to circulate in WhatsApp groups. Each information material has a moment of dissemination, according to the implementation phase of the Center.

The visual identity sought to follow that applied to the Center (Figure 4), with black, green, and white as the basis and graphics that refer to the waste. Typography is without serif, to facilitate reading, and modern lines, to convey the contemporaneity of the model.

Thus, 15 newsletters and 14 posts were prepared. The approach was always positive and informal, employing simple and accessible language, to generate the curiosity and friendliness of the reader to participate in the new form of separation. At the time of the creation of the materials, we tried to convey the message first through images, with the support of short texts. This strategy considered the attractiveness of colors and vector illustrations and photos, the short reading time in elevators, and the tendency of people to read less and less.

The layouts that were designed to be published first aim to support the resident or employee in their new method of separation of recyclable waste and also materials that usually cause hesitation at the time of fractionation, such as laminated packaging and foams. For environmental reasons, only that presentation of the Center and that explains the way of separation of waste will be printed to be distributed to all residents. The other prints will be for collective reading in murals and elevators (Figure 6). Following the recommendations for the generation of graphic products of less impact, will be used for printing: recycled paper of low weight, digital printing, and print shop with environmental licensing and located in the same municipality of the condominium where the collection will be implemented. To show that the efficient separation of waste does not only benefit the environment but also the cooperative members, videos with their statements were developed and will be released through QRCode and on the social networks of the condominium, bringing residents and employees closer to the reality of the cooperative members.

Figure 6 - Layout samples to be printed and shared via WhatsApp

Source: Ninter, 2021.

As conceived, this communication proposal to promote environmental education has the potential to transform the quality of waste separation in condominium units, but beyond that, the critical perception of the public given the composition and volume of packaging offered in the market and the contact with the reality of the cooperative members, who live in a situation of extreme social vulnerability.

4 THE PROPOSAL FROM THE DIMENSIONS OF SOCIAL INNOVATION

The proposal was categorized using the constituent dimensions of social innovation, developed by Choi and Majumdar (2014). In the **formalization** dimension, it can be understood from the perspective of a management model that includes a product-service system [United Nations Environment Programme (UNEP), undated] and, therefore, is strongly dependent on the target audience and context. Brazilian municipalities adopt different strategies for the management of household waste produced within their territory. Thus, it is assumed that the model to be replicated and disseminated shall be adjusted to the specificities of the local conjuncture. For example, in a municipality where there is no selective collection as a continued public service, it will be necessary to educate the consumer regarding the importance of this separation and create partnerships with waste pickers, who work in the territory determining periodicity and way of collecting materials with potential for recyclability. It may even be important to assist recyclable waste pickers in identifying potential buyers for some difficult-to-market materials, such as glass.

The second dimension of Choi and Majumdar's proposition (2014) refers to the **processes of changes** in social relations. Regarding the way of separation of waste, we can affirm that habits of residents in condominiums are changed since the local public system collects door-to-door waste in 2 fractions and the proposal comprises a separation in 13 fractions. Also, concerning practices and routines, there is an important change in the way of collecting some materials, such as cells, batteries, medicines, and lamps. In the usual collection format, these are taken by the resident to a voluntary delivery point and scattered in the urban territory. From the implementation of the Center, the materials began to be part of the door-to-door collection system. This change in the collection system facilitated the activity of proper disposal of post-consumer materials since the distance traveled by the resident is close to zero.

The proposal also brought a change in processes for Reciclus, a business association established to manage the mandatory reverse logistics of lamps in Brazil, since, from networks, a program was created for direct collection in large registered condominiums. This is very relevant because studies conclude that the convenience and accessibility of waste disposal sites have a positive effect on the behavior and adhering of individuals (Li et al., 2020; Barr, 2016).

The multi-selective separation, aligned with the communication to residents about the importance of washing recyclable packaging and proper sorting, facilitates the work routines of the cooperative that receives the materials. Some materials, such as cardboard and glass, as they are packed in the Center as monomaterials, do not need to go through the screening mats.

Regarding the transformations of social interactions, it is important to mention that the communication focused on the residents sought to bring them closer to the conditions of vulnerability, challenges, and routine difficulties of the members in the handling of the material with recycling potential. The communication materials have images and speeches of the waste pickers bringing those professionals to the social life of the residents since they were elaborated to be fixed in different areas of common circulation of the building. We sought to minimize social abuse by bringing greater visibility and appreciation to this category of professionals to sensitize residents to the importance of the practice of separating domestic recyclable waste and its relevance to the cooperative. Important works developed by Buch (2015) and Gonçalves-Dias, Sakurai and Ziglio (2020) point to the importance of this social reconnection.

We can say that the proposal created a more efficient governance structure for waste generated in condominiums, concerning the usual model adopted by the City Hall, since it formed specific channels of destination for household waste that has been neglected at the local level, like textiles and cleaning sponges that, although they have recycling potential, ended up with the landfill recommended as their final destination.

The third and final dimension covers the **social results** desired with innovation. The social value created through changes in routines, processes, and relationships meets relevant social needs of environmental and human well-being. Among them, we can highlight the gains by:

· Creating new attitudes and behaviors towards disposal from the development of communication material focusing on sensitizing residents to reduce waste generation, encouraging reuse and increased recycling;

· Contributing to the proper disposal of household waste by creating a waste plant layout linked to a multi-selective collection, as well as more efficient reverse channels for special materials not inserted in the traditional selective collection;

· Improving the income of workers of the recycling cooperative from the expansion of the mass and the best quality of the material with recycling potential destined to the cooperative, due to the reduction of cross-contamination by mixture;

· Adding value to materials with recycling potential due to the improvement of the separation process at the generating source, which contributes to the reduction of the *per capita* mass of tailings destined to the landfill;

· Expanding the circularity of materials by promoting the proper collection of post-consumption materials, directing them to their production chain;

· Contributing to the improvement of public policies by meeting the objectives present in the National Solid Waste Policy (art. 9, 25, and 33), especially when presenting alternative collection flows in the reverse chains of special materials with mandatory reverse logistics.

In short, the proposition described in this article allowed articulation and new relational arrangements between asymmetric social agents with diverse rationalities, to create reciprocal relationships and cooperate with new strategies of action in the scope of the management of household waste generated in verticalized residential condominiums.

CONCLUSION

The proposal presented in this article covers a set of solutions that will support the management of household waste in vertical residential condominiums, and that includes the design of a multi-selective waste segregation system (Waste Center), an environmental education program to stimulate new behaviors and separation habits of residents, and the structuring of new channels for the disposal of screened materials. The social innovation presented proposes new dynamics and structures to improve society's capacity for action in reducing material waste by increasing logistics efficiency, recovering the economic value of the material, and socio-productive inclusion of waste pickers.

The proposition is innovative for the field, region, and user, and can be framed as an incremental social innovation regarding the management of household waste. However, in some respects, it presents characteristics of radical innovation as it articulates new formats of relation and interaction between agents or social groups, and by reinserting different materials that were locally treated as tailings into the economic system.

The model presented can be replicable to other localities as long as it is adjusted to the partners and the peculiarities of the local context, which is made possible by the modular and adaptable character with which it was conceived. Finally, we highlight the strategic and challenging role of the university in this technical-political process of promoting emancipatory solutions, based on interdisciplinary investigations empowered to talk to each other without imposing academic responses and pasteurized policies.

REFERENCES

Aligleri, L., Aligleri, L. A., & Gois, G. L. (2020). Embalagens de vidro pós-consumo no sistema de coleta seletiva: estudo de caso da cidade de Londrina. *Revista de Administração da UFSM, 13,* 1193–1215. https://doi.org/10.5902/1983465944450 Aligleri, L, & Lopes, C. S. D. (2022). Logística reversa de embalagens pós-consumo: análise crítica interdisciplinar das intenções empresariais propostas no termo de compromisso do Recircular para cumprir a Política Nacional de Resíduos Sólidos. *Revista Brasileira de Políticas Públicas, 12*(1), 319-344. https://doi.org/10.5102/rbpp.v12i1.7483

Aligleri, L, & Lourenço, V. A. (2013, novembro). Análise gravimétrica dos resíduos sólidos não reciclados oriundos das cooperativas da cidade de Londrina. *Anais do Seminário Nacional de Resíduos Sólidos.* Associação Brasileira de Engenharia Sanitária e Ambiental. Cuiabá-MT, 13.

Altiok, T., & Melamed, B. (2007). *Simulation modeling and analysis with arena*. New Jersey, USA. Elsevier Science, 440 p.

Amaro, A. B.; & Verdum, R. (2016). *Política Nacional de Resíduos Sólidos e suas interfaces com os espaços geográficos:* entre conquistas e desafios. Porto Alegre: Letra1. https://doi.org/10.21826/9788563800237

Anjos, E. de O., Bueno, D., Anjos, A. C. P., Pinheiro, J. K., & Jardim, G. N. (2020). Estudo de caso dos resíduos sólidos e a percepção dos habitantes urbanos e catadores na cidade de Mundo Novo - Mato Grosso do Sul. *Revista de Gestão Ambiental e Sustentabilidade - GeAS,* 9(1), 1-20e16218. https://doi.org/10.5585/geas.v9i1.16218

Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais. (2019, novembro). *Panorama dos Resíduos Sólidos no Brasil 2018/2019*. 68p.

Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais. (2020, dezembro). *Panorama dos Resíduos Sólidos no Brasil 2020*. 52p.

Abramovay, R., Speranza, J. S., & Petitgand, C. (2013). *Lixo zero:* gestão de resíduos para uma sociedade mais próspera. São Paulo: Planeta sustentável: Instituto Ethos.

Barr, S. (2016). *Household waste in social perspective:* values, attitudes, situation and behaviour. London: Routledge, Taylor e Francis Group. https://doi.org/10.4324/9781315253206

Bauman, Z. (2008). Vida para consumo. Rio de Janeiro: Zahar.

Besen, G. R., Freitas, L. C., & Jacobi, P. R. (2017). *Política Nacional de Resíduos Sólidos:* implementação e monitoramento de resíduos urbanos. São Paulo: IEE-USP: OPNRS.

Besen, G. R., Jacobi, P. R., & Silva, C. L. (2021). *10 Anos da Política Nacional de Resíduos Sólidos*: caminhos e agendas para um futuro sustentável. São Paulo: IEE-USP: OPNRS.

Brasil. (2010, 2 de agosto) *Lei federal nº 12.305*. Institui a Política Nacional de Resíduos Sólidos; altera a lei n° 9.605 de 12 de fevereiro de 1998; e dá outras providências.

Brasil. (2021). *Sistema Nacional de Informações sobre Saneamento: Diagnóstico Temático Manejo de Resíduos Sólidos Urbanos – visão geral ano de referência 2020.* Ministério do Desenvolvimento Regional. Secretaria Nacional de Saneamento - SNS. Brasília: SNS/MDR, 59p.

Bringhenti, J. R. (2014) *Coleta seletiva de resíduos sólidos urbanos: aspectos operacionais e da participação da população.* Tese de Doutorado, Programa de Pós- Graduação, Faculdade de Saúde Pública, Universidade de São Paulo, São Paulo, SP.

Bringhenti, J. R., Bassani, P. D., Laignier, I. T. R., Braga, F. S., & Günther, W. M. R. (2019). Coleta seletiva em condomínios residenciais verticalizados do município de Vitória (ES): características operacionais e de participação social. *URBE. Revista Brasileira de Gestão Urbana,* p. 1-13. https://doi.org/10.1590/2175-3369.011.e20170223

Bringhenti, J. R., & Gunther, W. M. R. (2011) Participação social em programas de coleta seletiva de resíduos sólidos urbanos. *Engenharia Sanitária Ambiental, 16*(4), 421-430. https://doi.org/10.1590/S1413-41522011000400014

Buch, H. E. R. (2015). *Catadores de retornáveis (lixo) e (in)visibilidade social: dimensões psicossociais e educativas.* Tese de Doutorado. Programa de Pós-Graduação em Educação, Universidade Federal do Paraná, Curitiba, PR.

Compromisso Empresarial para Reciclagem (2020). *Pesquisa Ciclosoft 2020***:** resumo executivo. Compromisso Empresarial para Reciclagem. Disponível em: https://ciclosoft.cempre.org.br/

Choi N., & Majumdar S. (2015). Social Innovation: towards a conceptualisation. In: Majumdar S., Guha S., & Marakkath N. (eds) *Technology and Innovation for Social Change* (pp 7-34). New Delhi: Springer. https://doi.org/10.1007/978-81-322-2071-8_2

Demajorovic, J., & Massote, B. (2017). Acordo setorial de embalagem: avaliação à luz da responsabilidade estendida do produtor. *Revista de Administração de Empresas, 57*(5), 470-482. https://doi.org/10.1590/S0034-759020170505

Franz, H., Hochgerner, J., & Howaldt, J. (2012). *Challenge Social Innovation*: potentials for business, social entrepreneurship, welfare and civil society. Springer, Berlim. https://doi.org/10.1007/978-3-642-32879-4

Cimpan, C., Maul, A., Jansen, M., Pretz, T., & Wenzel, H. (2015). Central sorting and recovery of MSW recyclable materials: a review of technological state-of-the-art, cases, practice and implications for materials recycling. *Journal of Environmental Management, 156*, 181–199. https://doi.org/10.1016/j.jenvman.2015.03.025

Gonçalves-Dias, S. L., Ghani, Y. A., & Cipriato T. A. R. (2015). Discussões em torno da prevenção e da Política Nacional de Resíduos Sólidos. *Ciência e Sustentabilidade, 1(*1), 34-49. https://doi.org/10.33809/2447-4606.11201534-49

Gonçalves-Dias, S. L. M.; Sakurai, T., & Ziglio, L. (Orgs). (2020). *Catadores e espaços de (in)visibilidades.* São Paulo: Blucher. https://doi.org/10.5151/9788580394108

Instituto de Pesquisa Econômica Aplicada. (2017). A organização coletiva de catadores de material reciclável no Brasil: dilemas e potencialidades sob a ótica da economia solidária. *Texto para discussão.* Rio de Janeiro.

Ison, R. (2017). Systems Practice: How to Act. In situations of uncertainty and complexity in a climate-change world. 2nd edition. Springer & The Open University. https://doi.org/10.1007/978-1-4471-7351-9

Kaza, S., Shrikanth, S., & Chaudhary, S. (2021). More growth, less Garbage. *Urban Development Series.* Washington, DC: World Bank.

Kaza, S., Yao, L. C., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: a global snapshot of solid waste management to 2050. *Urban Development.* Washington, DC: World Bank http://hdl.handle.net/10986/30317

Latouche, S. (2014). *Hecho para tirar*: la irracionalidad de la obsolescencia programada. Barcelona: Editorial Octaedro.

Li, C., Zhang, Y., Nouvellet, P., Okoro, J.O., Xiao, W., & Harder, M. (2020). Distance is a barrier to recycling - or is it? Surprises from a clean test. *Waste Management, 108* (1), 183-188. https://doi.org/10.1016/j.wasman.2020.04.022

Mair, J., Gegenhuber. T. (2021, fall) Open Social Innovation. *Stanford Social Innovation Review*, 26-33. Disponível em: https://ssir.org/articles/entry/open_social_innovation

Maccallum, D., Moulaert, F., Hillier, J., & Vicari, S. (Orgs). (2009). *Social Innovation and Territorial Development.* Ashgate e-book, 2009. https://doi.org/10.1177/0266242610028003060 3

Miliute-Plepiene, J., Hage, O., Plepys, A., & Reipas, A. (2016). What motivates households recycling behaviour in recycling schemes of different maturity? lessons from Lithuania and Sweden. *Resources, Conservation and Recycling, 113*, 40–52. https://doi.org/10.1016/j.resconrec.2016.05.008

Moulaert F, Martinelli F, Swyngedouw E, & Gonzalez S. (2005). Towards Alternative Model(s) of Local Innovation. *Urban Studies, 42(*11), 1969-1990. https://doi.org/10.1080/00420980500279893

Murase N, Murayama T, Nishikizawa S, & Sato Y. (2017). Quantitative analysis of impact of awareness-raising activities on organic solid waste separation behaviour in Balikpapan City, Indonesia. *Waste Management and Research, 35*(10), 1013 –1022. https://doi.org/10.1177/0734242X17719499

Murray, R.; Caulier-Grice, J., & Mulgan, G. (2010). *The Open Book of Social Innovation.* UK: The Young Foundation. https://youngfoundation.org/wp-content/uploads/2012/10/The-Open-Book-of-Social-Innovationg.pdf

Netto, M. M., Guimarães, V. A., & Leal Junior, I. C. (2017). Coleta seletiva de lixo reciclável em Angra dos Reis/RJ: análise da evolução municipal e da participação popular. *Revista de Gestão Ambiental e Sustentabilidade - GeAS*, 9(2), 164-181. https://doi.org/10.5585/geas.v6i2.453

Neves, F. O. (2020). Inovações sociais e territoriais na gestão de resíduos sólidos urbanos: troca de lixo reciclável por alimentos. *Sociedade e Território, 32*(1), 132-151. https://doi.org/10.21680/2177-8396.2020v32n1ID19446

Nunes, A. C. T., & Bastos, V. P. (2018). Políticas públicas de sustentabilidade urbana no gerenciamento de resíduos sólidos. *O Social em Questão***,** 11 (40), 253-266.

Phills Jr, A. J, Deiglmeier K, & Miller D. T. (2008, fall). Rediscovering social innovation. *Stanford Social Innovation Review*, 34–43. Disponível em: https://ssir.org/articles/entry/rediscovering_social_innovation

Pontes, M. A. B., Barrella, W,.Giordano, F., & Ferreira, R. S. (2018). Resíduos sólidos secos recicláveis em condomínios verticais de Santos -SP. *Anais do Encontro Nacional de Pós-Graduação***.** Universidade Santa Cecília, Santos-SP, 7.

Provanov, C. C., & Freitas, E. C. (2013). *Metodologia do trabalho científico:* métodos e técnicas da pesquisa e do trabalho acadêmico. 2. ed. Novo Hamburgo: Universidade Feevale.

Rispo, A., Williams, I. D., & Shaw, P. J. (2015). Source segregation and food waste prevention activities in high-density households in a deprived urban area. *Waste Management, 44*, 15-27. https://doi.org/10.1016/j.wasman.2015.04.010

Rittel, H.W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences,* **4**, 155-169.

Ropohl, G. (1999). Philosophy of Socio-Technical Systems. *Society for Philosophy and Technology Quarterly Electronic Journal, 4*(3), 186–194. https://doi.org/10.5840/techne19994311

Santos, A. (2018). *Seleção do método de pesquisa:* guia para pós-graduandos em design a áreas afins. Curitiba, PR: Insight.

Seyring, N. et al. (2015, november). *Assessment of separate collection schemes in the 28 capitals of the EU.* European Commission, Brussels.

Siqueira, H. H. S. (2018). *Manejo de Resíduos de Embalagens do tipo "Snacks"*. Dissertação. Mestrado em Ciências Ambientais, Universidade Estadual Paulista Júlio de Mesquita Filho, Campus Experimental de Sorocaba: Sorocaba-SP.

Teodósio, A. S. S., Gonçalves-Dias, S. F. L., & Santos, M. C. (2016). Procrastinação da Política Nacional de Resíduos Sólidos: catadores, governos e empresas na governança urbana. *Ciência e Cultura, 68*(4), 30-33. http://doi.org/10.21800/2317-66602016000400011

Thogersen, J. (2005). How may consumer policy empower consumers for sustainable lifestyles? *Journal of Consumer Policy, 28*(2), 143–177. http://doi.org/10.1007/s10603-005-2982-8

United Nations Environment Programme. (n.d) *The role of product service systems.* France, Paris: United Nations Environment Programme Division Of Technology, Industry And Economics.

Venâncio, A. A. M. (2020). Case study: recycling and reuse of glass in Belo Horizonte-MG. *Brasilian Journal of Development, 6*(5), 32123-32161. https://doi.org/10.34117/bjdv6n5-602

Vienna Declaration (2011). The Most Relevant Topics in Social Innovation Research. *Concluding resolution provided by the conference "Challenge Social Innovation. Innovating Innovation by Research – 100 Years after Schumpeter".* Disponível em: https://wbc-rti.info/object/document/7133/attach/Vienna-Declaration_final_10Nov20111.pdf

Wagner, T. P (2013). Examining the concept of convenient collection: an application to extended producer responsibility and product stewardship frameworks. *Waste Management, 3*(3), 499-507. https://doi.org/10.1016/j.wasman.2012.06.015