

## Environmental Management

# Green waste management methods in educational institutions: a systematic review focused in sustainability

Métodos de gestão de resíduos verdes em instituições de ensino: uma revisão sistemática com foco na sustentabilidade

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## ABSTRACT

The proper management of solid waste and sustainable alternatives of treatment are trends that affect all levels of society, including educational institutions (EI). This study addresses a systematic review of the literature available on gardening waste management methods in EI, aiming to find publications in the Scopus and Google Scholar databases, using a personalized search string. A total of 14 documents were obtained and included in the study, meeting all the criteria. These documents were listed according to the methods of quantification and disposal of garden waste already existing for EI. The leading topic about the disposal of this type of waste in EI is composting. The methods of total weighing and volume definition were the leading topic for quantification. The study collaborates with sustainability practice within the EI, revealing sustainable alternatives of green waste management.

**Keywords:** Educational institutions; Waste management; Garden waste; Green waste; Green areas

## RESUMO

O adequado gerenciamento dos resíduos sólidos e alternativas sustentáveis para tratamento são tendências que atingem todos os níveis da sociedade, incluindo as instituições de ensino (IE). Diante disso, o estudo aborda uma revisão sistemática de literatura sobre os métodos de gerenciamento de resíduos de jardinagem em IE, com o objetivo de triar as publicações encontradas nas bases de dados Scopus e Google Acadêmico, a partir de um string de busca personalizado. Obteve-se no total 14 documentos incluídos no estudo, atendendo todos os critérios propostos. Estes documentos foram relacionados de acordo com os métodos de quantificação e destinação dos resíduos de jardinagem já existentes para IE. A alternativa mais discutida sobre a destinação deste tipo de resíduo em IE é a

compostagem. Em relação à quantificação, os métodos de pesagem total e obtenção do volume foram os mais utilizados. O trabalho colabora com a prática de sustentabilidade dentro das IE, revelando alternativas sustentáveis utilizadas em IE para o gerenciamento de resíduos verdes.

**Palavras-chave:** Instituições de ensino; Gerenciamento de resíduos; Resíduos de jardinagem; Resíduos verdes; Áreas verdes

## 1 INTRODUCTION

The growing solid waste generation stimulated proper management and became a matter of great importance worldwide. According to the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE), more than 79 million tons of urban solid waste (USW) were generated in 2019 (ABRELPE, 2020).

Due to population growth, rapid urbanization and economic development, waste management has become one of the most urgent problems on the planet. In 2012, according to World Bank data, it is expected a 70% increase of the urban waste by the year of 2025 worldwide (ONU, 2016).

The Brazilian Solid Waste Policy (PNRS), established by the 12.305/2010 law, states that solid waste is classified according to its origin and considers household and public cleaning waste as USW (BRASIL, 2010). Within the USW fraction, there are also organic solid waste (OSW), which includes food waste and green waste. According to ABRELPE (2020), each person discards an average of 170 kg of organic waste each year, which is the main component of the USW.

Green waste is commonly generated from green area maintenance activities, such as pruning, weeding and tree removal. The significant amount of green waste generated, due to maintenance activities, is reflected in the large volume deposited in dumps and landfills, contributing to the reduction of its useful life (BARATTA JÚNIOR *et al.*, 2010). The disposal of these wastes in dumps and landfills can cause problems when they are mixed with pre-existing waste, which can contain hazardous substances and biodegradable biological materials, interacting chemically and biologically and, therefore, impacting the environment (ARAÚJO,

2011). In 2019, more than 140 thousand tons of waste were received in tree branches and pruning management units, suitable for waste management in Brazil (SNIS, 2019).

The reuse of waste pruning contributes to a significant reduction in the damage caused by disorderly disposal. According to Baratta Júnior (2007), composting is an alternative that reduce pressure on natural resources and enables the production of compost for agricultural use and landscaping areas. Another viable alternative OSW treatment is biomethanization, which results from anaerobic fermentation with biofertilizer and biogas (MALINOWSKY, 2016).

Within educational institutions (EI), activities that impact the environment, such as the waste generation, must be controlled and minimized by applying the institutions technical and organizational abilities to make environments sustainable, and be models for modern society (CADAVID-RODRÍGUEZ *et al.*, 2017).

Given the EI's commitment to building sustainability, the development of studies on the subject is of great relevance, since universities have an important role in studying and implementing projects involving waste reuse methods and generating new knowledge for its correct use (BRINGHENTI *et al.*, 2018). Sustainable development has great relevance and involves the social aspect where EI are inserted, playing a significant role in promoting sustainability in order to encourage society to transition to sustainable lifestyles (ALEIXO *et al.*, 2018).

According to the PNRS (BRASIL, 2010), solid waste management is a set of actions carried out in stages of collection, transport, transshipment, destination and environmentally appropriate final disposal of solid waste and tailings.

In this perspective, green waste management and the implementation of sustainable alternatives create opportunities for education activities inside and outside the EI, since the proper management of this waste involves, in addition to students and internal employees, the community around the institution. These groups benefit from the development and application of studies and also from the compost and fuel gas (methane) generated.

This paper reports a systematic review of the literature on garden waste management methods on EI to identify, in articles and event publications, existing methods. A systematic review was used to the search for available evidence on the subject, to do a comprehensive evaluation of works on the subject (DRAHEIN *et al.*, 2020). Studies that address green waste generation and management in EI are very important to achieve an environmentally sustainable campus, implementing efficient management alternatives in institutions.

## 2 GREEN WASTE

According to the Brazilian Standard (NBR) 10.004/2004, pruning waste are classified as class II A solid waste, which are those considered non-hazardous, according to the impacts and risks they may cause (ABNT, 2004).

According to the PNRS, the USW include household waste, originated from domestic activities in urban residences and urban cleaning waste, originated from sweeping, public spaces cleaning, public roads and other urban cleaning services (BRASIL, 2010). USW are characterized according to their composition, as a form of management guidance. Gardening waste, also known as green waste, is characterized together with food waste and losses as organic matter, corresponding to 45% of all waste generated in the country, approximately 36 million tons (ABRELPE, 2020). Most of this fraction is still sent for final disposal without recovery, being sources of greenhouse gas (GHG) emissions (ABRELPE, 2020).

According to Paritosh *et al.* (2017), green waste mainly consists of dry leaves, grass clippings and tree branches that are collected in open areas such as parks, backyards and gardens, and can be a source of biomass reused for energy production when properly disposed. This type of waste tends to be sent, most of the time, inappropriately to landfills, dumps or other disposal sites (MEIRA, 2010). EIs must consider their position as a waste generator and educator of future professionals, and thus, must ensure access to sustainability practices, such as the

implementation of sustainable alternatives for the safe disposal of solid waste generated in these spaces.

### **3 SUSTAINABLE PRACTICES WITH GREEN WASTE**

Proper management of solid waste is important for the Sustainable Development Goals (SDGs) to achieve the sustainable goals of the 2030 Agenda. One of the goals to be achieved by the year 2030 is to reduce negative environmental impact per capita in the cities, paying special attention to air quality, municipal waste management and others. As proposed in SDG 11, the goal is to make cities and human settlements inclusive, safe, resilient and sustainable (ONU, 2015).

SDG 4 determines “to ensure access to inclusive, quality and equitable education, and to promote lifelong learning opportunities for all” (ONU, 2015). Teachers are highlighted by the UN as essential actors for raising awareness for future generations and the school community. Along with this, Education for Sustainable Development (ESD) aims to include fundamentals about the SDGs in teaching and learning, contributing to the encouragement of changes that can generate a more sustainable future in terms of environmental integrity, economic viability and a just society for present and future generations (UNESCO, 2014).

OSW treatment alternatives are recommended to avoid land filling and reduce GHG emissions, such as composting and anaerobic digestion. According to data from Abrelpe (2020), these alternatives avoid emissions in a proportion of 2.3 kg CH<sub>4</sub>/ton of OSW from anaerobic digestion and 3 kg CH<sub>4</sub>/ton of OSW through composting. These alternatives stand out in the PNRS, being suggested as environmentally adequate forms of final disposal (BRASIL, 2010).

#### Solid waste management in educational institutions

The EI produce various residues, including OSW from food handling, green areas maintenance and cleaning (pruning), glass, plastic, metal, paper/cardboard, sweeping residues and others. These institutions play an important role in the

construction of increasingly sustainable spaces and in raising awareness among students and employees, involving environmental education (FURIAM *et al.*, 2006).

Therefore, alternatives to dispose garden waste in an environmentally correct way within the EI are important to minimize the associated problems. Composting is an important form of socio-enviro OSW minimization and valorization, can contribute to institutional sustainability (BRINGHENTI *et al.*, 2018).

Projects that focus on environmental education in EI have been gaining ground aiming to improve sustainable development and contribute to ensure the quality of higher education (HÉRNANDEZ-DIAZ *et al.*, 2020). In a case study of a Brazilian university, Barros *et al.* (2020) developed environmentally sustainable practices in EI and the initiatives that the university is adopting are exposed, such as solid waste management. Furthermore, the inclusion of these projects within the EI generates perspectives for achieving sustainability at various levels of society.

Sustainable practices studies in EI, according to Aleixo *et al.* (2018) and Carbach *et al.* (2017), report on ESD, a topic of the 21 Agenda, in which the expansion of activities related to sustainability issues, such as climate change, are debated. These studies examine the challenges and benefits of applying sustainability across different EIs. Despite the growing involvement of EIs in promoting sustainability, there are still obstacles to those initiatives, such as the lack of financial resources (ALEIXO *et al.*, 2018) and the lack of incentives to minimize the generation of solid waste and increase reuse and recycling alternatives (CADAVID-RODRÍGUEZ *et al.*, 2017).

These surveys are important so that more students develop and disseminate environmental awareness throughout their academic education by promoting the adoption a sustainable lifestyle. In addition, sustainable practices within EI contribute to SDG 4, that addresses quality education, ensuring that all students should acquire the knowledge and skills necessary to promote sustainable development through ESD and sustainable lifestyles until 2030 (ONU, 2015).

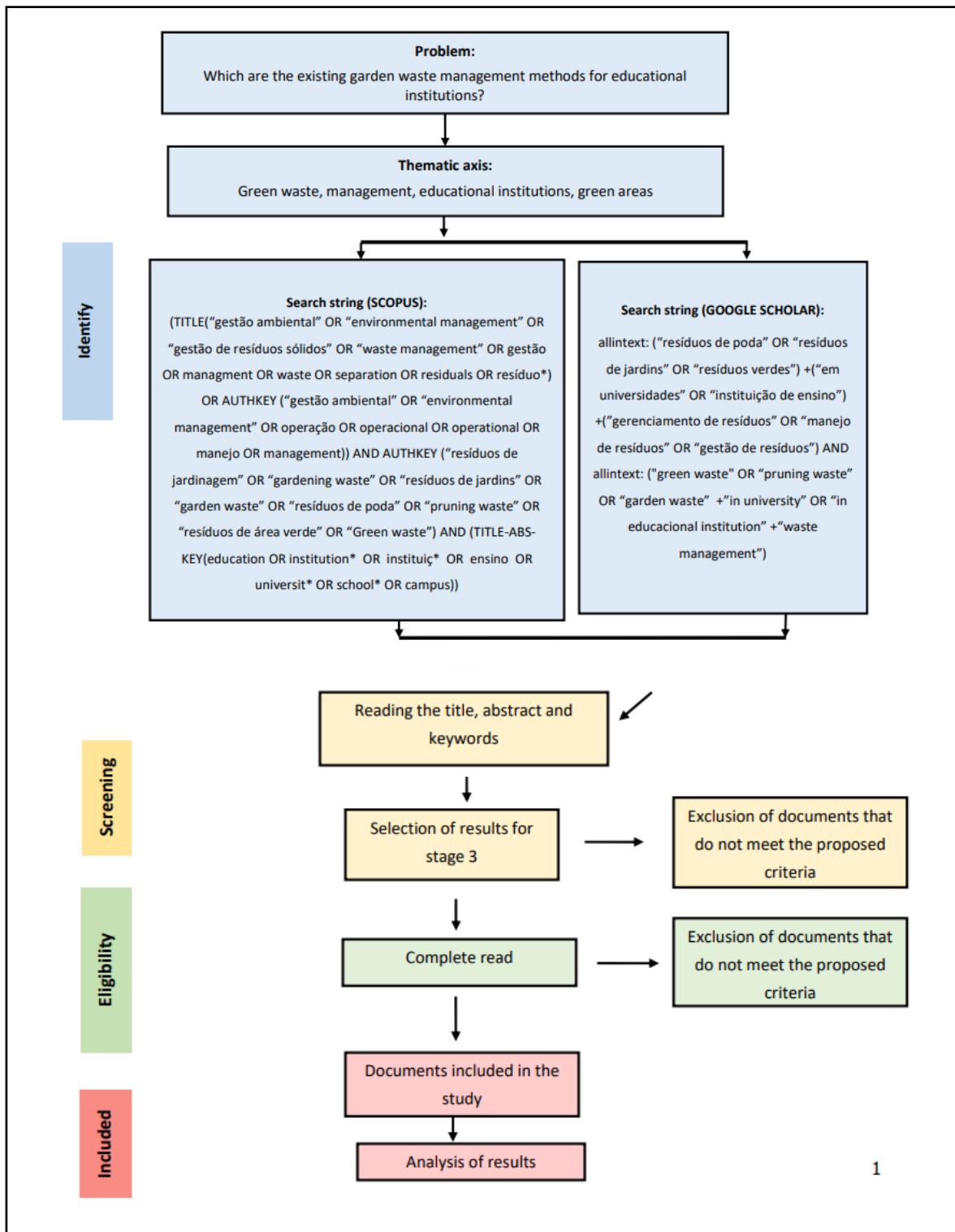
Gardening waste management methods within the EI contribute to the theme addressed in SDG 4, being an opportunity for sustainable action, education, extension and a final product of economic interest (compost or biofertilizer). Lira's study (2018) reports a green waste reuse plan in a Federal University and the green waste generated in this EI is quantified. This study highlights the added value of its reuse, relating to its social, economic and environmental benefits.

## **4 METHODOLOGY**

The systematic review was divided into two stages: the first using the Scopus database, in 02/28/2021, and the second using the Google Scholar tool, in 03/03/2021. The research time horizon has not been defined. The question that led to the study was "Which are the existing garden waste management methods for educational institutions?" and its thematic axis addressed words in English and Portuguese to refer to green waste, management and educational institutions. The main objective of the study was to identify articles and publications of events that addressed methods of garden waste management existing in educational institutions. The steps performed are described in Figure 1.

A systematic review of the literature was carried out in the Scopus database, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (LIBERATI *et al.*, 2009), making it easier to organize the identification, screening, eligibility steps and inclusion of documents in the study. In the first stage, the identification, the problem was identified, defining the thematic axis and the search string. After the identification, the first screening of the results was performed, in which the titles and abstract were read and the studies that did not meet the defined criteria were excluded (Table 1). In the eligibility stage, the documents that underwent the first screening were completely read and those that actually fit the topic were included in the study.

Figure 1 – Stages of systematic review



Source: Adapted from Liberati *et al.* (2009)



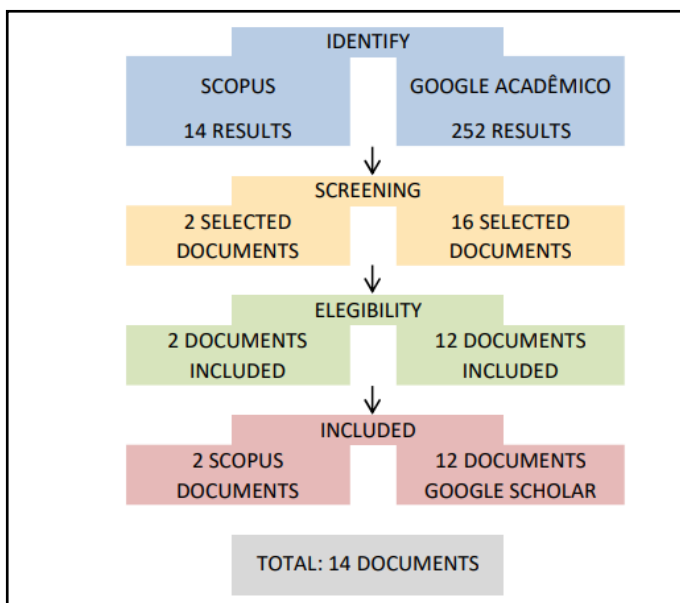
Table 1 – Inclusion and exclusion criteria from the systematic review

Inclusion criteria (IC)			Exclusion criteria (EC)
IC1	IC2	IC3	EC1
Publications in Portuguese or English	Scientific articles, publications at events, monographs or dissertations	Documents reporting on pruning and gardening waste management methods in IE	Documents that do not report on management methods in IE

Source: Authors (2021)

To complement the systematic review, given the low number of publications found in the Scopus database, a simple Google Scholar search was performed with the same descriptors already used and the steps of the PRISMA method checklist were later adapted to this platform. In each of the search platforms, different findings were obtained regarding the type of document (Figure 2). The search results were managed in spreadsheets created in Microsoft Excel and the information was organized by year, title, author, type of document and place of publication.

Figure 2 – Types of documents identified on each platform



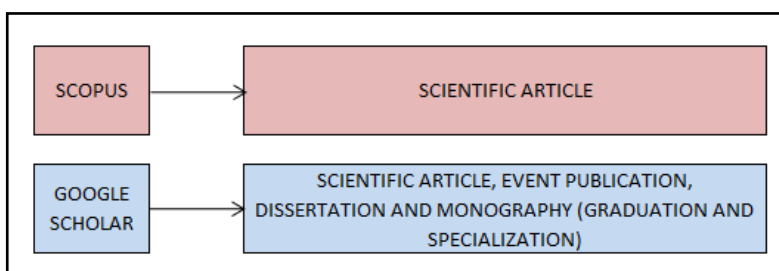
Source: Authors (2021)

## 5 RESULTS AND DISCUSSION

### 5.1 Systematic review

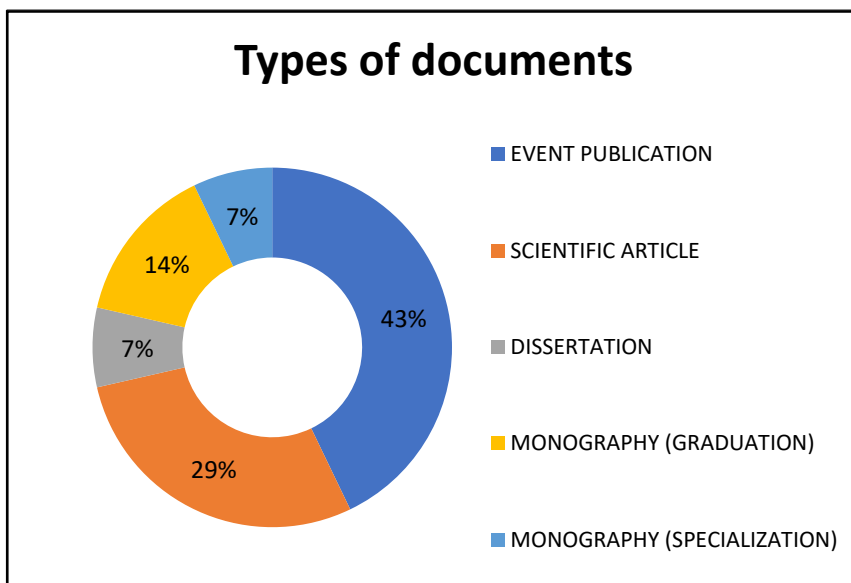
The results from the Scopus and Google Scholar database searches included 14 documents meeting all the proposed criteria (Figure 3).

Figure 3 – Flow diagram with results obtained



Source: Authors (2021)

Figure 4 – Types of documents included in the review



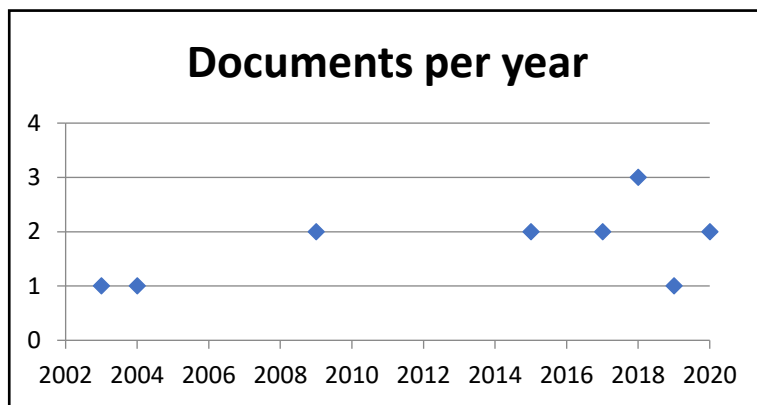
Source: Authors (2021)

The types of documents found were identified: event publication, scientific article, dissertation and monography (graduation and specialization) (Figure 4). This variation in the types of documents found is justified by the search on

Academic Google. Most documents found on the topic of green waste management were publications at events, followed by scientific articles. The large number of publications in events on the subject is explained by the search on Google Scholar. The base returned documents from different events, mainly Brazilian, followed by conferences in countries such as Colombia, Indonesia, and Malaysia.

The data show a greater number of publications after the year 2015 (Figure 5). This increase can be explained due to the fact that it is a theme addressed with emphasis in the SDGs, raised by the UN in 2015. It is also related to an adaptation to the PNRS instituted in 2010 (BRASIL, 2010).

Figure 5 – Year of documents included in the review

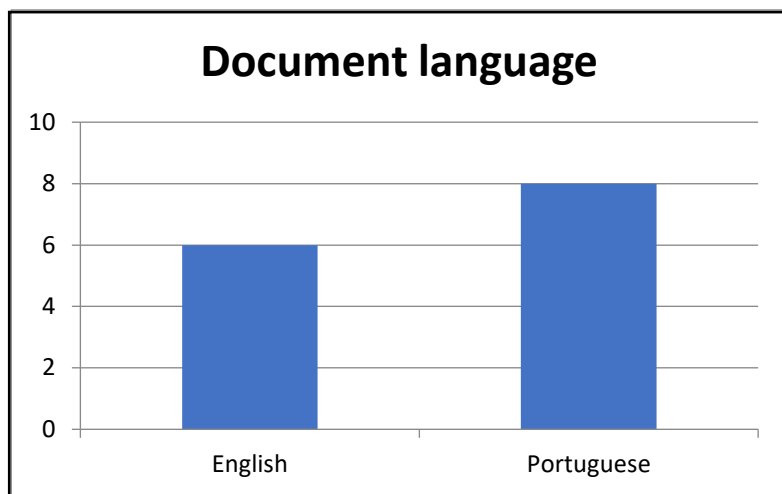


Source: Authors (2021)

The “language” criteria review shows documents in English and Portuguese (Figure 6). Highly relevant periodical publications in the English language as it is a widely used language worldwide. The Scopus database research revealed only articles in English, while on Google Scholar this study found documents in both Portuguese and English.

In terms of relevance of scientific documents, articles indexed on Scopus and Google Scholar database have more credibility as they are submitted to evaluation by specialists in the field.

Figure 6 – Language of included documents



Source: Authors (2021)

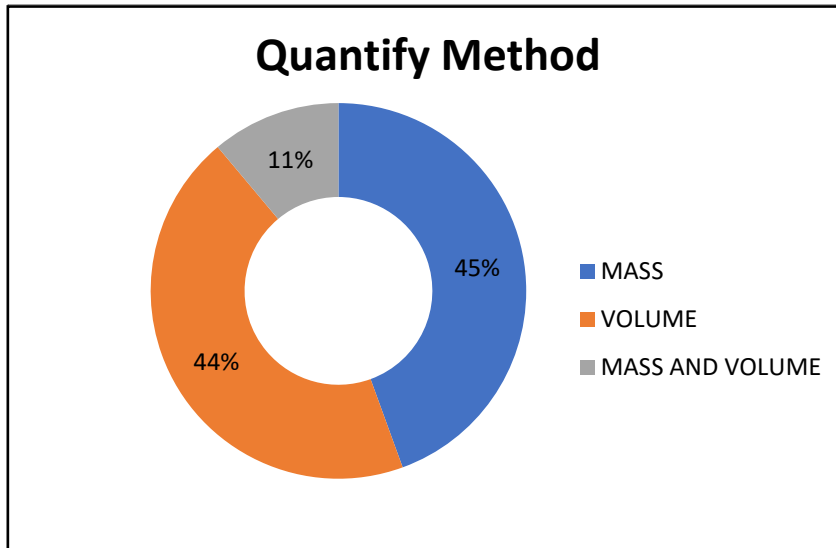
## 5.2 Gardening waste management in educational institutions

After characterizing the documents included in the study, the methodology used to quantify and dispose of garden waste in the reported IE was analyzed. Regarding the methods for quantifying green waste, nine documents quantify and six do not quantify this class of waste generated in the institution (Figure 7). Of the documents that quantify, the method varies between total weighing, obtaining its mass, and quantification through the generated volume. The method used in four documents is the total weighing with the aid of a scale, in which all waste generated was weighed and the unit of measurement varies between kilograms and tons, depending on the collection time. In four studies, volumes were quantified and instruments for quantification vary between trailers (MASON *et al.*, 2003) and transport buckets (LIRA *et al.*, 2018) to obtain the total volume of garden waste.

Out of 14 documents surveyed, 12 report the final destination (Figure 8). In nine studies, the use of the composting technique is mentioned as the destination of pruning residues, which is a viable solution for the treatment of these residues within educational institutions. The biodigestor reuse technique was also used in a magazine article carried out at a university in India (PARITOSH *et al.*, 2017), in

addition to the final disposal in a landfill in a monograph carried out at the Brazilian Federal University of Rio Grande do Norte (ARAÚJO, 2019).

Figure 7 – Quantify method cited by the literature



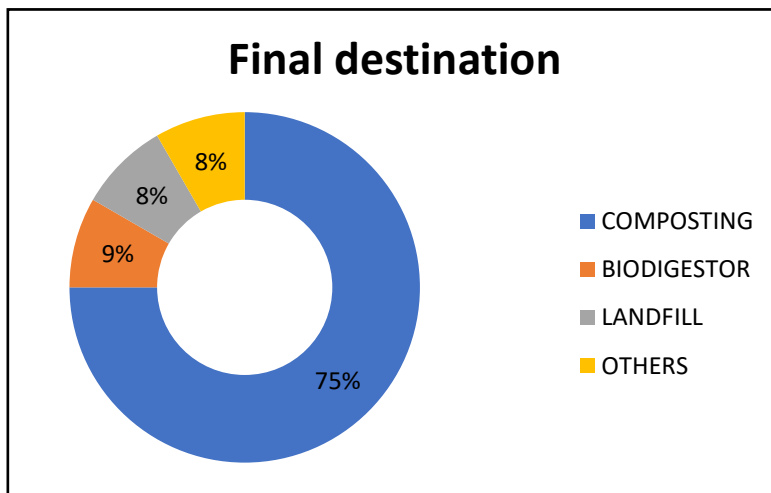
Source: Authors (2021)

One article framed a different way of managing green waste generated within EI, such as burning. The hazards of this practice are reported, and composting is recommended, but in this EI the green waste is transported to the back of the campus and as there is no collection, it is periodically burned (CONCEIÇÃO *et al.*, 2020). In two studies, there was no comment on the way of destination.

Composting was the alternative discussed in 75% of the studies and it aims to produce high quality organic fertilizers for university urban gardens while reducing the environmental burden of waste management (VÁZQUEZ *et al.*, 2020). Diverting these residues from the landfill and destined for composting, while recycling organic materials, converts them into a beneficial product (YUSSOFF, 2018). The treatment of these residues by means of biodigesters was reported in 8% of the studies and has focus on treating and minimizing waste, producing

biogas, which is a renewable energy source and can be used for direct heating, power generation and in automotive applications (PARITOSH *et al.*, 2017).

Figure 8 – Final destination of green waste



Source: Authors (2021)

In some of the documents, none of the valuation techniques for green waste are used in practice, but the composting technique is recommended by the authors, such as Cadavid-Rodríguez *et al.* (2017) in an event publication in Colombia. In another document published at the event, only a survey of all waste generated in a higher, technical, and integrated education institution in the state of Pará, highlights the importance of promoting future actions at the institute focused on sustainability and environmentally responsible practices, improving its image in society, and contributing to the sustainability of future generations (MOTTA *et al.*, 2015).

In documents that report the proper green waste disposal, as well as those that present no form of reuse, the importance of applying viable alternatives for reuse and management in the EI are highlighted as a way of disseminating sustainable practices inside and outside the EI.

## 6 CONCLUSION

The search using the PRISMA method (LIBERATI *et al.*, 2009) is safe and reliable and allows the survey and organization of studies on the subject. An obstacle is still the low number of bibliographical materials found in the research for green waste management within the EI.

It is observed that green areas waste management constitutes a potential to be explored in carrying out sustainable actions in the environmental, sanitary, economic and social aspects. Scientific research covering the subject can contribute to the recovery of this waste and involve the institution's students and employees. In addition, practices such as the green areas mapping, and raising awareness of the responsible teams are sustainable actions suggested to be applied in the EI.

Considering the importance of disseminating sustainability inside and outside the EI and the potential for reusing green waste presented in the study, it is observed that there is a need to do even more research on green waste management in EI and related topics.

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