

REVISTA AIDIS

de Ingeniería y Ciencias Ambientales:
Investigación, desarrollo y práctica.

YARD WASTE COMPOSTING AS A VIABLE COST REDUCTION PROCESS

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Recibido el 23 de marzo de 2021. Aceptado el 8 de septiembre de 2021

Abstract

Yard waste consist of garden waste, generated by public parks and private gardens routine maintenance such as grass clippings, leaves from deciduous trees, flowers, fallen fruits, branches, twigs and logs and its composition vary greatly depending on the original location due to climate and other environmental conditions. Yard waste may represent a problem to Municipal Solid Waste Management Programs due to its large volume thus, it is necessary to incentivize local composting programs. In this study we show a brief disposal cost estimation from different cities from United States of America and Canada and we discuss how this biowaste can be managed in order to reduce costs with storage, transportation and disposal fees, encouraging the utilization of the final product as a soil amendment, stimulating and reinforcing the circular economy concept. The composted yard waste may not substitute the use of commercial products but it can reduce the cost of acquisition of this soil conditioner as well costs waste management. Update in environmental public policies is essential to foment sustainable economy in this context.

Keywords: composting, landfill fees, yard waste, yard waste disposal.

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Introduction

Organic waste comprises a larger percentage of the solid waste generated in low-income countries, about 50 to 70% (Modak *et al.*, 2015). A Municipal Solid Waste (MSW) environmental impact analysis in Algeria showed that biodegradable waste, specifically food waste, represents 69.4% of the total waste sent to landfills (Mouhoun-Chouaki *et al.*, 2019). The Brazilian Solid Waste Management Diagnostic Report informed that organic degradable waste corresponded to almost 50% of the total solid waste in the studied country (Brasil, 2015). A preliminar National Plan for Solid Waste does not contemplate specific programs or strategies to improve the correct disposal of biodegradable waste although it advises public institutions to implement composting systems for organic solid waste (Brasil, 2020).

Yard waste consist of plant-based material, gardens and parks maintenance waste such as trees pruning, wood and bark, leaves and grass clippings. This waste represents a major problem for MSW management due to its large volume (Kalamdhad *et al.*, 2009; Manu *et al.*, 2021) and because of its low bulk density and low value, it's not financially attractive to manage (López *et al.*, 2010).

For a complete and stable composting process and to achieve a good final compost it is important to prepare the feedstock prior to composting to create optimized conditions for microbial activity. Reyes-Torres *et al.* (2018) stated that it is important to conduct studies on starting materials impacts, identifying the physicochemical quality as a function of the physical composition, to improve and optimize the process. Blending the right amounts of nitrogen and carbon sources is one of the most important pre-processing step as it defines many parameters along the process such as moisture content, pH, temperature, electrical conductivity, solubility and biological properties (Mohee, 2007).

Once as up to 70% by weight of the solid waste generated in developing countries is organic materials suitable for composting, local composting systems should be incentivized and achieved through segregation at source, not only as an alternative treatment but as a policy, incorporated in municipal strategies of solid waste management (Moretti *et al.*, 2015). Most of the organic biodegradable waste, mainly from municipal collections, local parks, gardens and community initiatives, is currently composted in simple outdoor turned windrow systems (Michie *et al.*, 2011). Composting should be decentralized in small scales, with low cost of implementation and reduction of collection, transportation and disposal costs (Kalamdhad *et al.*, 2009).

The characterization of yard waste is challenging because of its diversity, high variability in the composition, climate and geographic local properties (Boldrin and Christensen, 2009). The decomposition of yard waste is an important ecological process for the cycling of organic matter, in which carbon and other nutrients are recycled to the atmosphere or back to the plants (Kalamdhad *et al.*, 2009). According to Reys-Torres *et al.* (2018), although the diversity limits the

categorization of this type of waste, it is possible to establish predominant features such as a C:N ratio higher than 25, a deficiency of important nutrients such as nitrogen, phosphorus and potassium and a high content of recalcitrant organic compounds like lignin.

In the context of negative impacts of improper destination of biodegradable waste, this study aims to discuss the yard waste composting as an option to public and private institutions with area availability to endure such process and we encourage the application of the produced compost as a soil conditioner on the same garden that generated this waste, recycling organic matter, reducing waste disposal, eliminating costs with storage, transportation and the environmental impacts caused by improper waste destination, focusing on the circular economy.

Materials and methods

Using the keyword “leaves composting”, the search led to a limited number of articles related to the composting process of dry leaves only. We included in the search the following keywords “green waste”, “yard waste”, “yard trimmings”, “plant waste”, “grass clippings” and “tree prunings”, and it resulted in an increased number of articles but, yet, just a few specifically to the management of yard waste and yard waste composting. Databases accessed until August 2021 included Web of Knowledge, SciELO and Google Scholar. Papers published in English, Portuguese and Spanish were included, when discussed management of composting wastes topic.

The majority of the articles found explore the utilization of this type of waste as an amendment of other composting starting material such as food waste and sewage sludge. To ensure the accomplishment of an overview of yard wastes composting, the information was withdrawn from these articles, partially related to the initial main search. Furthermore, due to the low number of articles published in the field and even to the commonsense knowledge’s features of this theme, the search was amplified once more, by screening reports and public documents published by non-governmental organizations (NGO), municipalities websites and National Agencies from different countries in order to expand the literature database.

Results and discussion

Yard waste – economic and environmental burden

According to the USEPA (2020), the generation of yard wastes in MSW was 35.4 million tons in 2018, approximately 12% of the total MSW in the United States. The agency estimated that yard wastes are composed of 50% grass clippings, 25% brush and 25% leaves. About 10.5 million tons of yard trimmings were sent to landfills, comprising 29.7%, and 22.3 million tons were recovered for composting, approximately 69% of all yard waste. Wood is accounted separately and it

represents 8.31% of the total MSW, more than 12 million tons in 2018. Hanc *et al.* (2011) study showed that in Prague, grass clippings are the main biowaste collected material from family houses as a seasonal garden component, ranging from 71%, in the summer, and 45.2% in the spring. The autumn and winter collections, comprised of leaves from deciduous trees, were 74.5% and 35.8% respectively. In a study about composting process conducted in a university facility, in Indonesia, yard waste, comprised mainly by leaves, represented 40% of the total solid waste by weight (Budihardjo *et al.*, 2018).

Once the generation of yard waste is significant, composting is recommended rather than landfill disposal. Since 2004, the landfill tipping fees average is increasing by about one percent per year. Tipping fees usually increase as landfills capacities decrease and, in 2018, the average value was U\$55.11 per ton. With a total of 292 million tons of MSW generated in 2018, and 50% of this total waste was landfilled, it is presumed that the costs with landfilling reached approximately 8 billion dollars (USEPA, 2020). As can be seen in Table 1, the disposal fees of yard waste vary greatly from city to city.

In Belo Horizonte, Brazil, an annual report of a public health institution, showed that the average cost with the rent of large containers to store the yard waste generated within its facility is of approximately 3 thousand US dollars per year (FUNED, 2020). It is important to highlight that costs of handling these wastes are associated with other factors such as the area of disposal and physical variables.

The destination of yard waste to landfills aggravates this serious environmental problem and contributes to severe pollution due to the leachate or biogas produced. The leachate is formed of heavy metals, organic matter, pathogenic microorganisms and, when it is inappropriately treated, can leach and percolate through the waste, dragging suspended and soluble compounds and infiltrate through the ground, contaminating surface and groundwater (Ng *et al.* 2020).

The biogas emission, mainly CO₂ and methane, is a process within the organic matter degradation and contributes to atmospheric pollution and, especially, to greenhouse effect and global warming (Mouhoun-Chouaki *et al.*, 2019; Riaz, 2021). Other gases are produced in the decomposition process of organic matter such as ammonia, sulfide, and 94 non-methane volatile organic compounds were found in air emissions from MSW landfills such as benzene, toluene and chloroform (Zhentong *et al.*, 2013; Fan *et al.*, 2021). Landfills are great contributors to global warming. Globally, 20% of anthropogenic methane emissions are originated in landfills (Damgaard *et al.*, 2011; Danthurebandara *et al.*, 2012). In Jordan, according to the Ministry of Environment, the waste sector contributes to more than 10% of the total greenhouse gas emissions (Qdais *et al.*, 2019).

Table 1. Disposal fees in different cities of United States of America and Canada

City/Country	Yard waste characterization	Disposal fees/ton (\$US)
Calgary, Canada (2021).	Yard Waste – Leaves, plants, brushwood, branches, hedgerow prunings, grass clippings, cold barbeque or fire place ashes	\$40.00
	Wood Waste – Untreated lumber and other wood item made of raw and wood (unprocessed)	\$72.00
Cedar Falls, USA (2021).	Yard waste - landfilling	\$29.50
	Yard waste – compost facility	Free disposal
Council Bluffs, USA (2021).	Yard Waste – Branches and logs	\$24.00
Edmonton, Canada (2021).	Yard waste – leaves, twigs, branches, fallen fruit, dead plants, grass. Branches should be no more than 4 feet long and 2 inches in diameter	Free disposal
Fairfax County, USA (2021).	Yard Waste – bagged leaves and/or grass	\$62.00
Hillsborough, USA (2021).	Yard and wood waste	\$35.00
King County, USA (2021).	Yard waste	\$75.00
Osceola County, USA (2021).	Yard Waste – green materials from maintenance of landscaping, as tree trimmings, grass clippings and stumps	\$38.62
Pierce County, USA (2021).	Yard waste – brush and roots, leaves, grass clippings, vegetable and fruit trimmings, flowers, and plants	\$100.00
Seattle, USA (2021).	Yard Waste	\$113.00
	Clean wood waste	
Springfield, USA (2021).	Yard waste – bulk or grass clippings, leaves, garden and flowerbed vegetation and small, non-woody shrub trimmings	\$15.00
Toronto, Canada (2021).	Yard Waste	\$96.00

Yard waste composting as a viable cost reduction solution

The best alternative for recycling yard waste is the composting process which is technologically and economically viable (Riaz, 2021; Zuberer and Zibilske, 2021). Compost helps strengthen soil's ability to retain water, reducing costs of irrigation and preserving water bodies. The use of organic mulch can significantly improve water infiltration (Barskov *et al.*, 2019). Compost use also restores topsoil and builds a stable soil structure, reducing soil erosion, improving porosity and soil aggregation, increasing gas and water permeability (Gomiero, 2016; Mohee, 2007).

Alluvione *et al.* (2010) observed that the substitution of synthetic urea fertilizer by compost helps to reduce the CO₂ emission from soils up to 49%. Compost also enhances carbon sequestration, removing carbon dioxide from the atmosphere and stored in the soil's carbon pool. Solid organic carbon increments nutrient cycling improves water dynamics, microbial activity and biodiversity (Tautges *et al.*, 2019).

The composting process is able to eliminate allelopathic effects or toxic substances from different plant species. Rajbanshi and Inubushi (1997) demonstrated that allelopathic molecules with significant phytotoxic activity were inactivated by composting. Reports show that after 60 days of composting, the concentrations of grayanotoxins, heat stable, non-volatile diterpenes, water and lipid soluble substances present in *Rhododendron* species were almost undetectable (Michie *et al.*, 2011). Monoterpenes from fresh conifer bark, toxic compounds with growth inhibitory effects, are also broken down or rendered non-toxic during composting (Aaron, 1982).

Microorganisms require some nutrients in larger quantities such as carbon (C), nitrogen (N), phosphorus (P), and potassium (K). The relative amounts of carbon and nitrogen have an important effect on the composting process (Graves and Hattemer, 2000). According to Epstein (2011), a C:N ratio higher than 30 slows the decomposition rate because there is not enough nitrogen to be immobilized by the microorganisms and a C:N ratio lower than 20, promotes an excessive release of nitrogen in the form of gaseous ammonia, resulting in nutrients loss. Silva *et al.* (2018) demonstrated that the microbiological activity was different in distinct starting materials. Leaves, composed of cellulose fibers, lignin, waxes and oils were difficult to decompose, taking a longer period to mature in comparison to the composting of grass clippings and aquatic plants, materials with less complex carbohydrate structures, thinner and less lignified cell walls. Lim *et al.* (2019), observed in a pilot scale digester study that different combinations of dry leaves, fruit, meat and vegetable wastes exhibited different values of C:N ratio, pH, and electrical conductivity on the final compost. Vegetables and fruit wastes contributed to a reduction in pH value and electrical conductivity, while meat waste increased pH and electrical conductivity values. The C:N ratio significantly increased with the addition of fruit waste.

About physicochemical properties of the composting process, the increase of temperature substantially accelerates the mineralization of organic nitrogen. For each 10°C increase in temperature, there is an increase of 2 to 3 times fold in the mineralization rate of organic nitrogen, considering a 10-40°C interval (Cantarella, 2007). Silva *et al.* (2018) showed that in the first three days of composting the pile with plant litter exclusively, achieved only 43°C as the peak temperature, while the shredded waste with manure pile achieved 53°C and the aquatic plant pile, reached 58°C. Most weed seeds are destroyed under high temperature, ranging from 40° to 70°C. This thermophilic phase from the composting process also kills undesirable insect larvae (Abdellatif *et al.*, 2011). Pile temperature depends on many factors including moisture content, C:N ratio, aeration, solar incidence and humidity and the temperature may vary greatly throughout the pile, resulting in partial or poor sanitation due to the fact that some areas may not achieve the required conditions to inactivate pathogens (Turner *et al.*, 2005).

Using compost amendments suppress widespread soilborne pathogens (Neher *et al.*, 2015). The composting process provides a consortium of microorganisms that are antagonistic to pathogens that are killed by competition and antibiotic effect of inhibiting substances produced by compost microorganisms. High temperatures and microbial diversity in the composting process kill weed seeds and eliminate most pests, human and plant pathogens, parasites and undesirable insect larvae (Hadar and Papadopoulou, 2012; Fan *et al.*, 2021; Abdellatif *et al.*, 2011).

The composting process may save money by cutting back on landfill fees, storage, transportation and disposal costs as shown in Figure 1.

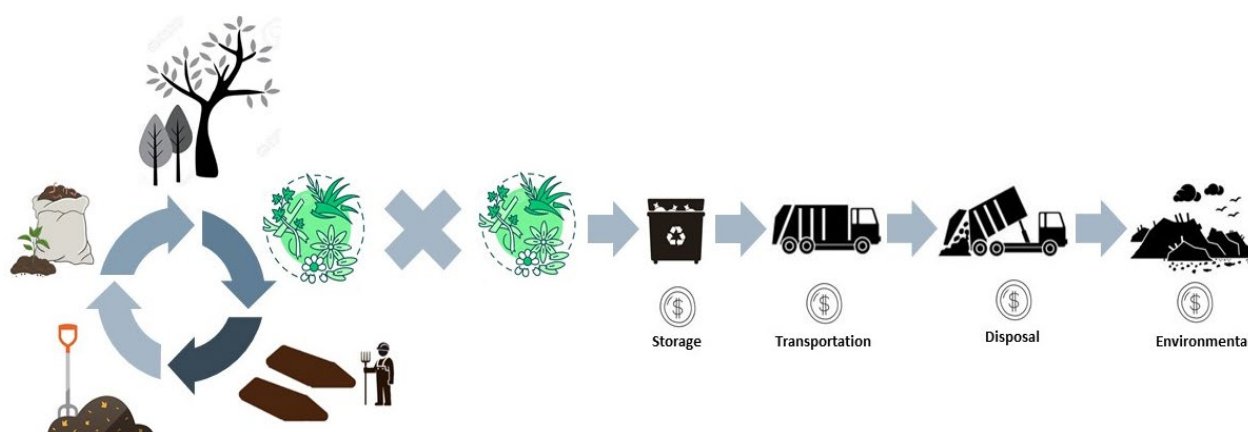


Figure 1. Infographic showing the cycling of the composting of yard waste versus the disposal in landfills, that results in storage, transportation, disposal costs and environmental impacts. *Source: authors.*

The San Francisco Rate Board has approved a commercial rate structure designed to promote recycling and composting by offering up to 75% discount on the volume-based commercial garbage fees for diverting materials to recycling and composting (USEPA, 2021). In Seattle, in the autumn, when there is an increase of leaf fall, households are encouraged by local government to keep fall leaves out of drains to reduce the risk of flooding by allowing the deposit of 10 bags of extra yard waste per collection day for free (Seattle, 2021).

Finally, similar studies showed potential viability of yard waste composting, with a final compost presenting properties that potentially benefit soil and plants. It is a simple, low cost and with an easy implementation and maintenance process that helps divert tons of this type of waste from landfills, especially in developing countries (Costa *et al.*, 2018; Costa *et al.*, 2020; Neves *et al.*, 2020).

Conclusions

The utilization of locally composted yard waste may not substitute the use of commercial products but it can reduce the cost of acquisition of this soil conditioner as well costs with transportation, storage and municipal disposal fees. Companies and institutions, as waste producers, should be able to process this biodegradable waste through composting and become the final users of this compost, completing the cycle. Finally, we recommend an update in the environmental public policies and incentives strategies and initiatives such as fees discounts around the world to increase this type of composting process, aiming for fomenting sustainable economy.

Acknowledgment

We greatly appreciate the technical support provided by Ezequiel Dias Foundation (FUNED).

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