

# COMPOSTING OF MUNICIPAL SOLID WASTE IN THE STATE OF SAO PAULO (BRAZIL)

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## Introduction

The generation of municipal solid waste (MSW) in Brazil has increased by 4.1% from 2012 to 2013, whilst during the same period population urban growth increased by 3.7% (ABRELPE, 2014). Organic waste constitutes the highest percentage of waste (51.4%) produced in Brazilian cities (IBGE, 2010). When disposed of in landfills or rubbish dumps this type of waste can cause negative environmental impacts, reduce the functional life span of landfill sites, and accrue costs which could have been avoid. One way which is both viable and sustainable for the recycling of large amounts of organic waste (more than 94 tones on a daily basis according to IBGE, 2010) is to process it through composting and then to use it in urban and rural agriculture as fertilizer. However it is estimated that only 1.6% of this type of waste is reutilized in this way in the country (IPEA, 2012).

The state of São Paulo, with a population of more than 44 million inhabitants and 645 municipalities, produces the most amount of MSW in Brazil (IBGE, 2010). Data on the quantity produced and the types of methodologies used vary according to different studies. The State Inventory for Municipal Solid Waste 2013 (CETESB, 2014) estimates that 39,864 tons of MSW is produced daily which differs from the Panorama of Solid Waste 2013 (ABRELPE, 2014) statistics, which puts the daily estimates at 59,291 tons. The National Survey on Basic Sanitation 2008 (IBGE, 2010), estimated that 37,839 tons of MSW is collected in São Paulo daily. Nevertheless irrespective of the quantity produced and collected, gravimetric analysis on its composition conducted in some regions in the state, showed that organic material is always prevalent. (São Paulo, 2014).

In 2013, the percentage of solid waste disposed in landfill sites in the state of São Paulo was 97.9% (CETESB, 2014). As the state indexes of disposal improve, landfills in big cities are moving towards saturation (JACOBI; BESEN, 2011). Indeed, the preliminary State Plan for Solid Waste showed that 424 municipalities (65% of total) send

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their MSW to landfills sites. These sites have a functional life of no more than five years (SÃO PAULO, 2014). In addition, 5,487 million tons of carbon dioxide was released into the atmosphere due to landfills in São Paulo in 2008 (CETESB, 2011). Composting is a process involving biological decomposition of organic matter conducted under aerobically controlled conditions where both the humidity and temperature are regulated, producing a stable product (DE BERTOLDI; VALLINI; PERA, 1983) called organic compost or fertilizer. Due to where MSW comes from (i.e. from residential households, commercial premises, high scale factory producers, waste from pruning trees and the sweeping of public streets), it can be very different (BRASIL, 2010a). Organic waste is considered the compostable organic fraction present in these materials. It should also be noted that in the same period, not all organic residues are amenable to composting. This is the case for wood that has been treated, rubber and leather waste.

The National Policy on Solid Waste (PNRS, Lei 12.305/2010) (BRASIL, 2010b) aimed to bring about major changes in the way in which solid waste is managed in Brazil. Among the various requirements, the PNRS stipulated that waste be sent, as a matter of obligation, to areas where it can be recycled and used in compost. Landfill sites were determined as being legally adequate for the disposal of waste only where the waste in question is deemed to not be in a position to be treated and reused using technological processes (BRASIL, 2010b).

The PNRS has, as one of its main tools, the National Plan on Solid Waste (BRASIL, 2012) which in its preliminary version sets the positive goal of the reduction by 25% in the amount of organic waste disposed of in landfills in the Southeast region by 2015. As a way of incentivizing composting the plan mentions the setting up of composting units (which are supported by priority collections of organic waste). It also mentions the need to make use of capacity in existing compost factories or plants. Aside from the aforementioned, the plan promotes local and decentralized strategies as forms of incentives for the treatment of residential composting and for the use of different modalities that exist (i.e. using worm compost and other types of domestic composts). For large producers the idea is to designate specific areas on their sites for composting. The setting up of school gardens and the use of compost in urban agriculture were also suggested.

In spite of the variety of possible actions mentioned above and the State Policy on Solid Waste in the state of São Paulo (PERS Law 12.300/2006) (SÃO PAULO, 2006), little is mentioned on the actual practice of composting. The policies of the federal and state governments aim to incentivize the regionalization of waste management (BRASIL, 2010b). The idea is to return to the use of large compost plants, which have a history of bankruptcy in Brazil and in countries where people have low incomes (ALI, 2004; EIGENHEER; FERREIRA; ALDER, 2005; FEHR, 2010). At the same time, a study carried out by the Federal University of Pernambuco, with the support of the National Bank for Economic and Social Development (UFPE, 2014) suggested technological routes for municipalities of different population ranges. It stated that the implementation of specific collections for recyclable material and for organic waste was not viable for the majority of Brazilian municipalities because they are facing financial difficulties.

With the above in mind, it is necessary to identify and make note of the different and varied experiences in composting of MSW in order to incentivize new technology road mapping processes and the diversification in waste management systems in municipalities. Understanding how such processes can be developed can help regions to be more efficient in their actions and it can help local authorities to stimulate different actors (i.e. private companies, non-governmental organizations, community managers, social businesses) to put back into the agro-ecosystem the nutrients contained in organic waste.

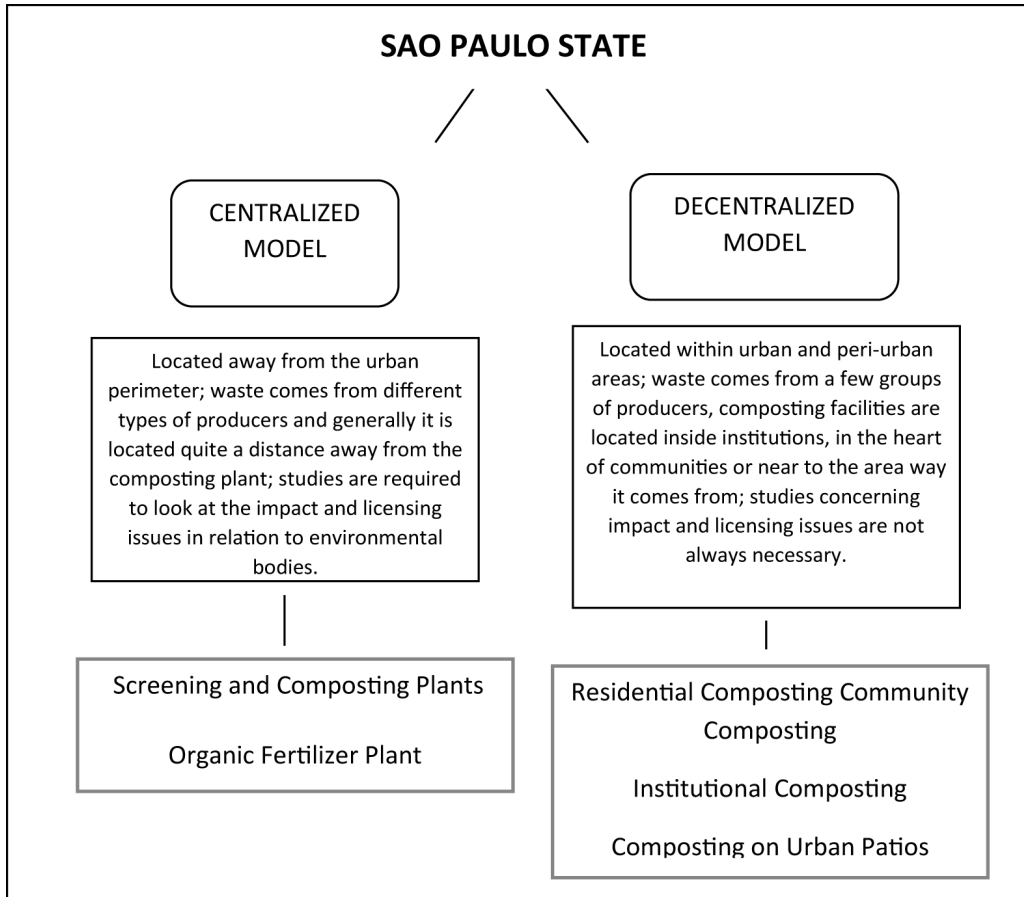
The objectives of this study were to: i) identify composting experiences of municipal solid waste (MSW) developed in the state of São Paulo, Brazil, ii) characterize the dynamics of the modalities identified, and iii) provide an overview of the present situation for composting of MSW in the state in order to contribute towards the management solid waste in Brazilian municipalities.

## Methodological Routes

Firstly a survey was done on the formal and informal experiences that brought about the development of composting of MSW in the state of São Paulo. The experiences considered came from the following areas: businesses project/programs (in progress or closed), district projects in different sectors, parks, schools, universities, companies, institutions, patios and compost plants. The survey sought to analyze the different types of experiences through conducting research using the following: the internet, reviewing bibliographic reports and journalistic articles, reviewing technical and scientific articles, contacting managers and professionals in this area (at congresses, seminars and conferences), contacting governmental and non-governmental institutions, and contacting private companies, all related to MSW. The information was collected between April 2013 and March 2014.

The experiences were systematized in modalities, based on the type of management structure, resulting in two main groups: centralized composting and decentralized composting (Figure 1). Licensed companies that carried out composting of waste in the state of São Paulo, registered on the Environmental Company for São Paulo (CETSB, 2013a) database, were classified as centralized experiences. These experiences were divided into two categories: screening/compost plants and organic fertilizer plants. The categorization of the decentralized experiences was based on the classifications identified by the “Group in Favor of Composting in São Paulo” (in Portuguese GRUPO PRÓ-VIABILIZAÇÃO DA COMPOSTAGEM EM SÃO PAULO, 2012). This classification was adapted based on the urban environment where composting was carried out. Using this classification, four types of decentralized experiences were identified: residential composting, community composting, institutional composting and composting on urban patios.

Figure 1. Categorization of the reports in relation to the experiences on composting of municipal solid waste in the state of São Paulo.



What then followed was an analysis of the different composting models that were identified with emphasis on the challenges that were overcome during their development. Checks were made on all the identified activities through either contacting the managers in charge or the personnel given responsibilities in an institution. Also, when the checks were made, information was obtained about: the nature of the activity, the location, working times and conditions, and the difficulties faced by the managers. Where the activity in question had ceased, enquires were made to find out why this had occurred. The following methods were used to obtain the above information: reviewing bibliographic material, talking with relevant people using semi-structured questionnaires through personal contact with certain individuals, or communicating with people via telephone calls and through emails. At this stage our principal focus was on the accounts of local experiences or on experiences where waste separation was done at source.

Accounts given in official documents, such as from academic papers and technical reports, were included in our study even where the responsible managers had not been contacted. In relation to the experiences from residential composting we only considered those that covered programs aimed at educating residents and projects for implementing home composting solutions in certain communities. These projects had to cover many households at the same time. Quantitative and qualitative analysis was undertaken which looked at what the data actually covered and its heterogeneity.

### **Characteristics of the models that were identified**

We identified 115 experiences amongst businesses, public programs, institutional actions, actions taken by civil society groups and experimental projects. Table 1 below provides further details of the different experiences and the different ways and methods used in composting of MSW covering those that were active and those that closed. However, 37 Screening and Composting Plants (UTCs) that were identified but later closed, were not included. They will be the subject of further discussion later in the text.

Table 1. Experiences for composting of municipal solid waste in the state of São Paulo (a=active, the shaded areas; c = closed/inactive).

Modality	Producer of Waste / Activity name	Operator, Year, Situation (A or C)	
<b>Centralized Composting<sup>2</sup></b>			
Screening and Composting Plants	The São José Local Authority in Rio Preto	CONSTROESTE, since 1989, a	
	The Adamantina Local Authority	Local Authority, since 1989, a	
	The Garça Local Authority	MACCHIONE, since 1993, a	
	The Parapuã Local Authority (in partnership with Rinópolis, Bastos e Iacri)	COTRALIX, since 1998, a	
	The Andradina Local Authority	CONSTROESTE, since 2009, a	
	The Feira Limpa (Clean Market) Program (São Paulo)	Local Authority, since 2002, c	
	Selective collection of organic waste (Itatinga)	Local Authority and ABD, 2008, c	
Organic Fertilizer Plant	Walmart	Biomix, since 2013, a	
	Carrefour	AgroDKV, a	
	CEAGESP	AgroDKV, a	
	The Piracicaba Local Authority - waste from pruning trees, plants and other vegetation	Bioland, a	
	Pilot Program for the Selective Collection of Organic Waste (Disticts: Jd. Paulista and Jd. Silvania, Mogi Mirim)	BASF, Visa Fértil, Prefeitura, and other partnerships, 2013, c	
<b>Decentralized Composting</b>			
Institutional Composting	Public Bodies	São Paulo Zoo	Autogestão, since 2003, a
		Viveiro Manequinho Lopes, Ibirapuera Park (São Paulo)	Local Authority, since 2009, a
		SABESP at the Costa Carvalho unit (São Paulo)	MenosLixo, c
		SABESP in Vila Leopoldina (São Paulo) <sup>i</sup>	MenosLixo, c
		SABESP in Ponte Pequena (São Paulo) <sup>i</sup>	MenosLixo, 2003 a 2009, c

Companies/ Businesses	The Eldorado Shopping Mall (São Paulo)	Local Authority, since 2012, a
	The Epice Restaurant (São Paulo)	The Guandu Institution, since 2013, a
	Cecil S/ A Laminação de Metais (Itapevi) <sup>i</sup>	Morada da Floresta, 2010, a
	Sanofi Indústria Farmacêutica (Suzano) <sup>i</sup>	Morada da Floresta, 2012, a
	Pfizer Indústria Farmacêutica (Guarulhos) <sup>i</sup>	Morada da Floresta, 2012, a
	Tekla (São Paulo) <sup>i</sup>	Morada da Floresta, 2012, a
	Quimicryl Soluções in Adhesives and Construction (Cotia) <sup>i</sup>	Trasix, 2012,a
	The Law Course Cafeteria, FAAP (São Paulo)	Trasix, since 2013, a
	The Bom Jesus (Aparecida) <sup>i</sup>	Trasix, since 2013, a
	Razzo Indústria (São Paulo) <sup>i</sup>	Trasix, 2013,a
	The Sesmaria Inn (São Sebastião) <sup>i</sup>	MenosLixo, since 1994, a
	Siemens Unit at Anhanguera (São Paulo) <sup>i</sup>	MenosLixo, since 2000, a
	The Pernambucanas Training Center (São Paulo) <sup>i</sup>	MenosLixo, since 2009, a
	SESC Itaquera	Self-Management, since 2003, a
	Natura (Cajamar) (NATURA, 2004)	Self-Management, since 2003, a
	General Motors (Indaiatuba) General Motors (Sorocaba) (GM, 2011)	Self-Management, since 2004, a Self-Management, since 2007, a
	Teaching and General Educational Institutions	On the Bauru campus at the São Paulo University (USP)
CEBIMar/USP (São Sebastião) <sup>i</sup>		Self-Management, since 2007, a
Mackenzie University (São Paulo) <sup>i</sup>		Morada da Floresta, 2010, a
The Computing Center in Ribeirão Preto/USP Nursing College at USP in Ribeirão Preto Law School at USP in Ribeirão Preto Physical Education School/USP in Ribeirão Preto		USP Recicla, since 2000, a USP Recicla, since 2011, a USP Recicla, since 2013, a USP Recicla, since 2014, a
The University Restaurant USP campus II (São Carlos)		Students, since 2013, a

	IEE/USP - the Creating Land Project (in Portuguese Projeto Criando Terra) in São Paulo	Students, since 2013, a
	USP campus (in São Paulo)	Self-Management, 1996 a 2010, c

Institutional Composting Teaching and General Educational Institutions	Creche/Pre-School in the west, on the USP campus (Sao Paulo)	USP Recicla, since 1994, a
	The Ermelinda Ottoni Queiroz Creche, ESALQ (Piracicaba) <sup>i</sup>	USP Recicla, since 2004, a
	The Carochinha Creche (Ribeirão Preto) <sup>i</sup>	USP Recicla, since 1998, a
	The Santa Cruz College (São Paulo) <sup>i</sup>	Morada da Floresta, 2013, a
	Unidentified School (São Paulo)	KMA, since 2013, a
	EE Alarico Silveira (São Paulo)	Self-Management, since 2013, a
	EE Dr João Vitor Lamanna (Jacareí) <sup>i</sup>	Ligados na Pilha, since 2008, a
	EE Dr Dorotheoveo Gaspar Vian (Jacareí) <sup>i</sup>	Ligados na Pilha, 2006 a 2014, c
	EE Prof. João Cruz (Jacareí) <sup>i</sup>	Ligados na Pilha, 2007 a 2011, c
	The Composting Program in Municipal Schools (Igaratá) <sup>i</sup>	Ligados na Pilha and the Local Authority, 2006 a 2008, c
Residential Households	Peri-urban Condominiums (Araras)	Residents, since 2013, a
	Research-Action in Environmental Education (in Vila Santo Antônio, Campos do Jordão) (LAMANNA, 2008)	PROCAM/USP, 2007, c
Community Composting (ComC)	The Vivenda Condominium in Lago (Sorocaba) <sup>iii</sup>	The Pé de Planta NGO, a
	The Vila Prada district - GIRO Projects (São Carlos)	Associação Veracidade, since 2012, a
	The Grevilhas Condominium (Araras)	Residents, since 2013, a
	Compostando no Ecoponto - in Vicente Rao (São Paulo)	SAJAPE, 2011 a 2012, c
	Residential Condominium (Guarujá) <sup>iii</sup>	KMA, 2006 a 2010, c
	The ABC Project for Composting (Santa Angelina, Santa Felícia e Planalto Paraíso, São Carlos Neighborhoods) (MASSUKADO, 2008)	CDCC/USP, SENAC, Local Authority, 2005 a 2010, c



	Casa do Estudante UNICAMP (Campinas)	Residents, c
	The Student Homes Projects Agroecology (Botucatu)	Residents, c
Composting on Urban Patios (PUC)	Pátio de Compostagem Aceita (São Bernardo do Campo)	Public Private Partnership (PPP) since 1988, a
	Viveiro Arthur Etzel, the Carmo Park (São Paulo)	Local Authority, since 1996, a
	The Lapa district Patio (São Paulo)	Local Authority, since 2009, a
	The Santo Amaro district Patio (São Paulo)	Local Authority, since 2011, a
	The São Mateus district Patio (São Paulo)	District, 2013, a
	Composting Waste Produced through Prunning Patio (Guarulhos)	Local Authority, since 2013, a
	Fast Composting Patio (Guarulhos) <sup>i</sup>	KMA and Local Authority, since 2013, a
	Chico Mendes Park Patio (Osasco)	Local Authority, a
	NGO Pé de Planta (Sorocaba) Patio - Sta Maria Condominiums (Votorantim) and Paraíso Marriot (Itu)	The Pé de Planta NGO, a
	Composting Waste Produced through Prunning, Patio (Campinas)	The Delta A Landfill site, 2006 a 2012, c
	The Municipal Herbarium (Ribeirão Pires)	Local Authority, 2006 a 2011, c
	The Municipal Garden in São Carlos	Local Authority, 2007 a 2012, c
	The Pilot Experiment using Innovative Technology, Municipal Garden in São Carlos	Aliança Orgânica and Local Authority, 2008 a 2011, c
	The Composting Pilot Plant at Urban Pomar (Sao Paulo) (CORTEZ, 2011)	CENBIO/USP and AES Eletropaulo, 2008, c

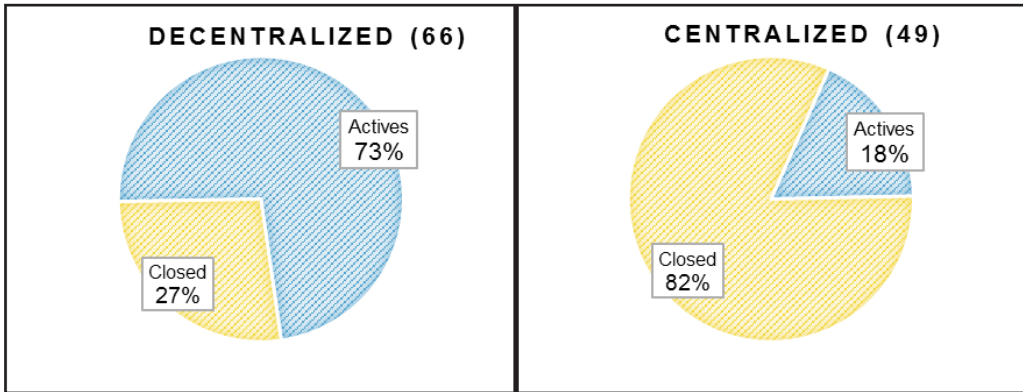
<sup>1</sup> In some cases it was not possible to specify the year, because this information was not given to us by the relevant manager. <sup>2</sup>The 37 Screening and Composting Units (UTCs) in the state that were closed were not included but they were registered on CETESB (2012). However we included two experiences that came to an end because they concerned programs that sent waste to the UTCs.

<sup>i</sup> Producers who contract out third party suppliers (or use volunteers) to implement composting and train their staff.

<sup>ii</sup> Producers that send their waste to be used in compost in another area. <sup>iii</sup>Producers that contract out third parties to operate an internal system.

Out of the total number of experiences that were analyzed, 49 were classified as centralized and 66 decentralized. Of the aforementioned, 18% of centralized experiences and 73% of decentralized experiences were in operation (Figure 2).

Figure 2. Percentage of centralized and decentralized experiences for composting of urban solid waste, actives and closed, that were identified in the state of São Paulo.



It should be noted that in some locations, when inquiring about the existence of composting in a given space (even on a small scale), those that were responsible for this expressed concerns in relation to the activity not being properly regulated. During the survey, some municipal plans for the integrated management of solid waste were observed that included a description of composting programs, which had not been implemented or were in the first phases of implementation.

## Centralized Composting

### *Screening and Composting Plants (UTC)*

Screening and Composting Plants (UTC) are private or public enterprises which have the following: a reception area for receiving waste, a central screening area that has a conveyor belt that separates the waste, a compost area, landfill for non-reusable waste, and a landfill leachate processing system (BARREIRA, 2005). On the screening belt the separation of the waste into its different components and the degree of separation depends on the quantity and efficiency of the staff involved. It also depends on the speed of the treadmill, with smaller ones ensuring more efficient screening processes (BARREIRA, 2005).

UTCs are considered the conventional method to compost MSW (UFPE, 2014). They have the advantage of being able to treat all MSW from one or more municipalities, in one place. The disadvantage is that they produce poor quality compost because of the poor way in which the waste is collected (mixed with different wastes). Aside from being deficient in nutrients, the presences of heavy metals and inert waste (BARREIRA, 2005) discouraging the demand for the compost produced, which often remains stored in large quantities in these units (SÃO PAULO LOCAL AUTHORITY, 2012). The selective collection of organic waste, beyond the technical criteria for composting, is essential for

obtaining good quality compost that can be used in agriculture and to make the business economically viable (ABREU-JUNIOR; PIRES; COSCIONE, 2009). Issues in relation to the technics used, the economic models and management structures were some of the reasons that explained why the majority of UTCs were closed down in Brazil in the 1980s (BARREIRA et al., 2009).

According to the State Inventory for Household Solid Waste 2011 (CETESB, 2012), 42 UTCs were registered in São Paulo since 1997 but only five (CETESB, 2013b) are currently functioning (Table 1). Private companies, with the exception of the Adamantina UTC, which is managed by the local authority, operate all of them.

What we observed from this model is that by simplifying the collection, in other words by collecting organic and inert waste together, this increases the complexity of the required treatment. The conventional collection by the local authority or by a third party company takes away the responsibility of residents to change their habits and increases the work on central processing units. Often, the problems in these units reach dimensions that are very hard to administer and reverse, culminating in their closure or in their use just as a dumping ground.

### *Organic Fertilizer Plant (UAO)*

In this research we consider organic fertilizer plants (UAO) those enterprises that focus on the production of organic compost or organo-mineral fertilizer and generally obtain only clean organic waste. Their priority is on the quality of the final product. Generally speaking, these establishments try to produce the final product in the least amount of time and using the least amount of space. They also aim to meet all legal requirements and they look after soil and/or plant requirements.

According to CETESB (2013a), in 2013 there were 14 organic fertilizer plants operating in the state of São Paulo. However, the majority of them processed industrial or agricultural waste and did not receive any type of material that came from large urban producers. In our study, we could only identify four UAOs that regularly obtained some type of municipal waste (Table 1).

The use of MSW as primary matter in UAOs is something that is still little used because, according to managers, in this area it is essential that the waste is thoroughly separated at source. Such action requires a change in mindset even in areas where the production of organic waste is common such as restaurants, outdoor markets, fruit and vegetable stores and warehouses. The case of the Warehouse and General Storage Company in São Paulo (CEAGESP) is a good example. In spite of being the largest producer of organic waste in Latin America, only 30% of it (in total 100 tons per day) is sent for composting at an UAO in the municipality of Campinas, as reported by CEAGESP management. From what is left, a small amount is collected for animal feed and the greater part is thrown away in landfills.

## Decentralized Composting

### *Institutional Composting (ComI)*

This modality is developed in big and small, public and private institutions that deal with internally produced organic waste. The experiences identified were grouped in three sub-groups, based on the environment where composting took place: i) public agencies, ii) private businesses, and iii) teaching/educational institutions. The system can be planned and developed by the institutions themselves (self-management) or a third party company can implement it. This company can take measurements of the designated area, plan the influx of waste, and operate the whole system. We also identified companies that, apart from planning how the composting system will work, also offer training to staff members until the system passes operating under self-management. Institutional groups and volunteer groups that assist the implementation of systems within educational institutions were also identified. Examples include the USP Recicla Program and the Ligados na Pilha Project (Table 1).

The compost developed by the majority of experiences, particularly from public agencies and educational institutions sub-groups, were natural aerobic systems. In companies that provide these types of services the methods used range from natural composting and vermi-compost to more modern technologies such as bio-accelerators (*Embiotic Line*®, [www.kmambiente.com.br](http://www.kmambiente.com.br)) and electric composters ([www.trasix.com.br](http://www.trasix.com.br)). In relation to the above, the method used has an important role in the costs of the system. The faster and more compact the system is, the more onerous it will inevitably be on all those involved. On the other hand, natural composting systems in areas that have employees and space can have negligible costs.

We noticed that a smaller number of initiatives were developed by public agencies than in the two other sub-groups (Table 1). Just like educational institutions, these places have the function of explaining and spreading the concept of recycling to other sectors in society. Conversely, composting in private companies, according to the contacted managers, can be used to reduce costs for transport and final offloading. We noted that composting is viable principally when: the production of internal waste is high, there is sufficient available space internally and the fertilizer is useful for the institution. Another advantage highlighted by the managers was positive marketing that raised the image of the company, even when the costs of internal treatment was higher than the final offloading costs.

One of the major challenges identified using this model is related to the institutionalization of the internal management. According to the activity reports and information from managers, special attention should be given to allocate staff to operate these composting sites, keep interventions under control and avoid situations in which the monitoring of the activity gradually diminishes. In this way, raising awareness and providing education are important actions principally when the turnover of internal teams and outsourcing teams is high. Aside from this, one of the managers mentioned the need to modify the contract with the maintenance and gardening company to also offering a composting service.

A lack of internal space in order to set up the system can be a bit of a barrier. However a lack of knowledge on the process for composting was the main reason why there was limited expansion of composting activities in the institutions. Some institutions had space but they took a while to realize that, in a well-designed system, the composting area can be perfectly integrated with the garden and the landscape as a whole.

### *Residential Composting (ComD)*

This modality covers experiences developed in residential households using waste produced by the actual residents. The compost that is produced is generally used locally in community and residential gardens. As mentioned in the methodology section above, we considered only ComDs that provided training to the residents in projects aimed at implanting domestic compost facilities in specific communities covering many domiciles at the same time.

During our study we identified companies that sold worm-based compost and electric composter. We also noted groups that encouraged the making of homemade composters and worm composts at a low cost. Also, some public institutions ran free courses for those wanting to create domestic compost. Thus although it was not the intention of this study to quantify how many individual households promoted composting, there were not many examples where the implanting of ComD in the community was promoted (see Table 1). One was fully active whilst the other was just a part of a trial. In both, the objective was to teach local residents that had expressed an interest, to make their own composter. This was done through providing support in the process of incorporating new habits, maintaining the composters and providing support on the use of compost in gardens and allotments. Pertaining to the above, the groups involved used various means to promote and teach such as: making informal contact with residents, distributing informational pamphlets, creating posters, holding workshops etc. The increase in autonomy was variable, ranging from residents who abandoned the practice, to others who started to act as disseminating agents in their areas.

### *Community Composting (ComC)*

Experiences of community composting were based on initiatives developed in districts, towns and condominiums where the treating of local waste from kitchens and pruning trees had already been envisaged. The spaces for composting are in the heart of the community and can be located in community areas, public areas, abandoned grounds or areas in institutions. One major characteristic of this model is the participation of the residents. This participation came in different forms from separating organic waste in their households and taking it to collection points to generally working together to design a workable system and finding solutions. The resultant compost is always given back and reused by the residents and local institutions.

We noted that the presence of someone (a community member or an operator group) in the community is fundamental to the operation of those systems. Groups like

district associations, community workers, social entrepreneurs, non-governmental organizations (NGOs), university groups and private businesses can develop educational activities designed to maximize efficiencies through accompanying and exchange with the community.

Eight experiences in the state of São Paulo were recorded (Table 1). Here we noted that little public participation was seen and there was a tendency for initiatives to be developed through voluntary work that came from community organizations. This was evident due to the difficulties in obtaining support and the minimum financial resources to: invest in the system, employ a worker or pay an active participant in the community. This means that the activity did not generate a direct income and public incentives had been very hard to come by.

### *Composting on Urban Patios (PUC)*

These are spaces in urban areas where organic waste coming from different places is processed. Previous modalities for composting described before were considered as composting *in situ* because they process waste that was produced locally. Composting urban patio (PUCs) was considered *ex situ*, because the waste is transported and treated elsewhere, and not inside the generating community. Then the material processed can either return to the community or not. With reference to the actual structure, the PUCs can be done manually or by a machine, with or without soil sealing and coverage.

Out of the fourteen PUCs that were identified during our study, five are now no longer operational (Table 1). The majority of the urban patios were developed by the local authorities with patios placed inside parks, nurseries, municipal allotments and other public spaces. We found only a small amount of private businesses and NGOs promoting initiatives in this area. Therefore the development of this model by other sectors that were not public is a challenge. This is due to the limitations in transporting organic waste and the restrictions in practicing composting in urban spaces. Managers contacted noted the lack of interest and support on the part of local governments to develop PUCs.

The most common type of waste that was processed was waste from pruned trees, plants and weeds refuse. The only initiatives that used food waste were: the District Patio initiative in São Mateus, in the city of São Paulo, processing waste from a local fair; the Fast Composting Patio in Guarulhos, processing 350 Kg of waste on a daily basis from the Restaurante Popular; and the now extinct Municipal Allotment Patio program in São Carlos, used to process waste from more than 30 restaurants, bakeries and bars in the city (Table 1). The exclusive composting of trees and plants waste requires constant irrigation due to the low levels of moisture in the material. However, the use of food waste helps with the moisture and nutritional quality of the final compost. This nevertheless requires care in handling to avoid impacts in the neighborhood (INÁCIO; MILLER, 2009), such as emission of odors and proliferation of insects.

The compost produced in these areas is frequently used in the maintenance of allotments, plant nurseries, municipal gardens and is made available to local farmers. Thus urban patios allow for the processing of waste in underused urban spaces and provides

fertilizers for agricultural use. This enables links to be made with urban and rural life and can benefit both landscapes.

## **An overview of composting activity in the state of São Paulo**

As a large amount of UTCs have been closed down, this would suggest that the centralized experiences that obtain waste from conventional collections are less prevalent in the state (Figure 2). We also discovered cases where the use of compost for agriculture was prohibited owing to contamination problems. The São José Plant in Rio Preto (the only one with the capacity to serve a medium size municipality) was the unique plant that in 2010, 21 years after being set up, managed to obtain a license as a compost producer in the category of “organic fertilizers” by the Ministry for Agriculture, Fishing and Supply’s (MAPA). With this in mind, recycling MSW in centralized plants requires an immense amount of experience in the area on the part of all those involved (ANDRADE, 2010). Aside from this, rarely were there major efforts used to improve the quality of the waste that went to this type of plant. Only two cases, including selective collections of organic waste undertaken and sent to the UTC, were identified: The Clean Market Program in São Paulo and the Selective Collection Program in Itatinga, both of which are no longer in operation. We also noticed that there were few UAO units that received MSW.

The survey conducted allows to identify that from the 1990s arose various decentralized initiatives for composting of MSW in both a formal and informal way, in different sectors. Each modality performs different roles in society and has positive and negative particularities in the municipal management of waste. Decentralized activities present more diversity in organizational arrangements and in agents involved, beyond variations in scale, public and spaces in the urban area (Table 1). They have been developed by public and private sectors, civil society, nonprofit sector (NGOs and associations), and informal community based organizations. Centralized models were principally developed by private initiatives or public/private partnerships. To a lesser extent some were developed exclusively by public agencies. These experiences also showed less diversity and variety in organizational arrangements compared to decentralized activities.

Separation of organic waste at source coupled with selective collections is essential for an efficient and successful composting system (INÁCIO; MILLER, 2009; ABREU-JUNIOR; PIRES; COSCIONE, 2009). Successful experiences with separation at source were seen in all decentralized activities and some centralized ones. In these activities, those that were involved had been in contact with some type of educational stimulus, which showed a change in behavior in citizens from different sectors and social classes. When people were incentivized by environmental education, this produced positive responses.

We observed that decentralized experiences aside from encouraging source separation and valorize educational processes that stimulate new habits, they also are formed by organizational arrangements that are able to optimize processes. These characteristics reflected directly on the quality of the final compost and its potential to be used in agriculture. From this model, we observed that such activities show the important role of

supporting the management of waste in municipalities due to its potential dissemination. It can be developed by different agents in varied environments.

According to Fehr (2006), centralized models for waste management are successful in countries with a developed economy, but they struggle in developing countries. In substitution for the large plants that make up the centralized system, decentralization of composting has been taken up by various countries in the world. Systems in small and medium scales have been set up in India (ALI, 2004; ZURBRÜGG et al., 2004) and Bangladesh (ROUSE, 2004). This is where decentralized composting became a viable option after numerous cases of unsuccessful large-scale composting of mixed urban waste. Such programs have increasingly become popular in other countries. Platt, McSweeney and Davis (2014) showed 31 examples of community composting in the United States. In Canada, investment was made in major educational campaigns to encourage the population to adhere to selective collections, recycling and composting. There, now 61% of families carry out some form of composting (with waste from their kitchen or garden) (MUSTAPHA, 2013).

In the state of São Paulo a halt in the majority of alternative programs to the conventional model (decentralized and with separation at source) occurred due to a lack of public support. It also was due to institutional vulnerability and the discontinuing of administrative policies (Table 2). Managers also blamed the considerable influence of existing markets that are made up of well-established transport companies and landfill site operators who make it difficult to implant composting programs. Ironically, many successful experiences, which were both logically simple and economically lucrative, were interrupted. This meant that waste which entered a valuation route, ended up being sent to landfill sites. This was also the case before the PNRS came into force (Table 1), in December 2010.

The PNRS has not been sufficient in prioritizing composting of MSW in municipalities in the state of São Paulo as well as divert organic waste from final disposal, according to this study. In the municipality of São Carlos, for example, we identified four initiatives concerning decentralized composting (Table 1) that were developed between 2005 and 2013. Currently all of the projects are no longer operational, with the exception of the Internal Management of Organic Waste Project (GIRO). This community composting project has been only partially operational and it has not had to rely on support from the public authorities. In 2013, according to the news in the regional press, the local authority opened a specific landfill site for organic waste and unusable waste collected in the city.



**Table 2. Causes for interruptions in decentralized activities or with the separation of organic waste at source.**

Reasons for Termination	Entity/Body
Cuts or a suspension of finances earmarked for the selective collection programs and to operate the system	UTC, Institutional
Termination of project due to impact in neighborhoods	UTC
Discontinuance due to political/administrative reasons or because of bureaucracy	Community composting, Institutions, PUC
The closure of landfill sites that provided services	PUC
A lack of support and interest on the part of the local public	PUC
A lack of people to operate the system	Institutional
The requisition of land in order to set up another enterprise or business	Institutional
There were no longer food waste in the unit	Institutional

(UTC = Screening and Composting Unit; PUC = Composting on Urban Patios).

Another situation which went against the PNRS occurred in Campinas where the local government implanted, in 2014, a pilot project for the collection of organic waste from containers placed in some residential neighborhoods. The local authority informed us that this waste was being transferred to a nearby landfill based in another municipality.

The saturation of landfill sites is a constant problem in Brazil. In spite of this, instructions given to deposit organic waste in these areas can also be seen in studies done to provide assistance to managers. In technological routes proposed for municipalities that have up to one million inhabitants, UFPE (2014) suggests that organic waste and household waste are collected together and are landfilled. This procedure was deemed environmentally correct and profitable. The study favored centralized systems as a model for collection and processing. In fact, this specific collection of organic waste would generate unviable costs for Brazilian municipalities (UFPE, 2014).

Strategies that include more recycling, repairs, reutilization, residential composting and sustainable consumption requires changes in people's behaviors. These types of strategies are becoming essential for sustainable development (WILSON, 2007). Aside from the projects identified in this study, those that were successful with separation at source, the collection of organic waste in communities and decentralized composting on patios can be seen in various regions in Brazil (FEHR, 2009; INÁCIO; MILLER, 2009; MOURA, 2012; ABREU, 2013). Centralized strategies had demonstrative efficiencies mainly when associated with selective collections in households and where there was this type of selection for large-scale producers of waste. However, Cortez (2011) noted the

lack of knowledge of local authorities concerning adequately dealing with urban waste from pruned trees and other plant derivatives. This was noted on a visit to municipalities in São Paulo where there was a woeful lack of preparation made and no efforts had been made to publish the benefits in public sector management of organic waste.

Incentives in the use of organic fertilizers and better integration with urban and peri-urban agricultural systems and rural systems are important strategies for sustainability programs in relation to composting. (DRECHSEL; KUNSE, 2001; INÁCIO; MILLER, 2009). The return of biomass and discarded nutrients in large urban centers to agricultural soils is linked to food and nutritional security where there is expanding urban populations (FUREDY; CHOWDHURRY, 1996; DRECHSEL; KUNSE, 2001). This is also the case for the running out of mineral fertilizers. Public authorities are essential for promoting sustainability programs for composting. It also needs to work to obtain new partnerships and to modify municipal plans to accommodate alternative composting systems. Public authorities should create ways to provide incentives, give advice, strengthen and plan relevant activities to deal with organic waste in the correct way as noted in the PNRS. Organic waste needs to be a part of the agro-ecosystem.

## Final considerations

Experiences that divert organic waste from final disposal have been little stimulated in the state of São Paulo. We noted that organic waste that was destined to be used in an efficient way in composting, often had this process stopped and this waste ended up in landfill sites. Nevertheless, there was a wide variety of different projects that were identified in the state. From this study, we can conclude that it is both possible and necessary to diversify the management of waste in municipalities.

Centralized systems were more likely to fail (82% of identified initiatives closed down) in comparison with decentralized systems. This was due to the systems being overly cumbersome and on many occasions the final product was more akin to waste than compost. Decentralized activities can be efficient in the task of preventing waste from not being treated correctly and it has the advantage of mobilizing and educating people. This is because it is more based on changing paradigms and social technology and less on engineering works. This does not mean that centralized activities should be dispensed with in relation to the management of municipal waste. Actions to better take advantage of composting plants that currently exist and which are associated with selective collection of organic waste, can be useful and successful. However, it was noted that decentralized activities were more successful in the adequate treatment of waste when projects were kept open for longer durations (Figure 2). In addition, if planned with the municipal agricultural sectors in mind, such initiatives can stimulate the production of local food and contribute to the enhancement of the quality of the soil for farming.

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# COMPOSTING OF MUNICIPAL SOLID WASTE IN THE STATE OF SAO PAULO (BRAZIL)

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**Abstract:** Organic waste composes more than half of municipal solid waste (MSW) collected in Brazil and most of it is not transformed into compost, creating serious environmental problems. This study aimed to: i) identify composting experiences of MSW developed in the state of São Paulo; ii) characterize the dynamics of the modalities identified; and iii) give an overview of MSW composting in the state. The characterization of the identified experiences allowed us to group them into six modalities within two management models: centralized and decentralized. Opportunities, challenges and demands have been observed for organizing efficient systems to collaborate with municipal management and produce quality compost for agriculture. The research has shown that organic waste brought into an efficient composting route has its recovery process interrupted, returning to landfills. This indicates that the National Policy of Solid Waste has not been sufficient to prioritize composting in cities in São Paulo state.

**Keywords:** Centralized composting; Decentralized composting; Organic waste; Organic fertilizer.

**Resumo:** Resíduos orgânicos compõem mais da metade dos resíduos sólidos urbanos (RSU) coletados no Brasil e a maior parte não é transformada em composto, gerando sérios problemas ambientais. Este trabalho teve por objetivos: i) identificar experiências de compostagem de RSU no estado de São Paulo; ii) caracterizar a dinâmica das modalidades identificadas; e iii) traçar um panorama da compostagem de RSU no estado. A caracterização feita nas experiências levantadas permitiu agrupá-las em seis modalidades dentro de dois modelos de gestão: centralizado e descentralizado. Foram observadas oportunidades, desafios e demandas para se organizar sistemas eficientes que colaborem com a gestão municipal e produzam composto de qualidade. Verificou-se que, com frequência, resíduos orgânicos que entram numa rota eficiente de compostagem têm seu processo de valorização interrompido e retornam para aterros, indicando que a Política Nacional de Resíduos Sólidos não tem sido suficiente para priorizar a compostagem nos municípios paulistas.

**Palavras-chave:** Compostagem centralizada; Compostagem descentralizada; Resíduo orgânico; Adubo orgânico.

**Resumen:** Residuos orgánicos constituyen más de la mitad de los residuos sólidos urbanos (RSU) recogidos en Brasil y la mayor parte no es transformado en compost, creando serios problemas ambientales. Este estudio tuvo como objetivos: i) identificar experiencias de compostaje de RSU en el estado de São Paulo; ii) caracterizar la dinámica de las modalidades identificadas; y iii) esbozar un panorama de la actividad de compostaje en el estado. La caracterización de las experiencias identificadas permitió agruparlas en seis modalidades dentro de dos modelos de gestión: centralizada y descentralizada. Se observaron oportunidades, desafíos y demandas para organizar sistemas eficaces para colaborar con la administración municipal y producir compost de calidad para la agricultura. Se constató que a menudo, los residuos orgánicos puestos en una ruta eficiente de compostaje tienen interrumpido su proceso de recuperación y regresan a los vertederos, lo que indica que la Política Nacional de Residuos Sólidos no ha sido suficiente para priorizar el compostaje en São Paulo.

**Palabras clave:** Compostaje centralizado; Compostaje descentralizado; Residuos orgánicos; Fertilizantes orgánicos.

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