Urban composting is currently booming, especially thanks to the new outlets that urban agriculture offers for organic materials. Faced with the challenges of the sustainable city of tomorrow, this practice, whether individual or collective, engages citizens and offers a decentralized response with positive impacts for the environment and for neighborhood social relations. Its success involves making material available in a common space, a communication system and support from residents’ initiatives. Technical, ecological, agricultural, economic and social aspects must be considered to ensure its success, while scientific knowledge is essential to inform, overcome certain obstacles and ensure the quality of this urban form of production.

INTRODUCTION

Although not required to do so, 30% of French households sort their biowaste at the source. Previously, these tended to be ad hoc local initiatives, but there is now a real buzz around urban composting. This is happening in connection with urban agriculture programs, as composted organic waste is used to supply urban and peri-urban agriculture. As of 2015, the average person in France was producing 437 kilograms of household waste a year. Of this waste, half is made up of recyclable materials and a third of organic waste. Composting therefore allows reduced consumption of resources by encouraging their recycling and local reuse.

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These two researchers received finance for their doctoral dissertations from the French Environment and Energy Management Agency (ADEME).

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COMPOSTING: THE PROCESS AND RECOVERY STREAMS

A TECHNIQUE FOR RECOVERING AND PROCESSING ORGANIC WASTE

Composting is the fermentation of organic waste in the presence of oxygen (under aerobic conditions) and humidity, in controlled conditions. This produces a stable fertilizing material rich in humic compounds: compost, which is used as an organic soil improver to enhance the structure and fertility of soil. But the renewed interest in composting should not overshadow the complexity of this technique. The composting process comprises four phases (mesophilic, thermophilic, cooling and curing), throughout which the composition of organic products and of living organisms changes.

The first three phases make up the decomposition phase (see Figure 1). During the mesophilic phase, large quantities of carbon dioxide are released and a great deal of oxygen is consumed, causing an increase in temperature. This is particularly significant in the mesophilic and thermophilic phases, when the energy contained in the organic matter is transformed into heat, and the temperature can reach between 50 and 60 °C (and even 70 to 80 °C in heaps measuring several dozen cubic meters). During the cooling phase, the temperature gradually drops and fungi colonize the material. At the same time, microbial activity lessens. Below 30 °C, microorganisms remain active, and larger organisms (macroorganisms), such as compost worms, mites, springtails, woodlice, beetles and centipedes start to appear. This is the curing phase. The decomposition of organic material continues and humus forms.

The four phases of the composting process

Figure 1
ORGANIC WASTE

Organic waste, also known as fermentable waste, biowaste and biodegradable waste, refers to green garden waste such as lawn clippings, dead leaves, hedge clippings, or wilted indoor flowers and plants, and animal waste, such as droppings, dung and manure. This waste can be broken down by microorganisms and organisms such as worms, mites and insects.

Organic waste also includes degradable kitchen waste, such as fruit and vegetable peelings, coffee grounds, tea bags, cheese rind, eggshells, vegetable food leftovers (bread, rice, potatoes), plus cellulose household waste such as absorbent paper (paper tissues, paper towels, coffee filters) and newspaper, wood ash, and untreated sawdust and wood shavings.

French biowaste regulations in a nutshell:
Biowaste or organic waste is defined in article R 541-8 of the environmental code as: “all non-hazardous biodegradable garden or park waste, all non-hazardous food or kitchen waste, including that from households, restaurants, caterers and retailers, and all similar waste from foodstuff production or processing facilities”.

Some key figures:
Households produce 18 million metric tons of biowaste per year, including:
- 5.1 million metric tons of mainly green waste processed in homes (mulch, compost, etc.)
- 3.8 million metric tons of green waste sent to disposal facilities
- 1.6 million metric tons of biowaste collected separately (mostly green waste – food waste amounts to 5-10% by weight).

Remaining biowaste amounts to around 40% of household waste, or more than 8 million metric tons, and is mostly food waste. The amount of kitchen and green waste processed in homes is equivalent to the amount collected by public services.
THE DIFFERENT COMPOSTING STREAMS

Composting is an organic waste recovery and processing stream that works at every scale, from the domestic to the neighborhood or town level, right up to industrial plant scale.

This makes composting suitable for a range of socioeconomic and geographical situations. There is a distinction to be made between domestic composting and industrial composting. The latter takes place in centralized, large-capacity industrial facilities producing from 2,000 to 100,000 metric tons per year, or even more. These facilities enabled the processing of more than 7.2 million metric tons of organic waste in France in 2010.

Domestic composting, on the other hand, covers individual and collective composting. Individual composting is carried out by individuals or private households, at the bottom of the garden, or by apartment dwellers, using a wormery. Use of the latter is showing a marked increase. Collective or semi-collective composting is carried out at the foot of an apartment building, or in a communal area or garden. These have seen strong growth in recent years.

THE REVIVAL OF AN ANCIENT URBAN PRACTICE

A HISTORY OF COMPOSTING

Composting is mentioned in the “Book of Nabatean Agriculture” from the third millennium BCE; the book is a synopsis of the agricultural knowledge of ancient Mesopotamia. Archeological digs have also found household waste in manure from the Middle Ages, but it is not known whether this was accidental or an informed practice. Although the medieval town was marked by the separation of agricultural areas located outside the walls from the intra-mural spaces, urban agricultural practices already existed. For example, places for medicinal plants or vegetable gardens have been observed behind some dwellings and in abbey gardens. The practices of composting and farming inside towns seem to have developed concurrently until the 20th century, through a phenomenon of “agrarianization of towns.” This phenomenon takes very different forms, from urban farms to family gardens; makes use of various surfaces, such as planted roofs and walls or gaps between buildings; and employs disparate techniques, such as organic growing and hydroponics.

The 20th century marks a separation. The urbanization of agriculture happened relatively quietly, but urban expansion accentuated competition for use of space. Areas that were previously agricultural were now located in urban or peri-urban settings. Beyond the usage conflicts provoked by urban expansion, composting developed significantly in the agricultural sector, and research work on composting techniques emerged in its wake. For example, in 1936, the botanist and agronomist George Washington Carver (1864-1943) published a study entitled “How to Build Up and Maintain the Virgin Fertility of Our Soil,” which recommended using compost to maintain the fertility of soil exposed to increasing environmental pressures. A few years later, in 1943, the publication of “An agricultural testament” by the English agronomist and botanist Albert Howard (1873-1947) rekindled interest in composting methods.

RENEWED POPULARITY

Urban composting is currently attracting strong interest through the expansion of urban agriculture, which is raising urban residents’ awareness of food production. Additionally, the sustainable city concept has highlighted the value of making compost from urban waste. The timeline in Figure 3 shows the main steps implemented since the 2000s to encourage composting on every scale, both individual and collective. In 2006, France’s National Plan to support home composting rounded off its national waste prevention plan of 2004. The publication of numerous research studies and methodological guides followed. A notable example is the in-house composting guide aimed at all public or private organizations with a shared canteen (schools, tourist attractions and restaurants, for instance), the guide to shared or semi-collective composting aimed at users of communal or co-owned gardens, and more recently, the practical guide to composting and mulching aimed at households.

The National Plan for Waste Prevention 2014-2020, along with the next Plan (in consultation since April 2019), highlight the increasing importance of composting in waste management. To achieve its 2025 waste reduction targets, the waste plan envisages increasing the number

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of neighborhood composting facilities, composting hubs and biogas plants, so that “everyone can access a neighborhood waste management solution.” Currently, according to ADEME, there are more than 600 composting hubs, and around 60 local government authorities have a doorstep biowaste collection system in place, serving 2.2 million residents\textsuperscript{15}. Thanks to these facilities, the volume of composted waste is increasing – it reached 7.7 million metric tons in 2014, which represents a 103% increase from the year 2000\textsuperscript{16}. This volume will probably continue to increase, as the 2018 roadmap for the circular economy included a reduced value-added tax on purchases of neighborhood composting equipment and compostable bags.

\textsuperscript{15} ADEME, \textit{Guide méthodologique du compostage partagé (ou semi collectif)}, op. cit.

FOCUS ON THE EXPANSION OF COMPOSTING IN SELECTED CITIES

In the urban community of Toulouse Métropole, composting has grown significantly. Between 2011 and 2012, the percentage of households with a garden composter increased by 53% in Aigrefeuille, by around 40% in Toulouse, Beaupuy and Mons, and by just under 20% in Drémil-Lafage, Quint-Fonsegrives and Pin-Balma.

In the urban community of Grand Chalon, the number of home composters distributed to households multiplied 14-fold between 2006 and 2013.

In Nantes, no fewer than 38 shared composting facilities were established in 2018, and 15 more in 2019. Currently, there are more than 200 shared composting facilities, in schools, homes and even family gardens.

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COMPOSTING IN A COMMUNAL GARDEN:
THE EXAMPLE OF THE LA CRAPAUDINE VEGETABLE GARDEN IN NANTES

Environmentally friendly practices adopted in communal gardens include collecting rainwater for watering, using compost as natural fertilizer and banning the use of chemical treatments. These practices were all implemented long ago in the La Crapaudine vegetable garden. Created in 1998, this family garden in south Nantes comprises 91 plots ranging from 35 to 150 square meters, with a total area of 16,580 square meters. The garden is managed by the Jardins de la Crapaudine association, which supports gardeners and organizes activities with other local associations to strengthen social links and make gardeners aware of chemical-free products and methods. Since January 1, 2017 the Labbé law prohibits the use of chemicals in green spaces, forests, roadways and paths accessible or open to the public.

Through the Compostri non-profit organization, composting has been used in this park since 2011 to reduce the use of pesticides. A 1,400-square-meter educational space is also available to the city of Nantes’s green space and environmental services as a master class and showcase for urban composting. This area also helps raise public awareness of composting and there is a training area dedicated to individual and shared composting using heaps and wormeries. Activities to raise park users’ awareness are also held during national neighborhood composting weeks, which take place every year in March and April. The composting space is not restricted to subscribers and members of the family garden — any local resident can dispose of their biowaste in the composting shed provided. In this way, the shared garden is helping to spread eco-friendly values and behaviors.

More than 200 shared composting facilities are currently operating in the Nantes Métropole area: more than 80 in homes, the same again at the foot of apartment buildings, and around 15 in family gardens.

Awareness poster issued for the 2019 French national waste composting awareness week
A PRACTICE WITH MULTIPLE BENEFITS FOR THE CITY

Compost helps sustain urban agriculture and is the source of numerous benefits in the multifunctional context of the city.

In physical terms, the use of compost improves the soil’s structure, reducing the risk of soil erosion by wind and water. Compost also increases the soil’s water retention capacity, making it more drought-resistant. Compost improves the soil’s plasticity, density and structure.

Chemically speaking, the use of compost increases the soil’s carbon, nitrogen, phosphorus and potassium content, as well as trace elements and organic matter. These substances are necessary for plant growth, and therefore for soil fertility. In biological terms, compost contains significant biomass and supports an extremely rich microbial population. Applying compost also increases microfauna in the soil. All these elements contribute to soil fertility.

The benefits of urban composting combined with urban agriculture

Urban composting

Urban agriculture

AGRONOMIC BENEFITS

Nutritive elements added

Soil fertility improved

ENVIRONMENTAL BENEFITS

Reduced pesticide and fertilizer use

Market for urban compost created

ECONOMIC BENEFITS

Market for urban compost created

Selling prices

Social benefits

Education and awareness of urban composting

Social acceptability of urban composting


From an agronomic viewpoint, therefore, the use of compost improves the physical, chemical and biological quality of the soil. In the city, it can enrich urban soil, planted roofs and terraces for growing vegetables. It therefore contributes to improving crop soil fertility in the urban environment. The practice of composting in the context of urban agriculture also alters its relationship to the city. Essentially, as the city eats, it also produces. Just like when they generate electricity from renewable sources, citizens who produce compost become suppliers to the city, providing it with fertilizer for its green spaces.

Economically, urban agriculture represents a potential market for compost produced in an urban setting. Also, from both the economic and environmental viewpoint, composting has the advantage of its short distribution chain, as it occurs where waste is produced. This also eliminates the difficulties and costs associated with transportation and industrial recovery, which involves incineration or landfill, especially given that these sites are relatively costly and difficult to establish, due to the nuisance they pose to local residents.

Composting also brings environmental benefits by reducing reliance on pesticides and chemical fertilizers, especially in the agricultural sector where their use is still widespread. On the other hand, using compost on contaminated soil can considerably reduce the pollutant content, including:


Rizwan Ahmad, Muhammad Aslam, Zahir A. Zahir, Muhammad Asghad, and Ghulam Ijani, “Economizing the use of nitrogen fertilizer in wheat production through enriched compost,” Renewable Agriculture and Food Systems 23, no. 03 (September 2008): 243249.
Using compost alongside roads offers another environmental bonus by absorbing rainwater and reducing soil washout. Also, through urban agriculture, the use of compost offers a route to social acceptability for growing crops off ground or on city rooftops. In return, urban agriculture initiatives also help to raise awareness and educate the public about composting practices, which enhances its social acceptability still further.

The benefits of composting extend beyond the boundaries of urban agriculture and also contribute to creating real circularity in the use of compost.

Despite the numerous positive effects of composting, there are significant obstacles limiting its use. Among these are environmental and health risks. Administrative and regulatory barriers and people’s perceptions of organic waste also constitute obstacles that require effective public communication with compost users to further promote its use.

Carbon dioxide is the main gas produced during composting. Several other gases in smaller quantities can also have a non-negligible effect on health or the environment: nitrous oxide and methane are greenhouse gases; ammonia contributes to environmental acidification and eutrophication; various other volatile sulfurous and organic compounds can potentially create odors and health issues.

Additionally, composting occurs in the presence of microorganisms that can cause disease. The risk of disease is potentially greater for people working in a composting hub. However, in recent years, the amount of kitchen and green waste processed in homes has been equivalent to the...
amount collected by public services. Home composting therefore presents risks that need to be mentioned.

In addition to microorganisms as a potential source of certain diseases, mostly respiratory, organic pollutants can also be found in compost because they are present in the organic waste that goes into the compost. There is therefore a disease risk when stirring, turning or collecting compost, or when adding dry material, for example. Diseases may be transmitted by inhalation or ingestion of organic dust particles, or through the skin. These organic dust particles can contain microorganisms of fecal or animal origin, especially animal by-products from category 3 such as egg shells and certain meat residues. Although these are usually destroyed during the composting process due to the rise in temperature, this temperature increase is not systematic, especially in the case of home composting and small shared composters where the volume of composted waste is low, as this does not permit the

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### Main environmental and health impacts of urban composting

- **Main gases produced during composting:** CO₂, NH₃, N₂O, CH₄
- **Increased risks during dry material operations**
- **Environmental acidification and eutrophication**
- **Odors and health risks from inhalation, ingestion and skin contact**
- **People most at risk:** Wear a mask and gloves – wash hands
- **Prevention methods:**
  - Respiratory ailments
  - Eye problems
  - Skin problems
  - Poisoning

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hygienization of the compost caused by the temperature increase.

In terms of other potential ailments, the main risk to humans is allergic or inflammatory in nature. Bacteria and fungi that grow during composting may also release toxins and allergens. Toxins of bacterial or fungal origin can cause respiratory discomfort or irritation (in the form of coughing and sneezing) and/or ocular discomfort, or non-allergic inflammation, such as irritation, chronic bronchitis or asthma flare-ups, for example. The multiplication of microorganisms such as aspergillus fumigatus, aspergillus flavus or stachybotrys atra can also cause necrotizing pneumonia, pulmonary disease, or hypersensitivity pneumopathy, also known as allergic alveolitis36. These diseases can also be caused by (involuntary) ingestion of soil or compost dust particles. This particularly affects unsupervised young children, who may subsequently develop gastroenteritis or acute diarrhea. Figure 5 summarizes the main potential environmental and health impacts of home composting.

However, the risk of infection is minimal. Chronic respiratory exposure to atmospheric emissions from compost are not likely to entail unacceptable risks.39 Effectively, this type of reaction generally occurs in cases of repeated and prolonged exposure to the organic materials contained in the compost. Additionally, immunosuppressed individuals are most at risk: infants, young children, older people, or people with chronic illnesses such as asthma. Furthermore, to prevent these risks, wearing a mask and gloves is recommended when handling compost. It is also important to allow the compost to mature long enough that pathogens do not survive. It is also preferable to spread the compost around trees and ornamental plants rather than on the vegetable garden. If the compost is used on the vegetable garden, vegetables from the garden must be thoroughly washed.

ADMINISTRATIVE ASPECTS AND PUBLIC PERCEPTIONS

On a social level, compost use enables residents to increase their awareness and sense of responsibility with regard to their own waste production40. Observations of composting practice in different urban areas such as Bordeaux41, Lyon42 and Strasbourg43 show that although compost users in an urban setting share the same aim in terms of sustainable development (reduction and recycling of waste), this clashes with regulations that are considered overly rigid. In addition, cooperation between the various volunteers and the urban community (including local government authority stakeholders) comes up against a difference in cultures linked to the need for each category of stakeholder to understand the challenges and expectations relating to recycling.44 Faced with a regulatory framework they consider too rigid, users adapt and at times liberate themselves from local composting regulations. A study of the local compost regulations in the Strasbourg inter-municipal authority (Eurométropole de Strasbourg) showed that the list of allowed waste differs from one site to another45. This may also be observed in the advice given to students in different teaching establishments.

The different types of waste not allowed on certain urban composting sites may be explained by different motives, whether for pragmatic reasons of fast waste sorting, avoiding odors or esthetic nuisance, or aiming at a rather extreme form of “neo-hygienism”46. Initial attempts in Lyon to encourage home wormery use revealed these kinds of difficulties, despite personalized support being offered. These experiments were nevertheless able to show the advantages of a composting solution at the foot of apartment buildings, with collection guaranteed by the municipality.

Another major difficulty is the number and duration of administrative procedures to be followed when installing a composter. These are seen as prohibitive. In the city of Lyon, for example, it sometimes takes two years for a composting project to see the light of day47.

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CONCLUSION

Advocates of the city as a service are currently questioning the content and methods of delivering public services, including through composting. Having previously been washed away in the tide of urban waste, more than a decade ago, biowaste rediscovered its historic route to recovery: composting. Composting offers an important resource for urban agriculture, which is constantly expanding. Public decision-makers and citizens have converged on a decentralized solution that is positive for the environment and enables a return to closer neighborhood social relations based on shared values, while also rationalizing costs for the municipality. The practice of urban composting has already passed beyond the confines of the family garden: education and awareness of composting are becoming more widespread, notably through urban agriculture and increasing public awareness of food production.48 In this context, it is essential to mobilize scientific expertise, and research programs are currently under way to expedite the composting of new forms of biowaste, especially bioplastics, which are already arriving in composters with best practice yet to be established.49 We now need to consider future conditions for efficiency and for safeguarding health and the environment.