THE REVIVAL OF URBAN AGRICULTURE: an opportunity for the composting stream

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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[1]. 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[2].

As of 2015, the average person in France was producing 437 kilograms of household waste a year.[3] 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.

1 ADEME, Fabienne Muller, Guillaume Bastide, Isabelle Deportes, Olga Kergaravat, and Cloé Mahé, "Comment réussir la mise en œuvre du tri à la source des biodéchets? Recommandations pour les collectivités," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), *Expertises*, 2018.

2 Joël Sotamenou, "Les facteurs d'adoption du compost en agriculture urbaine et périurbaine au Cameroun," *Terrains & travaux* 1, no. 0, 2012: 173187.

3 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Déchets - chiffres clés," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), *Faits & Chiffres*, 2018.

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

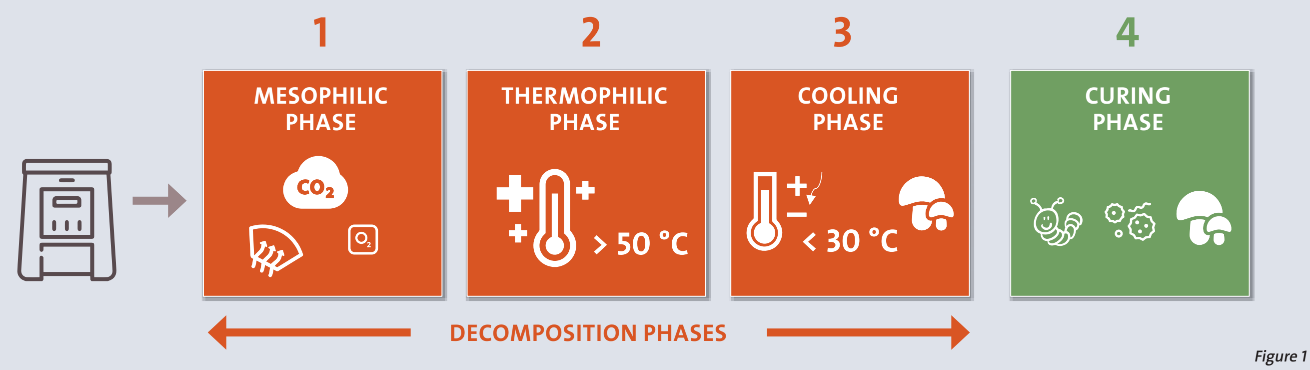

Figure 1

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.

ORGANIC WASTE AND MAIN SOURCES OF WASTE

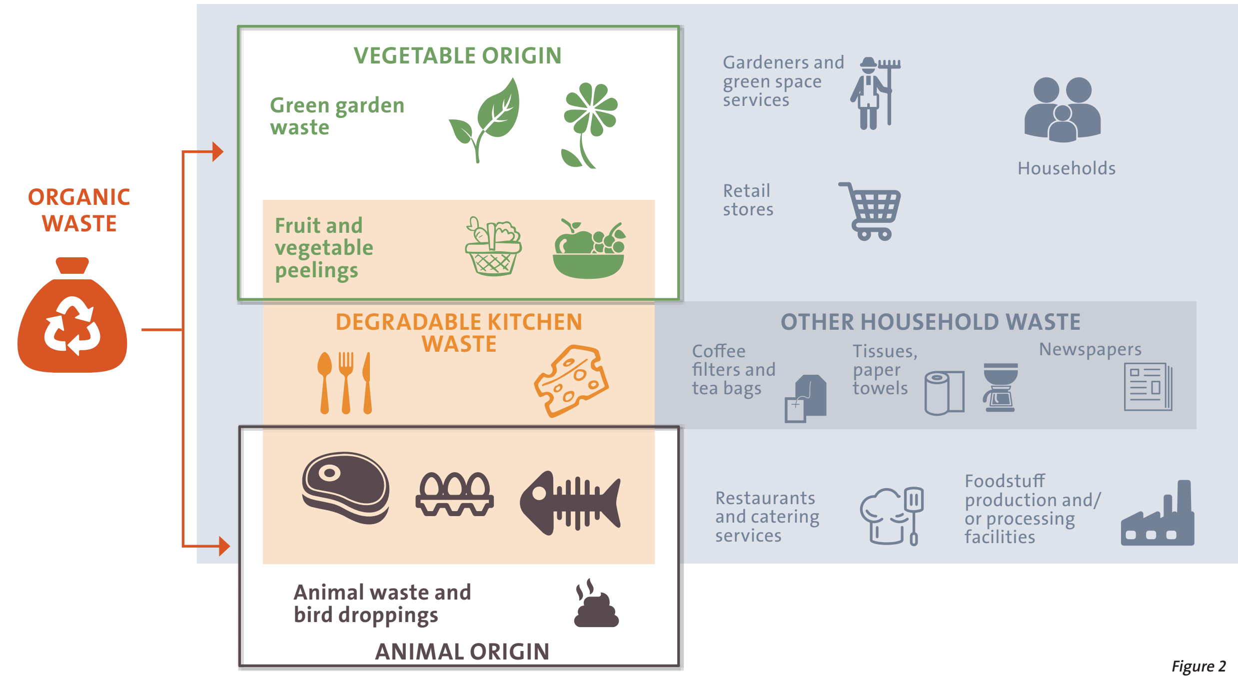

Figure 2

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[4].

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[5]. 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[6]. Although the medieval town was marked by the separation of agricultural areas located outside the walls from the intra-mural spaces[7], urban agricultural practices already existed[8]. 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[9].

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[10].

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[11] 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[12] aimed at users of communal or co-owned gardens, and more recently, the practical guide to composting and mulching aimed at households[13].

The National Plan for Waste Prevention 2014-2020[14], 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

4 ADEME, *Le compostage - fiche technique*, [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), 2015.

5 Sabine Barles, *L'invention des déchets urbains : France 1790-1970*, Champ Vallon, Milieux, June 15, 2005. Mohammed El Faiz, "Un traité des engrais d'après le 'Livre de l'Agriculture Nabatéenne'," *Journal d'agriculture traditionnelle et de botanique appliquée* 39, no. 1 (1997): 525.

6 Nicolas Poirier and Laure Nuninger, "Techniques d'amendement agraire et témoins matériels. Pour une approche archéologique des espaces agraires anciens," *Histoire & Sociétés rurales* 38, no. 2 (2012): 1150.

7 Paula Nahmias and Yvon Le Caro, "Pour une définition de l'agriculture urbaine : réciprocité fonctionnelle et diversité des formes spatiales," *Environnement urbain/ Urban environment*, 6 (2012): 116.

8 Pascale Scheromm, Coline Perrin, and Christophe Soulard, "Cultiver en ville... Cultiver la ville? L'agriculture urbaine à Montpellier," *Espaces et sociétés* 158, no. 3, (2014): 49.

9 Marion Ernwein and Joëlle Salomon-Cavin, "Au-delà de l'agrarisation de la ville : l'agriculture peut-elle être un outil d'aménagement urbain? Discussion à partir de l'exemple genevois," *Géocarrefour*, 89, December 23, 2014, no. 12: 3140.

10 Grace Gershuny and Deborah L. Martin (ed.) *The Rodale book of composting: simple methods to improve your soil, recycle waste, grow healthier plants, and create an earth-friendly garden, Second revised edition-1992* (New York: Rodale Books, Rodale Classics, 2018).

11 Agnès Demolles, Christian Nanchen, Pascal Retière, and Roger Proix, "Guide méthodologique du compostage autonome en établissement," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), 2012.

12 ADEME, *Guide méthodologique du compostage partagé (ou semi collectif)*, [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), 2012.

13 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Le compostage et le paillage," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), *Clés pour agir* (2019).

14 ADEME, *Le compostage - fiche technique*, [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), 2015.

Major dates relating to composting since the early 2000s

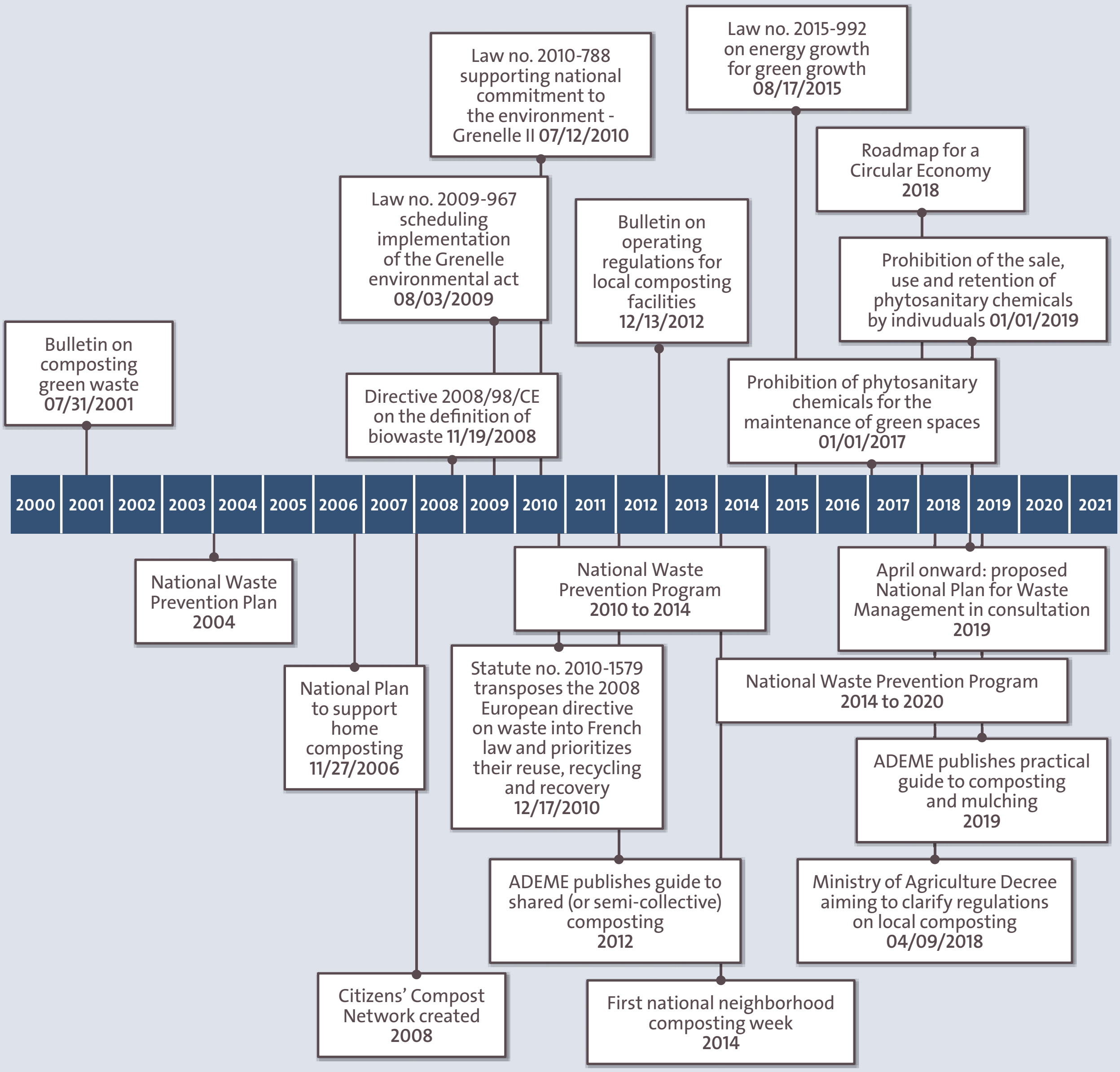

Figure 3

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[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[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.

15 ADEME, *Guide méthodologique du compostage partagé (ou semi collectif)*, op. cit.

16 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Déchets - chiffres clés," op. cit.

FOCUS ON THE EXPANSION OF COMPOSTING IN SELECTED CITIES[17]

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.

17 Data source: https://www.data.gouv.fr/fr/datasets/compostage-domestique/ et http://www.compostri.fr/carte/

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[18] and is the source of numerous benefits[19] 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[20]. Compost improves the soil's plasticity, density and structure[21]. Chemically speaking, the use of compost increases the soil's carbon, nitrogen, phosphorus and potassium content, as well as trace elements and organic matter[22]. 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[23]. Applying compost also increases microfauna in the soil. All these elements contribute to soil fertility[24].

18 Camille Blaudin de Thé, Amandine Erktan, and Charles Vergobbi, *La filière agricole au cœur des villes en 2030*, AgroParisTech, Paris, France, 2009.
Camille Dumat, Tiantian Xiong, and Muhammad Shahid, *Agriculture urbaine durable: Opportunité pour la transition écologique*, 2016.

19 M. Charland, S. Cantin, M-A. St-Pierre, and L. Cote, *Recherche sur les avantages à utiliser le compost*, [Report], Québec, Centre de Recherche Industrielle du Québec (CRIQ), Dossier CRIQ, 2001.

20 Heba Ahmed Khalil Ibrahim and Mohamed Abdel aziz Balah, "Study the Use of Compost Tea in Weed Suppression," *International Journal of Environmental Research* 12, no. 5 (October 2018): 609618.
Suwandi, Armi Junita, Suparman, Abu Umayah, Harman Hamidson, A. Muslim, and Chandra Irsan, "Curative Activity of Watery Fermented Compost Extract as a Bark Treatment against Tapping Panel Dryness," *The Open Agriculture Journal 12*, no. 1, April 30, 2018: 7483.

21Thuy Thu Doan, Thierry Henry-des-Tureaux, Cornelia Rumpel, Jean-Louis Janeau, and Pascal Jouquet, "Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: A three year mesocosm experiment," *Science of The Total Environment* 514 (May 2015): 147154, doi:10.1016/j.scitotenv.2015.02.005.

22 M. Mladenov, "Chemical composition of different types of compost," *Journal of Chemical Technology and Metallurgy* 53, no. 4 (2018): 712716.

23 C. Aubry and C-T. Soulard, "Cultiver les milieux habités : quelle agronomie en zone urbaine ?" *Agronomie, Environnement et Sociétés* 2, no. 1 (2011): 89101.

24 Miguel A. Sánchez-Monedero, María L. Cayuela, María Sánchez-García, Bart Vandecasteele, Tommy D'Hose, Guadalupe López, Carolina Martínez-Gaitán, Peter J. Kuikman, Tania Sinicco, and Claudio Mondini, "Agronomic Evaluation of Biochar, Compost and Biochar-Blended Compost across Different Cropping Systems: Perspective from the European Project FERTIPLUS," , *Agronomy* 9, no. 5, May 4, 2019: 225
Rubén Forján, Alfonso Rodríguez-Vila, Beatriz Cerqueira, Emma F. Covelo, Purificación Marcet, and Verónica Asensio, "Comparative effect of compost and technosol enhanced with biochar on the fertility of a degraded soil," *Environmental Monitoring and Assessment* 190, no. 10 (October 2018).
Thuy Thu Doan et al. "Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam," *op. cit.*

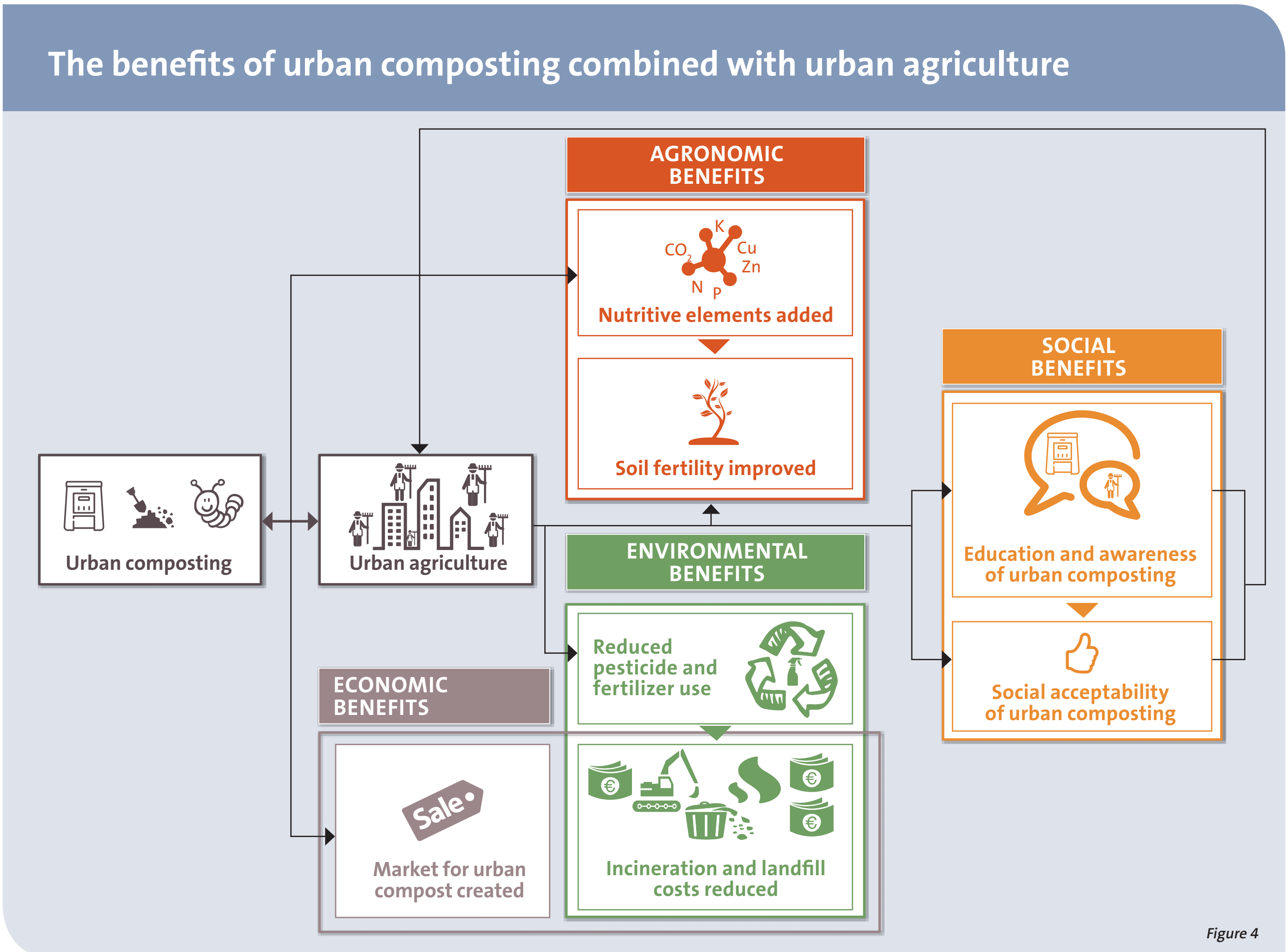

Figure 4

Composter at the foot of an apartment building – ©City of Nantes

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[25]. It therefore contributes to improving crop soil fertility in the urban environment[26]. 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[27]. 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[28], 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

25 B. P. Grard, N. Bel, N. Marchal, F. Madre, J. F. Castell, P. Cambier, C. Chenu, S. Houot, N Manouchehri, S. Besancon, J. C. Michel, N. Frascaria-Lacoste, and C. Aubry, "Recycling urban waste as possible use for rooftop vegetable garden," *Future of Food: Journal on Food, Agriculture and Society 3*, no. 1 (2015): 2134.
Mert Eksi, D. Bradley Rowe, Rafael Fernández-Cañero, and Bert M. Cregg, "Effect of substrate compost percentage on green roof vegetable production," *Urban Forestry & Urban Greening* 14 no. 2 (2015): 315322.
Baptiste J.-P. Grard, Claire Chenu, Nastaran Manouchehri, Sabine Houot, Nathalie Frascaria-Lacoste, and Christine Aubry, "Rooftop farming on urban waste provides many ecosystem services," *Agronomy for Sustainable Development* 38, no. 1 (February 2018).

26 Rosanne Wielemaker, Oene Oenema, Grietje Zeeman, and Jan Weijma, "Fertile cities: Nutrient management practices in urban agriculture," *Science of The Total Environment* 668 (June 2019): 12771288.
Rosanne C. Wielemaker, Jan Weijma, and Grietje Zeeman, "Harvest to harvest: Recovering nutrients with New Sanitation systems for reuse in Urban Agriculture," *Resources, Conservation and Recycling 128* (January 2018): 426437.
O. Cofie, A. A. Bradford, and P. Drechsel, "Recycling of urban organic waste for urban agriculture," in *Cities farming for the future, Urban agriculture for sustainable cities*: 209242.
J. P. Harris et al. "The potential use of waste-stream products for soil amelioration in peri-urban interface agricultural production systems," in *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa*, ed. P. Drechsel and D. Kunze (Wallingford, United-Kingdom): 128.

27 Giulia Giacchè, *"De la ville qui mange à la ville qui produit: l'exemple des Horteloes Urbanos de Sao Paulo,"* [Report], Nantes, France, Laboratoire ESO (Espaces et Sociétés), *ESO Travaux et Documents - Dossier Transition sociale et environnementale des systèmes agricoles et agro-alimentaires au Brésil*, 2016.

28 Mohammad H. Golabi, M. J. Denney, and Clancy Iyekar, "Value of Composted Organic Wastes as an Alternative to Synthetic Fertilizers for Soil Quality Improvement and Increased Yield," *Compost Science & Utilization* 15, no. 4 (September 2007): 267271.
Teresa Hernández et al. "Use of compost as an alternative to conventional inorganic fertilizers in intensive lettuce (Lactuca sativa L.) crops—Effects on soil and plant," *Soil and Tillage Research* 160 (July 2016): 1422.
Rizwan Ahmad, Muhammad Naveed, Muhammad Aslam, Zahir A. Zahir, Muhammad Arshad, and Ghulam Jilani, "Economizing the use of nitrogen fertilizer in wheat production through enriched compost," *Renewable Agriculture and Food Systems* 23, no. 03 (September 2008): 243249.

Composter in an urban garden – ©City of Nantes

lead, copper and oil-based products in enriched soil.[29] Using compost alongside roads offers another environmental bonus by absorbing rainwater and reducing soil washout.[30]

Also, through urban agriculture, the use of compost offers a route to social acceptability for growing crops offground 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.[31] Urban agriculture raises public awareness of food production and organic waste management and recycling.[32] The benefits of composting extend beyond the boundaries of urban agriculture and also contribute to creating real circularity in the use of compost.

29 Wan Namkoong, Eui-Young Hwang, Joon-Seok Park, and Jung-Young Choi, "Bioremediation of diesel-contaminated soil with composting," *Environmental Pollution* 119, no. 1 (August 2002): 2331.
AM. Taiwo, A.M. Gbadebo, J.A. Oyedepo, Z.O. Ojekunle, O.M. Alo, A.A. Oyeniran, O.J. Onalaja, D. Ogunjimi, and O.T. Taiwo, "Bioremediation of industrially contaminated soil using compost and plant technology," *Journal of Hazardous Materials* 304 (March 2016): 166172.
Nadège Oustriere, Lilian Marchand, Gabriel Rosette, Wolfgang Friesl-Hanl, and Michel Mench, "Wood-derived-biochar combined with compost or iron grit for in situ stabilization of Cd, Pb, and Zn in a contaminated soil," *Environmental Science and Pollution Research* 24, no. 8 (March 2017): 74687481.

30 Noura Bakr, David C. Weindorf, Yuanda Zhu, Allen E. Arceneaux, and H.M. Selim, "Evaluation of compost/mulch as highway embankment erosion control in Louisiana at the plot-scale," *Journal of Hydrology* 468-469 (October 2012): 257267.
Karen Finney, Bahram Gharabaghi, Ed McBean, Ramesh Rudra, and Glenn MacMillan, "Compost Biofilters For Highway Stormwater Runoff Treatment," *Water Quality Research Journal* 45, no. 4 (November 2010): 391402.

31 Raymond Asomani-Boateng, "Closing the Loop: Community-Based Organic Solid Waste Recycling, Urban Gardening, and Land Use Planning in Ghana, West Africa," *Journal of Planning Education and Research* 27, no. 2 (December 2007): 132145.

32 Yuji Hara, Takashi Furutani, Akinobu Murakami, Armando M. Palijon, and Makoto Yokohari, "Current organic waste recycling and the potential for local recycling through urban agriculture in Metro Manila," *Waste Management & Research* 29, no. 11 (November 2011): 12131221.

OBSTACLES TO COMPOSTING

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.

POTENTIAL ENVIRONMENTAL AND HEALTH RISKS

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[33]. However, in recent years, the amount of kitchen and green waste processed in homes has been equivalent to the

33 Jeroen Douwes, Inge Wouters, Helianthe Dubbeld, Lukas van Zwieten, Peter Steerenberg, Gert Doekes, and Dick Heederik, "Upper airway inflammation assessed by nasal lavage in compost workers: A relation with bio-aerosol exposure," *American Journal of Industrial Medicine* 37, no. 5 (May 2000): 459468.
Martie Van Tongeren, Ludovic Van Amelsvoort, and Dick Heederik, "Exposure to Organic Dusts, Endotoxins, and Microorganisms in the Municipal Waste Industry," *International Journal of Occupational and Environmental Health* 3, no. 1 (January 1997): 3036.
O. Schlosser, A. Huyard, K. Cartnick, A. Yañez, V. Catalàn, and Z. Do Quang, "Bioaerosol in composting facilities: occupational health risk assessment," *Water Environment Research* 81, no. 9 (2009): 866877.

amount collected by public services.[34] 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.[35] There is therefore a disease risk when stirring, turning or collecting compost, or when adding dry material, for example.[36] Diseases may be transmitted by inhalation or ingestion of organic dust particles, or through the skin.[37] 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

34 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Impact sanitaire et environnemental du compostage domestique," op. cit.

35 Gwenaëlle Lashermes, Enrique Barriuso, and Sabine Houot, "Dissipation pathways of organic pollutants during the composting of organic wastes," *Chemosphere 87*, no. 2 (April 2012): 137143.
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Main environmental and health impacts of urban composting

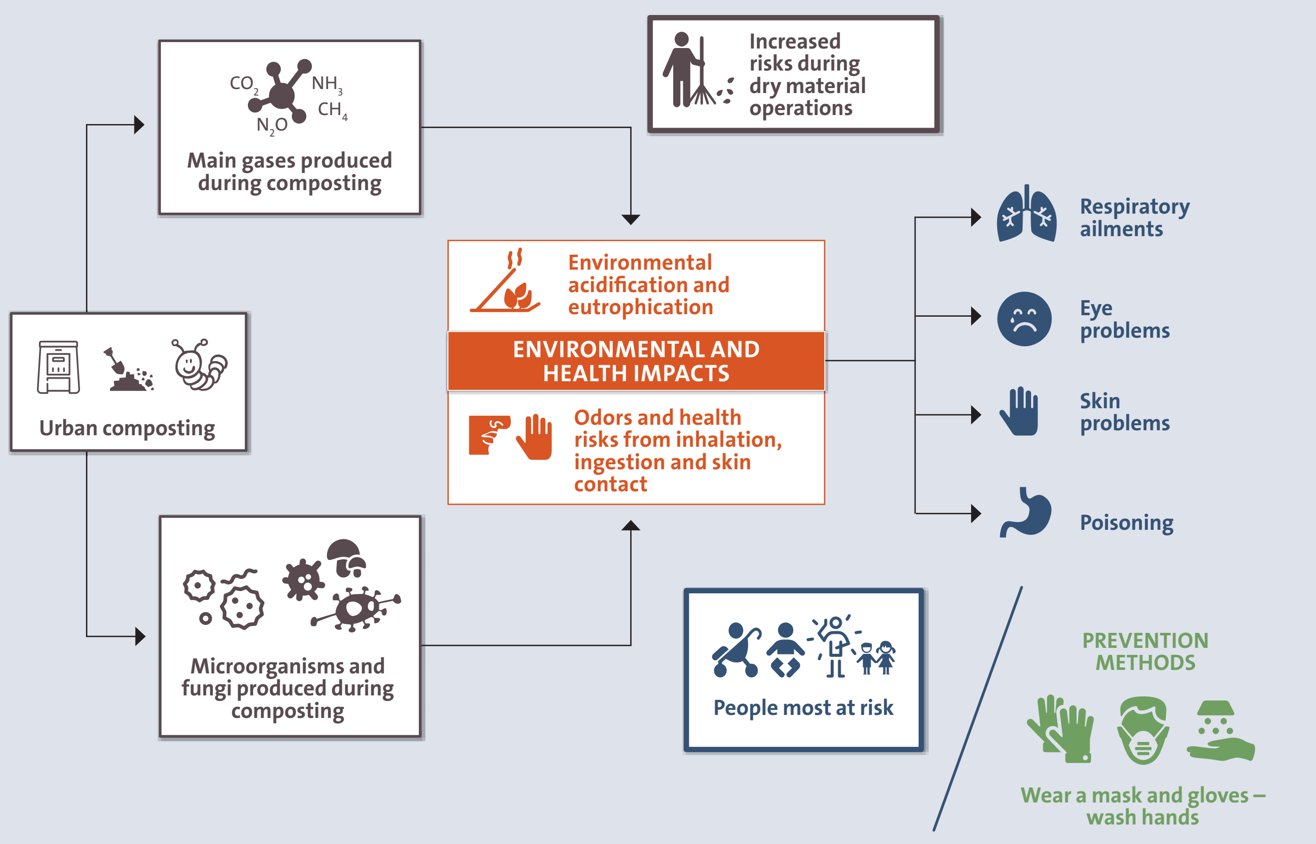

Figure 5

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 alveolitis[38]. 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.

38 Kari Reijula and Tapani Tuomi, "Mycotoxins of Aspergilli: exposure and health effects," *Frontiers in Bioscience* 8 (2003): s232s235.

39 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Impact sanitaire et environnemental du compostage domestique," op. cit.

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 production[40]. Observations of composting practice in different urban areas such as Bordeaux[41], Lyon[42] and Strasbourg[43] 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 another[45]. 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 day[47].

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41 Nicolas D'Andrea and Pascal Tozzi, "Jardins collectifs et écoquartiers bordelais : De l'espace cultivé à un habiter durable?" *Norois*, no. 231, September 30, 2014: 6174, doi:10.4000/norois.5087.

42 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel : les courts-circuits du compost," *Flux* 108, no. 2 (2017): 22.

43 Véronique Philippot and Sandrine Glatron, "Le compostage collectif urbain à l'épreuve de ses interdits: Enquête sur des sites strasbourgeois," *VertigO* 18, no. 2, September 5, 2018, doi:10.4000/vertigo.20743.

44 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel," *op. cit.*

45 Véronique Philippot and Sandrine Glatron, "Le compostage collectif urbain à l'épreuve de ses interdits," *op. cit.*

46 Pascal Tozzi, "Ville durable et marqueurs d'un 'néo-hygiénisme' ? Analyse des discours de projets d'écoquartiers français," *Norois*, no. 227, June 30, 2013: 97113.

47 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel," *op. cit.*

DICTIONARY OF COMPOSTING

Anaerobic digestion: another natural treatment method for organic waste. It produces gas that can be converted into energy (biogas) from the biological decomposition of organic matter in anaerobic (zero-oxygen) conditions. Anaerobic digestion mostly involves organic waste that is rich in water: wastewater treatment sludge, grease and matter from pumping out septic tanks and drains, and certain agricultural, agri-food industry and household waste.

Compost (or ripe compost): fertilizer obtained from composting.

Dry material: wood shavings or leaves used in waste composting to obtain an aerated compost.

Humus: the upper layer of soil formed, maintained and enriched by decaying organic matter.

Macroorganisms: living creatures that can be seen with the naked eye.

Microorganisms: microscopic living creatures such as bacteria, viruses and single-celled fungi (yeasts).

Wormery: plastic tanks containing layers of worms, which break down vegetable matter and peelings. It is the only viable composting solution in an apartment.

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.

48 Evelyne Boissonneault, *Sol, terre, compost : quels enjeux pour l'agriculture urbaine ?* Québec, Université du Québec à Montréal, 2017.
Sarah Taylor Lovell, "Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States," *Sustainability* 2, no. 8, August 4, 2010: 24992522.

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