Decentralized Community Composting

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In recent years, there has been a huge interest from local communities in decentralized composting. Decentralized community composting refers to a community-scale network in a specific neighborhood that diverts and composts biowaste in a controlled operative environment. In fact, the lack of centralized composting facilities in small towns or rural areas can be supported by decentralized solutions. Decentralizing waste treatment facilities and thus creating local solutions to urban waste management strategies will help to achieve the resource recovery and valorization targets in line with the circular economy.

biofertilizer | community composting | decentralized composting | municipal solid waste | recycling | organic waste management

1. General Overview

Considering the limitations of centralized waste treatment facilities originating from diverting food waste and increased costs for collecting and transporting waste in long distances, some of municipal composting programs may not be fully successful. In addition, high operational costs and operational complexity are other factors that should be taken into consideration for centralized systems [1][2][3]. At this point, alternative strategies must be identified and developed, such as decentralized collection and treatment. Decentralized composting, also known as community composting, refers to a community-scale network in a specific neighborhood that diverts and composts biowaste in a controlled operative environment [4]. The main advantages of decentralized composting over centralized systems are summarized in Table 1. In a broad perspective, decentralized composting can help to decrease the cost and effort for transportation of waste for processing and treatment, and further reduce the need to construct new disposal facilities, enable local reuse of organic matter, create local small-scale enterprises as well as reduce costs associated with commercial fertilizer purchase [4][5][6]. Furthermore, the final compost product is comparatively of higher quality due to efficient separation and less intercontamination of wastes [7][8]. Community composting is thus attracting some attention from policymakers, who consider this as a logical implementation [9]. However, some drawbacks are also faced during decentralized composting. The collection of organic waste in containers may result in an uncontrolled degradation of organic matter that leads to odor problems and leachate generation in the case of poor management [10]. Furthermore, logistic problems can lead to unsatisfactory implementations [4]. In this regard, new composting technologies should be well-addressed, and the information gathered from the operative environments should be thoroughly analyzed for a win-win situation for all stakeholders.

Table 1. Main advantages of decentralized composting over centralized composting [8][11].

Centralized	Decentralized
Transportation costs relatively high	Transportation costs relatively low
High operation and maintenance costs	Comparatively less maintenance costs
A high degree of specialized skills to operate and maintain	Low level skills required
Advanced technology with highly mechanized equipment	Simple technology with labor intense
Large facilities	Small facilities
Low quality of compost due to poor separation of wastes with high risk of contamination	High quality of compost since waste is efficiently separated and risks for contamination are minimized
Final product transported to farms or regional markets	Final product to fields or local markets as soil conditioner

2. Community Composting in the Operative Environment

When a decentralized composting system at the community-scale is demonstrated in a specific city or urban area, current and future proposed land use availability, and status of vacant land and community interest are initially considered within the regulatory frameworks. Once the location type and the individual site within each area are selected, the composting capacity is latter calculated within the city or specific region, based on the population size and waste generation trend [4]. The next step is then the decision on the composting technology. Community composting reactors can be different, in other words, "simpler", than centralized composters. Plastic bins in any shapes (i.e., rectangular, cylindrical, conical) are often used for community composting reactors [8][12]. Plastic drum reactors were also recently reported [13]. These reactors can be operated in batch, semi-continuous or continuous mode, based on the sustainability of the wastes. The reactor capacity is usually between 100–1000 L [12][13]. In most cases, holes are constructed at the bottom or on the periphery for aeration and turning/mixing is applied manually. Some examples of decentralized composting practices in Europe are presented in Table 2. The biggest drawbacks of these bin-type reactors is the uncontrolled emission of GHGs, such as methane, ammonia or nitrous oxide [14][15], non-homogenous matrix of the final compost product due to inadequate mixing [16]; odor and leachate [10]. For instance, gas emissions (i.e., (CH_4, N_2O, NH_3 and volatile organic compounds (VOCs)) of a bin-type composter were calculated in the range of 30–148 kg CO_2 eq/Mg leftovers of raw fruits and vegetables [17].

Table 2. Characteristics of selected decentralized composting systems in Europe.

Site	Population	Demographic Characteristics	Waste Origins	Bulking Agent	Reactor Type/Model	Waste/Reactor Volume	Leachate/Gas Collection	Aeration	Mixing	Operation Mode	Composting Duration	Reference
Allariz (Spain)	5982 inhabitants, density of 70 inhabitants/km^2	Residential area with shops and an industrial estate	Yard waste and kitchen waste	Shredded wood	Modular composter made of recycled plastic slat	1000 L	-	-	-	Continuous	-	[12]
Ballymun (Dublin-Ireland)	89 apartments	Apartment complex	Household kitchen waste	Wood pellet	In vessel technology (Big Hanna T-120)	26 t/y	Biofilter to treat exhaust gases from the Big Hanna	-	-	Continuous	-	[18]
Dublin (Ireland)	-	Residential area	Organic waste, primarily catering waste	-	In vessel technology (Big Hanna T-120)	2 m^3	Biofilter	Rotating cylinder	Rotating cylinder	Continuous	-	[19]
Lithuania	-	Catering company	Catering, biodegradable waste	-	Batch reactor (Oklin GG 10s composting machine)	10 t/y	Activated carbon filter	Forced ventilation system	-	Batch	24 h inside the machine plus maturation time outside	[20]
Barcelona (Spain)	-	Universitat Autònoma de Barcelona	Leftovers of raw fruit and vegetable and pruning wastes	-	Bin-type composter Model 400 RRR Compostadores SL	0.5 m^3	-	Holes on the periphery	Mixing tool: Compostadores SL. Shredding tool: electric garden chipper (BOSCH AXT 2500 HP)	Continuous	12 weeks	[21]

Considering the negative impacts of conventional composting reactors on the environment, new generation composting reactors are therefore highly promising. The greatest advantages of these reactors are: pre-treatment units, biofilters, automatic mixing, leachate collection reservoirs and aeration modules. For instance, a community-scale novel drum bioreactor was reported to be a promising system for efficient pre-treatment of organic household wastes [10]. Noteworthy to mention is that the composting process can last between nine and eleven weeks if mechanical mixing is applied, and up to fifty weeks under static conditions. Currently promoted electromechanical reactors can be generally divided in two main categories: systems with only one chamber and systems with a double chamber. In the first case, the composter constitutes a rotating cylinder without any mechanical tool inside, the waste is introduced, and the rotation allows mixing, aeration and advancement of the material up to the exit point [19]. The two chamber machines work in a different way, and these systems are usually equipped with a shredder and a mechanical mixing tool in both of the chambers; waste is introduced in the first chamber where it is continuously mixed, and when the chamber is full, the second starts to be filled, while the first is closed in order to complete the composting process.

3. Socioeconomic Perception

In most agri-environmental programs, the lack of participation of interested stakeholders in designing frameworks, the poor information basis to support policy formulation and the failure to consider local specificities in the scheme design are reported to be the main reasons for low success achievements [22]. In a recent survey [23], the farmers' perception of compost production was found to be 83.9%, in which the participants showed also a high, yet lower, willingness level (63.6%) of the more salient option to produce compost themselves and use it in agriculture. In another survey, 67% of respondents indicated that they are interested or very interested in community composting systems [24]. Without a doubt, public acceptance and encouragement are the key factors for a successful decentralized composting implementation. As the actual processing volume is dependent on the participation of residents in a community, low participation rates can be a major challenge in such cases [4]. By community composting, local resources community participation can be established [25] and people may be more motivated to reduce their food waste when they see it separated out from the rest of their waste [24]. In a common sense, decentralized composting systems should be inexpensive, require low maintenance and easy handling [13]. Identifying a suitable location in a city/region is critical and logistical characteristics such as the distance from waste sources, need/use of compost, demographic characteristics, and environmental characteristics such as drainage, potential or existing environmental conditions, should be all considered during the identification. A lack of technical support in operating and building community composting facilities has also been a critical challenge in maintaining decentralized composting systems [4]. Hence, training and navigating the community within the specific region is crucial.

References

1. Sakarika, M.; Spiller, M.; Baetens, R.; Donies, G.; Vanderstuyf, J.; Vinck, K.; Vrancken, K.C.; Van Barel, G.; Du Bois, E.; Vlaeminck, S.E; et al. Proof of concept of high-rate decentralized pre-composting of kitchen waste: Optimizing design and operation of a novel drum reactor. *Waste Manag.* **2019**, *91*, 20–32.
2. Vasiliki Panaretou; Stergios Vakalis; Aggeliki Ntolka; Aggelos Sotiropoulos; Konstantinos Moustakas; Dimitris Malamis; Maria Loizidou; Assessing the alteration of physicochemical characteristics in composted organic waste in a prototype decentralized composting facility. *Environmental Science and Pollution Research* **2019**, *26*, 20232-20247, 10.1007/s11356-019-05307-7.
3. Jeltsje De Kraker; Katarzyna Kujawa-Roeleveld; M. Villena; Claudia Pabon; Decentralized Valorization of Residual Flows as an Alternative to the Traditional Urban Waste Management System: The Case of Peñalolén in Santiago de Chile. *Sustainability* **2019**, *11*, 6206, 10.3390/su11226206.
4. Shantanu Pai; Ning Ai; Junjun Zheng; Decentralized community composting feasibility analysis for residential food waste: A Chicago case study. *Sustainable Cities and Society* **2019**, *50*, 101683, 10.1016/j.scs.2019.101683.
5. Joan Colón; Erasmo Cadena; Ana Belen Colazo; Roberto Quirós; Antoni Sánchez; Xavier Font; Adriana Artola; Toward the implementation of new regional biowaste management plans: Environmental assessment of different waste management scenarios in Catalonia. *Resources, Conservation and Recycling* **2015**, *95*, 143-155, 10.1016/j.resconrec.2014.12.012.
6. Juan Pablo Arrigoni; Gabriela Paladino; Lucas A. Garibaldi; Francisca Laos; Inside the small-scale composting of kitchen and garden wastes: Thermal performance and stratification effect in vertical compost bins. *Waste Management* **2018**, *76*, 284-293, 10.1016/j.wasman.2018.03.010.

7. Chuanbin Zhou; Rusong Wang; Yishan Zhang; Fertilizer efficiency and environmental risk of irrigating Impatiens with composting leachate in decentralized solid waste management. *Waste Management* **2010**, *30*, 1000-1005, 10.1016/j.wasman.2010.02.010.
8. Mebrahtom Negash Araya; A Review of Effective Waste Management from an EU, National, and Local Perspective and Its Influence: The Management of Biowaste and Anaerobic Digestion of Municipal Solid Waste. *Journal of Environmental Protection* **2018**, *9*, 652-670, 10.4236/jep.2018.96041.
9. Slater, R.; Aiken, M; Can't you count? Public service delivery and standardized measurement challenges—The case of community composting. *Public Manag. Rev.* **2015**, *17*, 1085–1102, 10.1353/aph.0.0214.
10. Sakarika, M.; Spiller, M.; Baetens, R.; Donies, G.; Vanderstuyf, J.; Vinck, K.; Vrancken, K.C.; Van Barel, G.; Du Bois, E.; Vlaeminck, S.E. Proof of concept of high-rate decentralized pre-composting of kitchen waste: Optimizing design and operation of a novel drum reactor. Waste Manag. 2019, 91, 20–32.
11. Öberg, H. A GIS-Based Study of Sites for Decentralized Composting and Waste Sorting Stations in Kumasi, Ghana. Master's Thesis, Uppsala University, Uppsala, Sweden, 2011.
12. Comesaña, I.V.; Alves, D.; Mato, S.; Romero, X.M.; Varela, B. Decentralized composting of organic waste in a European rural region: A case study in Allariz (Galicia, Spain). In Solid Waste Management in Rural Areas; InTechOpen: London, UK, 2017.
13. M.K. Manu; Rakesh Kumar; A. Garg; Decentralized composting of household wet biodegradable waste in plastic drums: Effect of waste turning, microbial inoculum and bulking agent on product quality. *Journal of Cleaner Production* **2019**, *226*, 233-241, 10.1016/j.jclepro.2019.03.350.
14. Joan Colón; Erasmo Cadena; Michele Pognani; Raquel Barrena; Antoni Sánchez; Xavier Font; Adriana Artola; Determination of the energy and environmental burdens associated with the biological treatment of source-separated Municipal Solid Wastes. *Energy & Environmental Science* **2012**, *5*, 5731-5741, 10.1039/c2ee01085b.
15. Bijaya K. Adhikari; Anne Tremier; Suzelle Barrington; Jose Martinez; Mylène Daumoin; Gas emissions as influenced by home composting system configuration. *Journal of Environmental Management* **2013**, *116*, 163-171, 10.1016/j.jenvman.2012.12.008.
16. Julia Martínez-Blanco; Joan Colón; Xavier Gabarrell; Xavier Font; Antoni Sánchez; Adriana Artola; Joan Rieradevall; The use of life cycle assessment for the comparison of biowaste composting at home and full scale. *Waste Management* **2010**, *30*, 983-994, 10.1016/j.wasman.2010.02.023.
17. Colón, J.; Martínez-Blanco, J.; Gabarrell, X.; Artola, A.; Sánchez, A.; Rieradevall, J.; Font, X; Environmental assessment of home composting. *Resour. Conserv. Recycl.* **2010**, *54*, 893–904.

18. Miller, S.; Wilson, A.; Warburton, R. Implementation of an Urban Community Composting Programme; STRIVE Report: Wexford, Ireland, 2013.
19. O'Sullivan, M.; Curran, T. Biofilter performance in small scale aerobic composting. Biosyst. Eng. Res. Rev. 2011, 16, 153–156.
20. Irina Kliopova; Jurgis Kazimieras Staniškis; Edgaras Stunžėnas; Elina Jurovickaja; Bio-nutrient recycling with a novel integrated biodegradable waste management system for catering companies. *Journal of Cleaner Production* **2019**, *209*, 116-125, 10.1016/j.jclepro.2018.10.185.
21. Roberto Quirós; Gara Villalba; Pere Muñoz; Joan Colón; Xavier Font; Xavier Gabarrell; Environmental assessment of two home composts with high and low gaseous emissions of the composting process. *Resources, Conservation and Recycling* **2014**, *90*, 9-20, 10.1016/j.resconrec.2014.05.008.
22. Stefano Fabiani; Silvia Vanino; Rosario Napoli; Pasquale Nino; Water energy food nexus approach for sustainability assessment at farm level: An experience from an intensive agricultural area in central Italy. *Environmental Science & Policy* **2020**, *104*, 1-12, 10.1016/j.envsci.2019.10.008.
23. Al-Madbouh, S.; Al-Khatib, I.A.; Al-Sari, M.I.; Salahat, J.I.; Jararaa, B.Y.A.; Ribbe, L. Socioeconomic, agricultural, and individual factors influencing farmers' perceptions and willingness of compost production and use: An evidence from Wadi al-Far'a Watershed-Palestine. Environ. Monit. Assess. 2019, 191.
24. Mcneill, B. The Viability of Community Composting at the Melbourne Food Hub; Independent Study Project (ISP) Collection; SIT Study Abroad: Nairobi, Kenya, 2018; Volume 2957.
25. Sudhakar Yedla; Replication of urban innovations - prioritization of strategies for the replication of Dhaka's community-based decentralized composting model. *Waste Management & Research* **2012**, *30*, 20-31, 10.1177/0734242x10380116.