Source separation and on-site management of municipal biowaste in a prototype composting unit: the case study of Tinos island, Greece

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Abstract

The necessity to comply with the European legal framework has reinforced the need for sustainability in the field of municipal waste management. During the last decades efforts have been focused on the development of systems that promote the waste hierarchy in management methods, highlight the responsibility of the various involved parties and especially, incentivize public participation. In particular, separating waste at source at the time of their generation, apart from making waste generation visible, also represents a key driver on the way of sustainable practices and towards implementing zero waste approaches. From an in an economic, environmental and social point of view and taking into consideration the fact that the fraction of biowaste could amount up to half of the total municipal solid waste generated (Hoornweg & Bhada-Tata, 2012), the benefit of diverting the specific waste fraction from landfills, is evident (USEPA, 2014). Biowaste as a resource has been acknowledged as key element of the future EU policy, moving towards a circular economy and holds great potential for the production of alternative added-value products, if treated in a safe manner.

The need for sustainable and efficient treatment of biowaste takes more serious dimensions in the case of island regions since these territories possess some 'weaknesses' directly related to their geographical specificities. The demands here become more pressing due to limited natural resources, restricted access to key infrastructures and services, high transportation costs, low population density, seasonal variations of waste flows due to tourism, limited land availability, non-favourable economies of scale and fragility of the environmental ecosystems. Common current practices observed in the majority of rural areas, including islands, is that biowaste are still landfilled or burned on-site, resulting in major odour nuisances, visual impact, human health and environmental hazards (Manios, 2004). The absence of appropriate infrastructure, the limited recycling initiatives, the lack of environmental public awareness and the fact that involved management costs usually exceed available funds pose a significant problem on local authorities who are primarily responsible for waste management. Scarcity on data collection and inconsistent information on biowaste quantities and composition is another critical issue as data availability is considered of major importance for establishing any environmental policy and sound waste management plans.

To this direction, the present paper acquaints with the implementation of an integrated solid waste management scheme for municipal biowaste, taking into consideration the principle requirements and waste hierarchy priorities set in the EU legislation (Landfill Directive 99/31/EC and Waste Framework Directive 2008/98/EC). Therefore, the pilot scheme which was applied in Pyrgos and Panormos, comprising two communities of Tinos island (i.e. 400 inhabitants approximately), was based on source separation and on-site management in a prototype composting unit, with the aim of turning biowaste back into valuable product (compost), as well as contributing to the overall sustainable local development of the area. A bring scheme collection system was employed, including 30 biowaste collection points' network, located in the periphery of the communities. The pilot scheme foresees that the participating population should separate their biowaste at source (i.e. household, shop, restaurant, public building etc.) using specific indoor equipment (i.e. kitchen caddies and biodegradable starch-based bags) and subsequently dispose them to corresponding outdoor wheelie bins of greater capacity (120 L). Collection and transport of biowaste is performed by a satellite vehicle, which operates at regulated frequency in order to transfer the pre-sorted organics to an innovative, prototype, composting unit. The prototype composting unit was constructed and installed within the study area, in order to reduce transportation costs, be manageable, compact and low cost in comparison with similar commercial systems, minimize contamination risk of pre-sorted biowaste and thus produce high quality compost. The innovative design and operational features of

the prototype composting unit include the following: the feeding compartment acquires an appropriate lifting mechanism in order to facilitate the loading and unloading of the source sorted biowaste within the bioreactor (total volume of 21 m^3). The composting process follows four successive stages in a continuous mode, with a retention time of the substrate of 20-60 days (min. 20 days if the maturing phase takes place outside the bioreactor). Moreover, the prototype unit has three innovative automated operations. The aeration system is ensured by a blower attached to a piping system which runs along the bioreactor at appropriate positions, providing the necessary air supply to the organic mass. The hydration system consists of three branches of plastic water pipes with regulating flow for each stage of the composting process through an electromechanically operated valve. The deodorization system includes a system for the suction of flue gases from the interior of the bioreactor to the biofilter, so as to avoid possible nuisances during the operation of the unit. The monitoring of the integrated biowaste management scheme was performed in three levels. Firstly, the biowaste fraction of the study area was examined by employing biowaste generation quantities and compositional analysis studies in order to evaluate the effectiveness of the source separation (<1.5% impurities ratio), record seasonal variations and determine the biowaste physicochemical characteristics, considering basic parameters such as pH, conductivity, moisture content, bulk density, C/N ratio, organic matter, heavy metals and nutrients content.. The study was oriented in this direction since the determination of the organic feedstock characteristics for the in-vessel prototype unit can provide valuable information on the evolution of the composting process and the quality of the final product (compost) as well. Secondly, the composting process was monitored and evaluated using specific parameters such as temperature, aeration, moisture content, organic matter, pH and EC evolution. For this reason, samples were examined from each stage of the composting process, during the implementation phase of the pilot biowaste management scheme. Finally, the physicochemical characteristics of the final product (compost) were determined, as well as the hygienic (*Salmonella sp.* & *E.*coli) and biological parameters (i.e. phytotoxicity – plant response, content of germinable seeds and plant propagules), as set in the End-of-Waste criteria for biodegradable waste subjected to biological treatment (compost & digestate). Regarding the conclusions and future work recommendations of the present study, the following could be highlighted:

- Source separation is of significant importance, especially for the sensitive MSW fraction of biowaste, since separately collected organics exhibit high purity levels so as to facilitate any further treatment and thus the products received (compost) have better quality and greater value.
- The recorded low impurities content (~2-3%) demonstrate that the participating households practice effectively the source separation of the generated biowaste.
- The physico-chemical and biological characteristics of the final product satisfied the limits set by EoW 2014 for biodegradable waste subjected to biological treatment (compost & digestate):

- No pathogens
- Low heavy metals content in comparison with compost produced from mixed waste collection

- The prototype composting unit can receive greater quantities of biowaste so as to operate at its maximum capacity and accomplish the full optimization of the composting process. This can be achieved by incorporating additional communities in the separate biowaste collection scheme.

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