Low cost composting options: the case-study of the Municipalities of Argos–Mycenae and Nafplio, Greece

This paper provides information on a low cost composting system within a decentralised solid waste management plant, with the prospect of the wider transferability of such schemes in other similar regions or developing countries.

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Abstract

Currently, incorporating composting in waste management strategies is stipulated by legislation and environmental standards and can be accomplished through several systems, ranging from small to large scale. This article presents the design of a low cost composting system, designed as integral part of the municipal solid waste management plant of two Municipalities in Peloponnese, Greece, the municipalities of Argos-Mycenae and Nafplio. The composting system consists of covered windrows with mechanical turning and can treat approximately 13,800 tons per year, producing about 7,400 tons of finished (refined) compost on an annual base. The operation of the decentralised MSW management plant in these two municipalities is anticipated to replace the current uncontrolled land disposal sites, enhance the environmental protection and prepare the ground for the acceptance and operation of a large-scale centralised Mechanical-Biological Treatment (MBT) plant. The transferability of this system in developing countries or regions facing similar waste generation and management issues is considered high and economically feasible.

Introduction

The European Commission has encompassed the concepts of sustainable waste management and developed its waste policy based on the idea of the waste hierarchy, which ranks waste management options in terms of their environmental impact. According to the revised Waste Framework Directive (2008/98/EC), waste prevention is placed at the top of the ladder as the most favourable option, followed by (in descending order) preparing for reuse, recycling (including composting), energy/material recovery and disposal in properly engineered landfills.

Sustainable solid waste management has moved to the forefront of the environmental agenda, advocating a change of policy, "triggering attitudes and methods that conserve natural resources and reduce the environmental impact of anthropogenic pollutants" (Lasaridi et al., 2014). Sustainable waste management presuppose the equal consideration of economic, social and environmental parameters (McDougall et al., 2001). Lately, the concept of integrated solid waste management (ISWM) is promoted. The United Nations Environmental Programme (UNEP) defines ISWM as "the strategic approach to sustainable management of solid wastes covering all sources and all aspects, generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency". Under the lens of ISWM, organic waste is increasingly considered as a

Technical data:

- The municipal solid waste plant is designed to treat 33,600 tons per year (approximately1 08tn/d), corresponding to a population of 77,400 inhabitants.
- The composting system is designed to receive 13,800 tons per year.
- Estimated compost produced after refinement: 7,400 tons per year.
- The composting process develops in two stages: the first one is taking place in windrows with mechanical turning and covers (1,500 m^2), and the second, maturation stage in open static windrows (500 m^2).

“recyclable” material and a useful resource (Tontti et al., 2011), bringing out organic waste treatment as one of the key tasks of current waste management. On that ground, composting systems, could play an important role in the diversion of biowaste from landfills (Seng et al., 2013), which accounts for approximately 30-50% of the total municipal solid waste (MSW) quantity, depending on the country. The inclusion of composting in the ISWM can be accomplished through several practices, including small, medium and large scale.

Since 2000, waste policies and legislation regarding municipal waste management in Greece have been going through drastic changes. As a Member State of the European Union (EU), Greece had to adjust its legislative framework to comply with the EU legislation. For instance, the European Landfill Directive 31/1999 promotes the gradual diversion of biodegradable waste from landfilling, allowing by 16 July 2016 the landfilling of 35% of the total quantity that was landfilled in 1995. However, for most waste streams, shifts in management, practices in Greece were implemented at a quite slow pace (Lasaridi, 2009). In order to counteract with this delay and catch up with the diversion from landfilling targets set by the EU legislation, the development of small, decentralised municipal solid waste (MSW) management plants was promoted. In many cases, the decentralised MSW plants include composting facilities, which can be constructed and operate in low cost and in short time. The decentralised plants, if properly operated, could prepare the ground for the acceptance of larger plants and be used complementary to them.

This paper presents the design and the development of a low cost composting system within a temporary decentralised MSW management plant, in two municipalities of Peloponnese (Greece). Since the plant can be adapted to suit various socio-economical conditions, the ultimate goal of this article is the wider transferability of such schemes in both developed and developing countries.

Composting as an alternative option

In the last three decades, composting has become increasingly popular, as countries move steadily away from landfilling. Both legislation and environmental standards stipulated “the development of a new generation of composting facilities throughout Europe” (Slater & Frederickson, 2001). A similar distinct trend is also shaped in USA and Asia.

In the European Union it is estimated that the organic material recovery has grown with an average annual rate of 5.3% from 1995 to 2014 (EUROSTAT, 2016). In USA it is estimated that around 254 million tonnes of MSW were generated in 2013, of which approximately 22 million tonnes were recovered through composting (US EPA, 2015).

In late ‘90s, in China approximately 20% of the MSW were treated through composting (Wei et al., 2000). Wei et al. (2000) report that Chinese MSW treatments plants favour the implementation of composting because of three reasons: 1) The MSW stream is unsuitable for incineration due to its composition; 2) The cost of composting is lower than the cost of incineration and landfilling; and 3) Composting and compost use in agriculture are part of tradition.

The inclusion of composting in the waste management systems deems as a necessity in the case of developing countries, where the biodegradable waste accounts for a large part of municipal solid waste. Many research and modelling studies have shown that composting as an alternative to the “traditional” disposal options for organic waste (i.e. landfilling and incineration), could be beneficial for developing countries in terms of organic material recovery, for prolonging the lifespan of the existing landfills, for improving sanitary conditions, and for the mitigation of the greenhouse gases (GHG) emissions (Papargyropoulou et al., 2015, Seng et al., 2013, Zurbrügg et al., 2005, Mendes et al., 2003).

The benefits of composting

Composting transforms, through an aerobic microbial process, raw organic matter into a stable product, the compost. It transforms drastically the various organic substances, mineralising the simpler and easily assimilable and humifying the more complex compounds. In this sense, composting fulfils, the objectives of a closed biological system, promoting the consideration of organic waste as a resource. The potential advantages of a composting system regard the reduction of the waste volume, the reduction of GHG emissions, and the many different uses of composts.

More specifically, as composting evolves, the volume of the composting substrate might decrease up to 50-60%. Therefore, it can be used to reduce the landfilled waste volume, prolonging the lifespan of existing landfills and reducing the need for more space (Slater & Frederickson, 2001, Tchobanoglous et al., 1993). Incorporating composting into a waste management plant, the GHG emissions (from the plant) decrease (Boldrin et al., 2009; Amlinger et al., 2008; Lou & Nair, 2009). Regarding organic material recovery, compost can be mainly used as a soil amendment (depending on its chemical composition, it may also be used as an organic fertilizer), and as a component of growing media in nursery crop sector (Lakhdar et al., 2009; Diaz et al., 2002).

The case-study of Argos – Mycenae and Nafplio municipalities

The Municipalities of Argos-Mycenae and Nafplio are located in the Central and Eastern part of Peloponnese (Greece), with a population of 42,022 and 33,356 inhabitants, respectively, in 2015. The municipal solid waste generation in the Municipality of Argos-Mycenae is 18,712 tons per year, while in the Municipality of Nafplio 14,854 tons per year. The development of a temporary decentralised MSW management plant in these two municipalities is anticipated to replace the current uncontrolled land disposal sites or waste dumps and consequently, enhance the environmental protection, improve the living standards, and prepare the ground for the large-scale centralised MSW plant, which is planned to be constructed in the region of Peloponnese in near future. Harokopio University assisted the two municipalities during the development of their waste management plan and provided guidance regarding the design of the temporary decentralised MSW management plant, including the composting system.

The waste management plant

The temporary MSW management plant is designed to treat 33,566 tons per year (approximately 108 tons per day). It will be constructed in "Grimaria" (Municipality of Argos-Mycenae), covering an area of 6,302 m^2 (Figure 1). The plant will comprise two main units, namely the packaging waste separation unit, and the composting facilities.

The technical requirements for the design of the MSW management plant are presented in Table 1, while the mass balance flowchart of the typical installation is illustrated in Figure 2. The operation of the decentralized MSW management plant is anticipated to provide the following benefits to the municipalities:

- A significant amount of packaging and organic waste will be diverted from landfilling
- CH_4 emissions and leachates in the sanitary landfills will be mitigated
- Hazardous/toxic substances in the composition of waste will be eliminated
- The decentralised plant will cost less and provide better working environment than a centralised one
- It will prepare the public to accept the construction and operation of a large-scale plant within the administrational boundaries of Peloponnese Region.

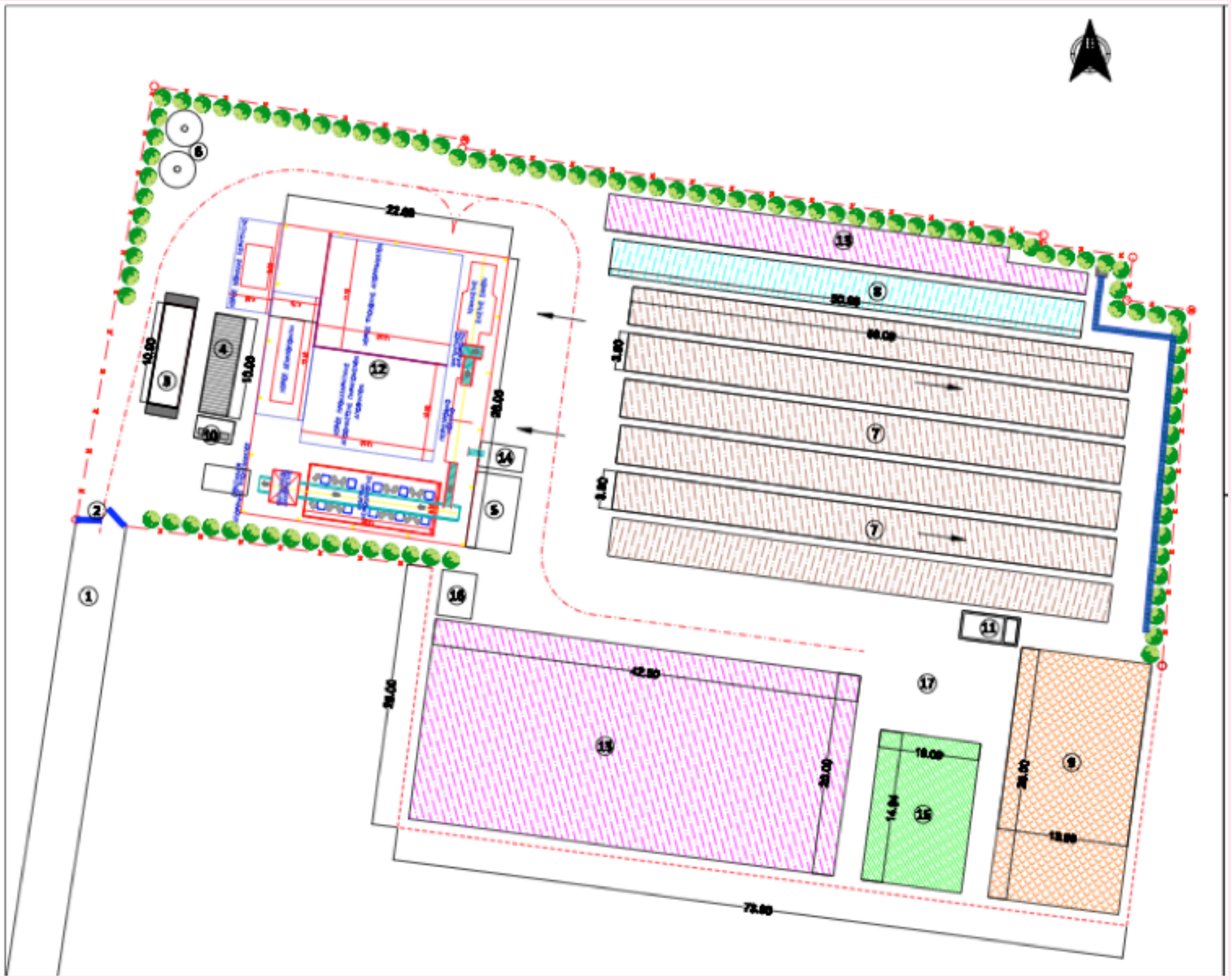

Figure 1. Schematic illustration of the decentralised MSW management plant in the Municipalities of Argos – Mycenae and Nafplio

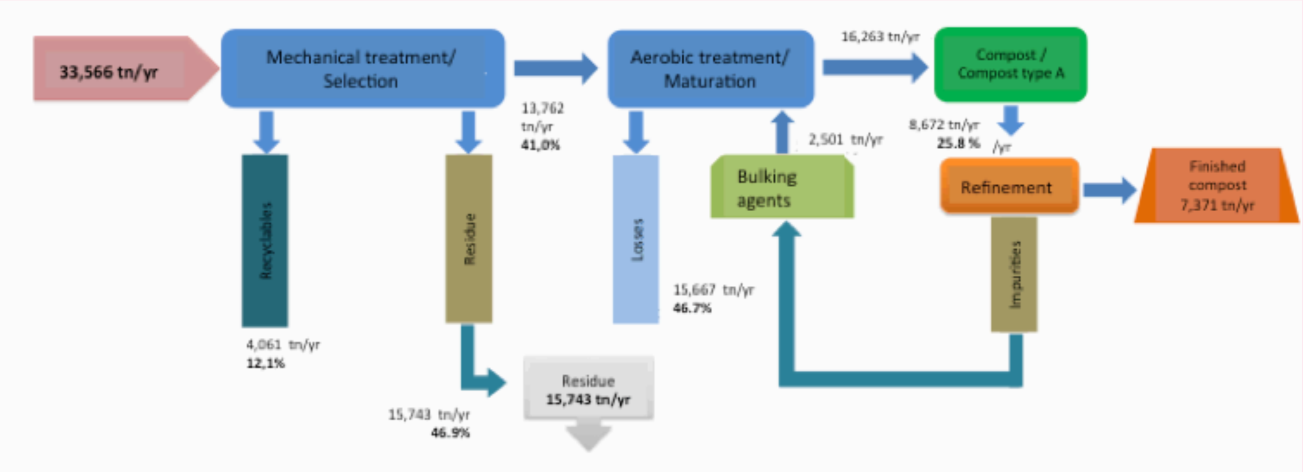

Figure 2. Mass balance of the decentralised MSW management plant in the Municipalities of Argos –Mycenae and Nafplio.

Table 1. Technical requirements for the design of the composting system

Parameter	Set value
Operation time	365 days per year - 15 hours per day
Waste input	108 tons per day – 7.2 tons per hour

The composting system

The development of the composting system was based on the following criteria (of equal significance):

- The cost of the construction and operation has to be low
- Low-expertise personnel has to be required
- The construction and operation has to be in compliance with the National and EU legislation
- The system has to be environmentally sustainable.

Taking under consideration the abovementioned criteria and the technical requirements of the MSW management plant, the composting system is designed to comprise feedstock and preliminary operations facilities (where grinding and mixing are taking place), the composting process facilities (six open windrows with mechanical turning and covers), the maturation phase facilities (static windrows), the refinement facilities, and the facilities for leachates treatment. In the following, the various components will be described in more detail.

Feedstock and preliminary operations facilities

These facilities include the entrance of the feedstock and preliminary operations, such as grinding and mixing. The surface will be properly configured for the avoidance of contamination of the groundwater and soil.

The composting process facilities

Open truncated triangular windrows with a height-to-width ratio of approximately ½ and with mechanical turning, will be installed in an area of 1,500 m^2. The technical and performance parameters of the composting process is shown in Table 2. These windrows will serve the first phase of the composting process, which typically lasts 20-28 days. The configuration of these windrows provides higher degree of homogeneity in comparison to the forced aerated windrows and higher hygienization degree.

The maturation phase facilities

The maturation process (2nd composting phase) will be taking place through the configuration of static windrows in an area of 500 m^2. The technical and performance parameters of the maturation phase is shown in Table 2.

The refinement facilities

These enclosed facilities will include all the refinement operations, such as screening, impurities cleaning and storage in piles.

The facilities for leachates

Floors in all facilities will be configured in order to 'lead" leachates in a storage tank. The leachates will be used in the windrows in order to achieve the proper moisture content of the composting substrate.

Conclusions

A wide range of implemented projects and a multitude of scientific studies demonstrate that composting - granted that it is properly managed and evolved - can provide an effective solution to the organic waste management issue. The apprehension and exploitation of the environmental benefits of composting and compost use create a solid ground for the development of more sufficient and sustainable waste management schemes as well as the rational use of resources. Full scale composting processes comprises within centralised and decentralised municipal

Table 2. Parameters for the configuration of the windrows

Parameter	**1st phase**	**2nd phase**
WINDROWS		
Width	3.6-3.8 m	4 m
Height	1.8-2.0 m	2.2 m
Length	50-55 m	50 m
Volume	254-298 m^3	346 m^3
Number of windrows	5-7	2
COMPOSTING MIXTURE		
Daily waste input	65.5-68.6 m^3/day	30.5 m^3/day
Windrow installation	3.9-4.4 days	11.3 days
Composting time	20-28 days	28 days
Volume reduction	35%	18%

solid waste management plants one of the most effective ways to recycle organic waste and promote the circular economy in both developed and developing countries.

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