Reuse of treated wastewater in remote Greek islands for landscape irrigation

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Water demand in the Aegean islands has been rapidly increasing in recent years, mainly as a result of tourism development and the need for greater water quantities to cover demand by new hotels and resorts (Gikas & Tchopanoglous, 2009). The majority of the islands face serious water scarcity problems due to their geomorphological conditions, variations in precipitation levels and seasonality of water demand. The water needs of Greek islands are covered either by groundwater, which however is rapidly becoming depleted, and through seawater desalination processes, which have high energy and cost requirements (Stathatou et al., 2015). If the water needs cannot be met using groundwater extraction and/or seawater desalination, then freshwater is imported from the mainland.

A sustainable and environmentally friendly solution for coping with water scarcity and demand could be the reuse of treated wastewater (Lazarova et al., 2001). Municipal wastewater can be further treated in wastewater treatment plants (WWTPs) achieving high quality standards allowing it to be reused instead of discharged into surface water bodies. The use of reclaimed water could be a vital solution for water resources increase, in water scarce and isolated regions (Stathatou et al., 2015).

Wastewater reclamation and reuse can supply the islands with water for a number of applications depending on the WWTP effluent quality (Gikas & Tchopanoglous, 2008). Nevertheless, in Greece, reuse of treated wastewater is not a common practice, given that the national legal framework for wastewater reuse (Joint Ministerial Decree 145116/2011) was developed very recently, in 2011. Based on the Greek reuse legislation, the quality standards for treated wastewater for landscape irrigation are not very high and can be met without excessive treatment. Reuse for landscape irrigation also offers the most potential as it reduces the use of potable quality water for these applications, a practice incongruous with the principles of sustainability.

In the Cyclades complex of the Aegean archipelago, the WWTPs of Antiparos and Thirasia islands, (Figure 1) achieve effluent quality suitable for landscape irrigation. Antiparos Island has an area of 35.1 km^2 with a total permanent population of 1,211 inhabitants (census 2011), while about 1,000 seasonal residents and tourists (census 2012) visit the island during summer (Tsoukleris et al., 2018). Until recently, the island faced serious water management issues, due to lack of infrastructure and its isolated location, as there was no sewage network or wastewater treatment facility, causing significant problems to the local economy and natural environment (Stathatou et al., 2018). The WWTP of Antiparos was constructed in 2015, for the treatment of municipal wastewater and its reuse for landscape irrigation, with a mean daily design capacity (for the year 2035) of 240 m^3/day during winter (1,500 p.e.) and 480 m^3/day during summer (3,000 p.e.). The WWTP involves natural treatment processes (i.e. constructed wetland & maturation pond) for secondary treatment combined with engineered processes (e.g. Imhoff tanks & chlorination) for pre- and post-treatment, in order for the reclaimed water to meet the quality standards for irrigation of public spaces in the proximity of the WWTP (Egnatia Odos, 2012).

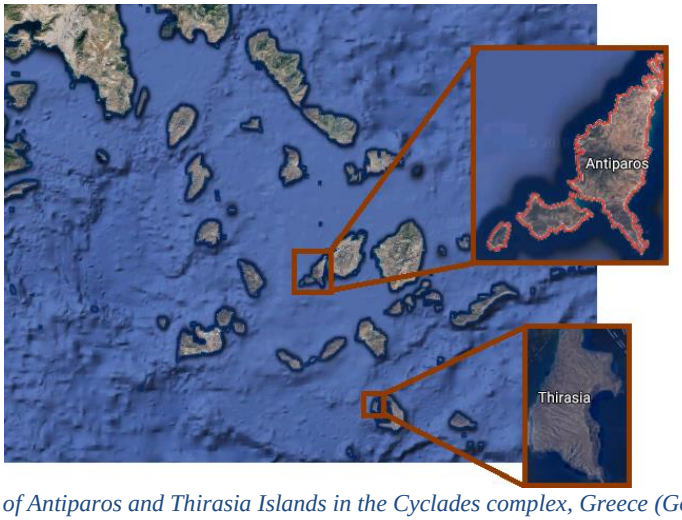

Figure 1. Location of Antiparos and Thirasia Islands in the Cyclades complex, Greece (Google Earth, 2019)

Thirasia Island belongs to the volcanic island group of Santorini and has an area of 9.3 km^2 with permanent population of 319 inhabitants (census 2011), which increases significantly during the summer period (about 1,350 seasonal residents and tourists in 2013). The lack of a properly designed wastewater treatment system caused significant problems in the island as the largest amount of the generated municipal wastewater flowed freely in the area causing pollution outbreaks. In 2016, an innovative wastewater treatment plant was constructed with a maximum daily treatment capacity (for the year 2045) of 218.6 m^3 for the treatment of the generated municipal wastewater and its reuse for landscape irrigation. The plant involves a constructed wetland as secondary treatment as well as solar photocatalysis and ultrafiltration for primary and tertiary treatment respectively. In addition, disinfection is applied after tertiary treatment, so that the effluent can meet national regulation standards on reuse for landscape irrigation (Egnatia Odos, 2013).

The aim of this paper is to present the WWTPs of Antiparos and Thirasia focusing on:

- The quality of the WWTP effluent in the last 2 years of operation
- The suitability of the effluent for landscape irrigation, based on the Greek legislation for water reuse
- The benefits (i.e. energy and cost savings) from water reuse in Antiparos and Thirasia in comparison to energy and cost requirements of landscape irrigation with water imported from the mainland or from desalination processes

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