Irrigation water use in Mediterranean islands – Fresh water or Wastewater reuse?

Maria K. Doula, Ch. Kolovos, A. Papadopoulos

Benaki Phytopathological Institute, 8 Stef. Delta str, 14561 Kifissia, Greece
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Presenting author email: mdoula@otenet.gr

Mediterranean region is among the most vulnerable regions in Europe as regard impacts of climate change. Apart from the natural particularities, this is also owed to the low level of adaptive capacity of the existed legislation and the defined processes of sustainable adaptation to climate change as well as, to the limited measures taken by the Mediterranean countries to address the challenge of climate change at local, regional and national level.

It is well known that environment quality; economic development and social wellbeing in the Mediterranean region are currently under multiple pressures such as desertification, water shortage and persistent urbanisation. Projected temperature rise and decrease in precipitation will result in water availability reduction while at the same time, water demand in the region will increase with a growing need for irrigation under a changing climate, changing lifestyle, rising demand for tourism, energy production and other economic activities. Hence, according to EEA (2005), the currently already acute water shortage problem in the Mediterranean region will be exacerbated under projected climate change.

Under these unstable conditions, wastewater reuse for irrigation seems a promising perspective and also a challenging topic that may provide benefits, as for example conservation of fresh water, but also cause significant adverse effects on the fragile Mediterranean agricultural environment as for example, on soil and underground water quality, human and animal health and others. Many researchers worldwide have studied the reuse of wastewater for irrigation, mainly the reuse of treated municipal wastewater (Suzuki *et al*., 2002), but also the reuse of wastewater originated from crops and food processing, e.g. olive mill wastewater (PROSODOL, 2012).

In comparison to municipal and industrial wastewater streams, the streams from crops/food processing are almost free of heavy metals and pathogens, which is, without doubt, a comparative advantage for their reuse on soils and for irrigation. Adverse effects are expected, however, due to their high content in salts and in some organic substances that are mainly protective to crops when on the trees, as for example polyphenols, which however, become highly phytotoxic when wastewater is distributed on soils.

Considering that the reuse of wastewater originated from food/crops processing may reduce the need for fresh irrigation water and provide nutrients to the cultivation, this study aims at comparing the impacts on soil caused by the use for irrigation of (1) underground water and (2) wastewater produced during crops processing. The study was conducted in the framework of the LIFE AgroStrat project, at a Mediterranean island (i.e. Aegina island) and by using the cultivation of pistachio trees as pilot case.

To estimate the amount of wastewater produced in Aegina island annually, after pistachio harvesting and processing, it was considered that on average, $2m^3/h$ of water are required for 1 tn fresh nuts during dehulling, while almost 1tn of nuts can be processed within an hour. Therefore, if we consider 40 tn of fresh nuts as mean farm production, the anticipated water consumption is almost $80m^3$. For the entire Aegina island it is estimated that for an average production of 1,500 tn of fresh nuts, almost 3,200 tn of water are used during dehulling, which is mainly discharged on soils or in streams and wells without any other monitoring and control measure. Wastewater is dark colored, bad smelling, has high electrical conductivity and is rich in polyphenols and in inorganics. Table 1 illustrates some of pistachio wastewater properties.

Table 1. Chemical parameters of pistachio wastewater collected in Aegina island.

Parameter	Mean value	Parameter	Mean value
pH	5.68	Total Fe, mg L^{-1}	0.49
Electrical Conductivity, mS/cm	6.1	Total Zn, mg L^{-1}	1.25
Polyphenols, mg L^{-1}	1,500	Total Mn, mg L^{-1}	0.68
K, mg L^{-1}	1,050	Total B, mg L^{-1}	0.062
P, mg L^{-1}	38	NH_4^+, mg kg^{-1}	60
Ca, % (w/v)	0.04	Cl^-, mg L^{-1}	710
Mg, % (w/v)	0.02	NO_3^-, mg L^{-1}	5.0
Na, mg L^{-1}	347	PO_4^{3-}, mg L^{-1}	52
Cu, mg L^{-1}	0.13	SO_4^{2-}, mg L^{-1}	135

To irrigate pistachio trees, farmers in Aegina island use water from wells and drilling, which is of bad quality and has very high electrical conductivity. Therefore, one of the main problems caused by the use of this low quality irrigation water is the accumulation of Na^+ in the root zone and of Cl^- in tree leaves. Apart from damages caused to trees (Photo 1), irrigation with underground water causes salts accumulation on soils and increase in their electrical conductivity, mainly at depths between 30-90 cm, which causes gradual but stable soil degradation.

Photo 1. Toxicity caused to pistachio leaves due to excessive Cl^- concentration.

To choose between the use of underground water or wastewater reuse, implies to consider a number of specific properties of these available resources that are relevant to yield, crops quality, maintenance of soil productivity and protection of the environment (Doula *et al.*, 2014). For this, two aspects were conidered in this study, i.e. (1) wastewater composition and the worldwide acceptable standards for irrigation, and (2) the impact of wastewater landpreading on soil parameters as these were defined through experimentation during the AgroStrat project. For the sustainable reuse of wastewater according to soil properties and local geomorphological properties, GIS land suitability maps were developed as well as a set of equations for estimating the appropriate amount of wastewater to be distributed on soils.

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