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Short-term effects of reclaimed water irrigation: *Jatropha curcas* L. cultivation

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ABSTRACT

In a growing concern of water and energy availability decrease, the sustainable growth of *Jatropha curcas* L. may be a feasible and complementary alternative within the local non-conventional energies field. This study emphasizes the idea of using reclaimed water agriculture implemented as a complementary local energy option. The main goal of this work focuses on monitoring the environmental affections and feasibility of treated water reuse for *J. curcas* L. irrigation. Two parcels were irrigated with two different water qualities: well groundwater (WG) and reclaimed water (RW). Differences were found in terms of nitrate, ammonia, sulphate, chloride, dissolved organic carbon (DOC), chemical oxygen demand (COD) and metals concentrations between the two irrigation water qualities. However, after one year of study, no significant differences in the leaves composition were measured with the exception of Fe (WG = 85.17 and RW = 102.63 mg/kg) and Mn (WG = 83.98 and RW = 43.51 mg/kg). The statistical analysis shows no significant differences in height, collar diameter and crown diameter (WG = 142.4, 5.7 and 157.1 cm; RW = 143.5, 5.4 and 154.7 cm, respectively). So far the aquifer water quality was only slightly affected in terms of total nitrogen (N_T) after irrigation when rainfall took place. DOC and COD in groundwater were always below 5 and 15 mg/L, respectively. As a conclusion, wastewater reuse for irrigation does not provide a negative effect in *J. curcas* L. feasibility, becoming an alternative option in the renewable energy field. An environmental monitoring is necessary to guarantee a sustainable management.

1. Introduction

The non-regular spatial and temporal rainfall distribution in most of the Mediterranean countries, generates a high cost in getting water of good quality available at the required place and time (Angelakis et al., 1999). Irrigated agriculture is the main water consumer (FAO, 2007a), becoming around 75% of the total water consumption in Spain (INE, 2008). This consumption is concentrated in the dry season (high potential evapotranspiration and low precipitation), what has been solved in a large number of cases by using groundwater as the main source of water. But this has generated groundwater overexploitation during the last decades, which in turn has limited the availability of this source of water.

To cope with water scarcity coupled with a growing water demand, the reuse of wastewater effluents derived from wastewater treatment plants (WWTP) is considered as a technically and economically feasible solution (Kiziloglu et al., 2008; Molinos-Senante et al., 2011). In this scenario, reclaimed water has become a good option for providing a high and constant volume of water for irrigation. As Gunston (2008) have stated, reclaimed water irrigation in agriculture might help in alleviating the limited availability in water resources. Many studies have shown the viability of water reuse for crops irrigation (Yadav et al., 2002), even in oilseed crops (Bedbabis et al., 2010; Parsons et al., 2010; Rebora et al., 2010).

Together with water scarcity, another cause of concern for the human population is the energy production and the energy dependence. The cultivation of *Jatropha curcas* L., non-interfering food security, might be a feasible option within the renewable energies field. This crop, if cultivated in a sustainable way (i.e. avoiding the

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big-dimension monoculture and so the environmentally related issues derived from it), emerges as an additional option within the non-conventional energies field, not only due to its oil (up to 30–40% converted into bio-diesel) but also by its secondary products: glycerin and the resulting cake from oil extraction, with a potential use as fertilizer (Achten et al., 2008), for biogas production and for livestock feed (FAO, 2010).

Maes et al. (2009) found that most of *J. curcas* L. specimens were located in temperate climates without dry season and with hot summer. The production in these areas is approximately double than in arid or semiarid regions. But the ability of *J. curcas* L. to grow in dry areas makes it especially attractive for revegetating degraded lands with what is an economically and socially valuable crop (Abou Kheira and Atta, 2009). That means one of the most important requirements for the cultivation of *J. curcas* L. is an additional irrigation.

J. curcas L. is an oil-bearing crop who produces a seed that can be processed into non-polluting bio-diesel (FAO, 2010). Based in a cost–benefit study, without including environmental issues, the cultivation and production costs to get the oil from *J. curcas* L. seed are about three to ten times the selling price of diesel and kerosene in most developing countries (Openshaw, 2000). However, taking environmental issues into account like climate change and pollution, the atmospheric contributions of *J. curcas* L. bio-diesel (as emissions of hydrocarbons and particulate matter) are 80% lower than mineral diesel contributions (Makkar and Becker, 2009). In addition, the mineral oil prices are likely to stay higher in the future (Makkar and Becker, 2009) as fossil reserves diminish and global demand increases, particularly in the newly emerging economies of Asia and Latin America (FAO, 2010). Nowadays, the search for renewable energy is being driven because of the crude oil prices fluctuation and the perceived threat to national security of over-dependence on foreign supplies (FAO, 2010).

On another front, growing *J. curcas* L. might improve rural development in developing countries. It is being considered that local production of bio-fuels has a broad range of positive economic, social and environmental implications, offering opportunities to get better income levels of smallholder farmers. Besides, as biofuels are renewable, non-toxic and biodegradable, they contribute to both energy security and the reducing environment contamination (Reddy et al., 2008). In addition, *J. curcas* L. can be used as a living fence to keep out livestock, controlling soil erosion and improving water infiltration (FAO, 2010).

The current study, located in the Experimental Plant of Carrión de los Céspedes (Seville, Spain), involves wastewater reuse in agriculture for *J. curcas* L. irrigation. The main goal of this study focuses on analysing the outstanding differences derived from irrigating *J. curcas* L. with either well groundwater (WG) or reclaimed water (RW). The specific objectives are two-fold. First, to determinate the major differences on *J. curcas* L. development so linked to *J. curcas* L. growth and leaves element composition, and second to analyse groundwater quality implications derived from irrigating with RW.

2. Methods

2.1. Site description

The study site is located south-east of Spain, in the experimental plant of Carrión de los Céspedes (Fig. 1). Carrión de los Céspedes is a small village with 2500 inhabitants. They produce an average wastewater volume of 400 m^3/d, which are treated in the experimental plant of Carrión de los Céspedes (managed by CENTA, www.centa.es). The average annual rainfall in the area is around 650 mm and 17.4 °C is the average temperature (AEMET, 2011). The climate is characterised by rainy events mainly in spring and autumn and by a hot dry summer. The soils in the experimental plot are clay or clay loam soils and have been classified as *Oxyaquic Xerofluvents* and *Calcic Haploxeralf* (De Bustamante et al., 2010b) according to the USDA classification (Soil Survey Staff, 2010). The water table depth in the study site ranges from 2 to 4 m.

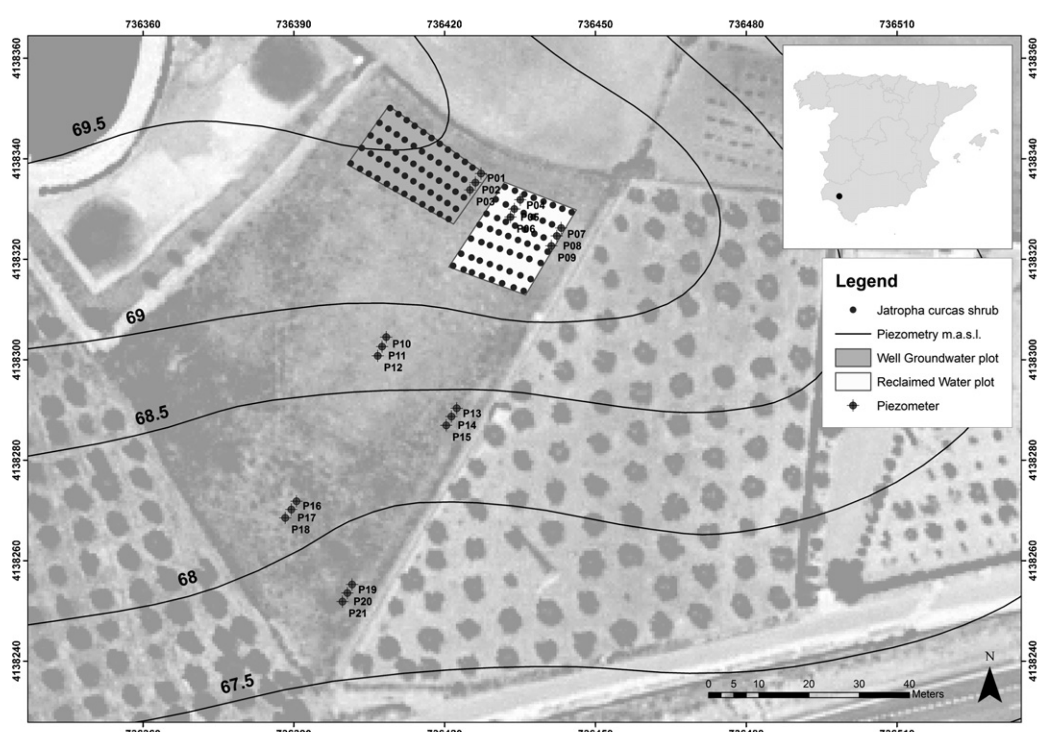

Fig. 1. Map of the CENTA experimental plant and water piezometry (survey May 2010).