



## Application of GIS-based multi-criteria analysis for site selection of aquifer recharge with reclaimed water

Francisco Pedrero<sup>a,1</sup>, António Albuquerque<sup>b,\*</sup>, Helena Marecos do Monte<sup>c,3</sup>, Victor Cavaleiro<sup>b,2</sup>, Juan José Alarcón<sup>a,1</sup>

<sup>a</sup> Irrigation Department, Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC), Campus Universitario de Espinardo, 30100 Murcia, Spain

<sup>b</sup> Department of Civil Engineering and Architecture, University of Beira Interior, Edifício 2 das Engenharias, Calçada Fonte do Lameiro, 6201-001 Covilhã, Portugal

<sup>c</sup> Department of Civil Engineering, High Institute of Engineering of Lisbon (ISEL), R. Conselheiro Emídio Navarro, 1, 1950-062 Lisbon, Portugal

### ARTICLE INFO

#### Article history:

Received 8 March 2011

Received in revised form 8 August 2011

Accepted 8 August 2011

#### Keywords:

Aquifer recharge

GIS

Multi-criteria analysis

Reclaimed water

Reuse

Site selection

### ABSTRACT

Reclaimed water from small wastewater treatment facilities in the rural areas of the Beira Interior region (Portugal) may constitute an alternative water source for aquifer recharge. A 21-month monitoring period in a constructed wetland treatment system has shown that 21,500 m<sup>3</sup> year<sup>-1</sup> of treated wastewater (reclaimed water) could be used for aquifer recharge. A GIS-based multi-criteria analysis was performed, combining ten thematic maps and economic, environmental and technical criteria, in order to produce a suitability map for the location of sites for reclaimed water infiltration. The areas chosen for aquifer recharge with infiltration basins are mainly composed of anthrosol with more than 1 m deep and fine sand texture, which allows an average infiltration velocity of up to 1 m d<sup>-1</sup>. These characteristics will provide a final polishing treatment of the reclaimed water after infiltration (soil aquifer treatment (SAT)), suitable for the removal of the residual load (trace organics, nutrients, heavy metals and pathogens). The risk of groundwater contamination is low since the water table in the anthrosol areas ranges from 10 m to 50 m. On the other hand, these depths allow a guaranteed unsaturated area suitable for SAT. An area of 13,944 ha was selected for study, but only 1607 ha are suitable for reclaimed water infiltration. Approximately 1280 m<sup>2</sup> were considered enough to set up 4 infiltration basins to work in flooding and drying cycles.

© 2011 Elsevier B.V. All rights reserved.

### 1. Introduction

In the context of the implementation of the 2000/60/EC Directive (water framework Directive) and the recommendations of the World Water Assessment Programme (UNESCO, 2009), sustainable management of water requires an approach that, on one hand, allows controlling of aquatic pollution and protecting of water resources, which can be achieved through the adequate provision of wastewater treatment facilities. On the other hand, it is essential to ensure the availability of this resource, in terms of quantity and quality, in order to satisfy uses such as public supply and agricultural irrigation. Approximately 40% of the total surface area of Portugal is utilised as agricultural land (3.68 million ha), 86.6% of which has a deficit in organic matter, nutrients and minerals, whilst

75% of the territory is covered by agro-forestry (Marecos do Monte and Albuquerque, 2010b). According to Marecos do Monte (2007), 58% of the country mainland suffers a water deficit that may bring serious consequences to the economy.

Over the last decade, the country has invested strongly in the construction and rehabilitation of low cost wastewater treatment plants (WWTP) for small populations (less than 2000 inhabitants, especially in the rural areas, which constitute 85% of the country), in the context of the 1991/271/EC Directive (urban wastewater treatment). According to UNESCO (2009), this kind of solution and the selective reuse of reclaimed water will constitute one of the great challenges for integrated water management in rural areas over the next two decades. The rural areas of the Beira Interior region have several golf course projects, SPA resorts with therapeutic treatment and important agricultural activities that represent an economic gain for the region and require a considerable availability of water. However, in recent years the region experienced a serious water shortage period that may undermine activities.

The nearly four hundred small WWTP operating in that region could contribute to satisfying the demands of those activities through the reuse of their treated effluents. Most of the small WWTP are constructed wetlands (CW), which are considered a low-

\* Corresponding author. Tel.: +351 275329981; fax: +351 275329969.

E-mail addresses: [fpedrero@cebas.csic.es](mailto:fpedrero@cebas.csic.es) (F. Pedrero), [ajca@ubi.pt](mailto:ajca@ubi.pt), [ajcalb@netvisao.pt](mailto:ajcalb@netvisao.pt) (A. Albuquerque), [hmarecos@dec.isel.ipl.pt](mailto:hmarecos@dec.isel.ipl.pt) (H. Marecos do Monte).

<sup>1</sup> Tel.: +34 968396303; fax: +34 968396213.

<sup>2</sup> Tel.: +351 275329981; fax: +351 275329969.

<sup>3</sup> Tel.: +351 218317002; fax: +351 218317021.