Recycling pulp mill sludge to improve soil fertility using GIS tools

Paulo Ribeiro, António Albuquerque, Luis Quinta-Nova, Victor Cavaleiro

Abstract

Pulp mill sludge produced in the Cova da Beira region (Portugal) contains organic matter (11–47%), nitrogen (38–2560 mg N/kg) and phosphorus (167–370 mg P/kg), which may be valuable for increasing soil productivity. The levels of heavy metals are below the limits recommended by legislation and the amount of nitrogen and phosphorous to be introduced in soils does not present a risk for nutrient leaching. After identifying the environmental and technical restrictions on its application, an area of 1650 ha was identified where the sludge can be applied in forage crops, fruit trees, olive groves and vineyards. A suitable area was also found for a biosolids storage centre. The use of GIS allowed to define a sludge application index and to produce land-use suitability maps, which can be useful for sludge management.

Keywords:
Pulp mill sludge
Land application
GIS
Suitability maps

Article info

Article history:
Received 26 November 2009
Received in revised form 9 May 2010
Accepted 15 May 2010

1. Introduction

The Cova da Beira region is located in the interior centre of Portugal and is influenced by the moderate Mediterranean climate. It has an area of 1375 km², the annual average temperature is 14.5 °C and the average rainfall is 820 mm. The majority of the soil in this region has low organic matter content (Ribeiro, 2000; LQARS, 2000), which could be a disadvantage for its use, taking into account the agricultural productivity expected under the Irrigation Cova da Beira System and the maintenance of tourism projects (e.g. golf fields).

Organic matter plays a very important role in soil conservation, due to the beneficial effect it has on its physical, chemical and biological properties, and protection against some forms of pollution and degradation. Some types of organic waste generated in urban areas and industries, including municipal solid waste and sludge from wastewater treatment plants (WWTP), may after treatment be a source of organic matter and nutrients (e.g. nitrogen, phosphorus and calcium) to incorporate in poor soils or under fast degradation processes.

Pulp mill sludge from the paper industry seems to have contents of both organic matter and nutrients (Nkana et al., 1999; Foley and Cooperband, 2002; Jordan and Rodriguez, 2004) which may be considered suitable for organic and nutrient correction of poor soil such as that covered by the Cova da Beira Irrigation System. This kind of application, besides improving soil fertility and waste reuse, may reduce treatment and disposal costs.

However, the use of organic residues in soil requires good application practices and periodic monitoring of the quality of the soils, residues and water resources near the application area. The presence of phosphorus and nitrogen compounds, heavy metals, refractory organic compounds and pathogenic agents may pose a risk to water quality (e.g. risk of eutrophication and groundwater contamination) and soil (e.g. toxicity of soils and plants) and public health. Restrictions on sludge application, based on its nutrient content and plant needs, are less rigorous but the recycling practice must ensure no conflicts with good agricultural practices set in codes and guides of good agriculture practices, both at national (MADRP, 1997; MADRP, 2000) and international (EPA, 1994; ESD, 1995; DELG, 2008a) levels.

The application of pulp mill sludge (produced during the treatment of effluents from pulp and paper industry) should therefore be treated with caution and according to safety regulations as presented in Jordan and Rodriguez (2004) and IFC (2007). In Europe, this practice is subject to regulation by the European Community through Directives 86/278/EEC (Sewage Sludge Directive) and 91/692/EEC (Standardizing and Rationalizing Reports on the Implementation of Certain Directives Relating to the Environment), namely in terms of annual maximum permitted application rates and annual maximum concentrations of metals and nutrients to be incorporated in soils. These acts seek to discipline and supervise the use of waste through regulations which ensure that its use does not contribute to soil contamination by heavy metals or to diffuse sources of pollution, especially for nitrogen compounds (Directive 91/676/EEC - Nitrates Directive). The legal framework sets application limits (Directive 86/278/EEC and Portuguese Decree-Law No. 118/06 – Agricultural Application of Sludge), according to the characteristics identified for waste, soils and spatial limitations.