Chapter 11
A Spatial Multicriteria Decision Analysis to Manage Sewage Sludge Application on Agricultural Soils

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ABSTRACT

In this chapter, the spatial problem of disposing sewage sludge on agricultural soils is addressed. Sewage sludge application on agricultural soils is recommended by governments in order to recycle nutrients and organic matter. Moreover, a new utility is given to a by-product of wastewater treatment. However, this managing practice may lead to environmental and human health risks. Soil amendment has also several related economic costs. In order to solve this decision problem, a spatial multicriteria decision analysis is presented. This method allows solving the decision problem taking into account the geographical peculiarities of each agricultural site. The purpose of this chapter is to present a methodology to solve the decision problem of managing sewage sludge on agricultural soils. For that, the most used multicriteria decision analysis procedures reported in the literature are reviewed and other novel methods are suggested. By the end of the chapter, a brief example of the method application is presented.

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INTRODUCTION

Managing an increasing production of residues is an issue of great interest nowadays, due to environmental and economic costs. This fact is not different for sewage sludge management. In recent years, an increased production of this residue has been experimented in several countries.

The main criteria for sewage sludge management nowadays are legislation and economic costs. Metal levels in sewage sludge and agricultural soil are defined in the European legislation (CEC, 1986). However, other issues such as potential impacts to humans and ecosystem, including human exposure to organic contaminants through different pathways (inhalation, ingestion, dermal contact) are not addressed. Another point of concern is that amending soils with sewage sludge may lead to surface and groundwater contamination, as a result of pollutants movement through the soil matrix. Besides that, economic issues such as the managing cost (function of the amount of sludge produced and the treatment process) and the transport cost (according to the distance between the wastewater treatment plants and the agricultural field) must be also taken into account.

The purpose of this chapter is to present a Spatial Multicriteria Decision Analysis (SMCA) to define the optimal allocation for amending agricultural soils with sewage sludge. For that, the problem of disposing sewage sludge is presented and novel decision support methodologies are described. SMCA allows assessing the impacts and the benefits of the different disposal alternatives. It involves a set of geographically defined alternatives (events) from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria.

The chapter is organized as follows. Section 2 describes the problem of sewage sludge management. Section 3 explains what a Multicriteria Decision Analysis (MCDA) is and how to integrate it in a GIS platform. It also gives a brief explanation about some techniques that could be implemented in this decision system. Section 4 elucidates the main parts of decision making and gives an example of this practice. Section 5 presents a brief case study and finally, section 6 concludes the chapter and points out some future trends.

SEWAGE SLUDGE MANAGEMENT

Sewage sludge is the main residue of Wastewater Treatment Plants (WWTP). It includes the sludge originated in treatment plants of domestic wastewater that is occasionally mixed with industrial wastewater and/or run-off rain water. Sewage sludge properties depend on wastewater pollution load, and technical characteristics of the treatment plant. Due to water treatment, the pollution present in water is concentrated and also some chemicals are transformed during the treatment process (Katsoyiannis & Samara, 2005). Some of these compounds, such as organic matter and nutrients, may be usefully reused. However, sewage sludge also presents some pollutants, as heavy metals (EC, 2001; Metcalf and Eddy, 2003), Persistent Organic Pollutants (POPs) (Eljarrat et al., 2003; Harrison et al., 2006) and pathogens (EC 2001; Metcalf and Eddy, 2003). Recent studies also point out the presence of pharmaceuticals in this residue (Radjenovic et al., 2009) as a consequence of these substances being extensively used by the population. For this reason, sewage sludge must be properly disposed to avoid risks to humans and ecosystems.

During the last few decades, the increase of sludge production, as a consequence of industrial development, population increase and amplification of treatment services, has become an environmental problem for several countries. Once treated, sludge can be recycled or disposed using one of the following 3 routes: application on agriculture, incineration (combustion) or landfilling. The valorization of this residue as an alternative energetic source in cement plants is nowadays a recycling route of increasing interest. Other

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