

LAND APPLICATION SYSTEMS AS ENVIRONMENTALLY FRIENDLY WASTEWATER AND REUSE SYSTEMS

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Abstract

Downsized conventional water treatment systems as used for small population wastewaters are extremely inefficient. In practice, due to high maintenance and operation costs, their use is frequently discontinued in many small municipalities that cannot afford to treat their wastewater, which is finally dumped untreated.

Land Application Systems have proved to be a suitable treatment system, due to their low operation and maintenance costs and their high performance. However, the most recent change in the Spanish legislation (RD 1620/2007) promotes their adaptation into the more socioeconomically beneficial water reuse systems.

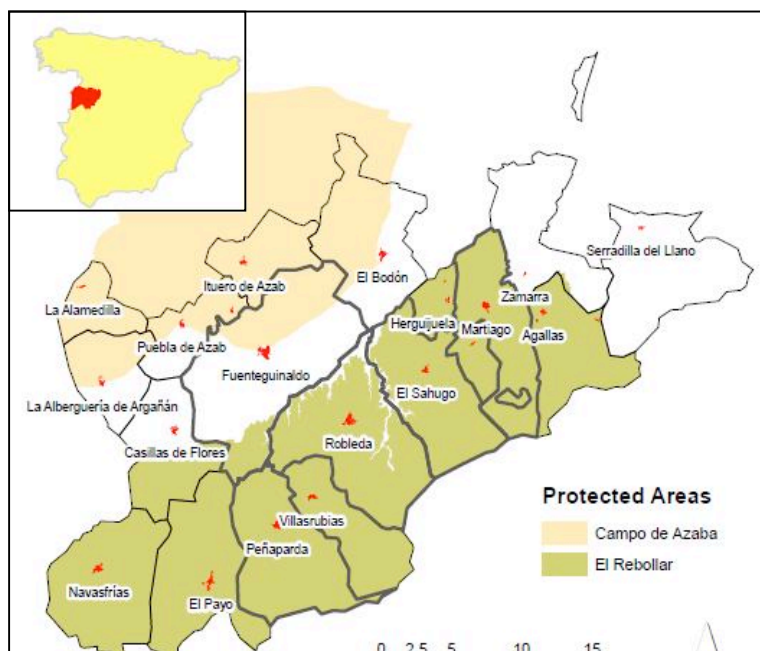
In this study, we present a techno geographical analysis for the establishment of Land Application Systems of water treatment and reuse in 5 municipalities located within the protected area of 'El Rebollar', Salamanca, Spain.

Keywords: Land Application System, protected areas, comprehensive management, water treatment and reuse.

1. Introduction

1.1 Description of the study area

The Protected Natural Landscape of 'El Rebollar' has a 50,040 hectares surface. It is located to the SW of the Salamanca province (Spain) (Fig. 1), in the northern slope of the Mountain Range Sierra de Gata. It was included in the network of Natural Areas of Castilla y León by rule 8/1991. At the moment, it is in



the process of upgrading its protection to the Natural Park level. Its surface covers 11 municipalities with around 4,000 inhabitants (INE 2009). It belongs, hydrologically, to the Águeda river sub-basin, within the Duero river basin. We have studied 5 municipalities within the park: Fuenteguinaldo, Robleda, Martiago, El Sahugo and Peñaparda.

1.2 Land application treatment system

Land Application System with forest mass (LAS) consists of a plot of land, determined by the influent to treat, where arboreal vegetation is planted and irrigated with wastewater. This one gets partially evaporated and the remainder is used by the tree roots or leaked through the ground. According to the current legislation on reuse matters (R.D 1620/2007), it is necessary to introduce a primary treatment system to eliminate some of the solids in suspension. LAS are beyond a simple wastewater treatment system, since they produce the highly economic valued biomass.

It is recommended the installation of a LAS, a low cost system, simple, but effective and robust, in our study area, due to the small size of these populations and their location within a protected area. The system must be able to hold the volume flow increases experienced during the summer time in this area, keeping minimum costs in the operation and maintenance. In addition, this system will create an environmental improvement, not only for the treated effluent, but for the environmental benefits involved (CO₂ capture and storage, landscape improvement, low energy costs, etc)

2. Methods

2.1 Technical analysis and main design variables

The main design variable is used to determine the applicable hydraulic load. Since the volume is a fixed variable, we will only work with the filter surface. If we consider that this type of facilities is based on a forest system subjected to hydric conditioners, the surface will be estimated with a hydric balance of the system. The hydric balance consists of the total water applied to the land (sum of precipitation and wastewater) and the one that returns to the atmosphere by evapotranspiration. Therefore, it is possible to evaluate the amount of wastewater that can be used without getting floods or water deficit, producing hydric stress. In this study, we have used a multi-stage land application methodology (De Bustamante, et al. 1998; 2001; 2009). To estimate the evapotranspiration we have followed the methodology proposed by Blannet and Criddle (1950).

2.1 Geographical analysis

We have carried out a geographical analysis to determine the most suitable areas for the location of the LAS. The analysis has been performed by a geographical information system (GIS), using a specifically design cartographic model. The model uses a series of limiting variables to

identify the suitable locations, including: slopes, mean altitude of the regarding town, distance to the main transportation networks, towns and stream flows, as well as land coverage, lithologic and edaphologic classes. We have extracted the cartographic information from the National Geographic Institute and the Land Use Map of the Ministry of the Environment (2000–2009).

It was set a minimum distance of 1.5 km to population centres, to prevent odours, and 100 m to rivers, to prevent possible contamination, where the facilities must not be located. At the same time, the location had to be within a radius of 500 m from a main road, to improve accessibility, and at an altitude 10 m below the mean altitude of the regarding town, to avoid pumping. The remaining variables were reclassified as shown in Table 1.

Table 1. Reclassified values of the variables used in the cartographic analysis

	Optimum	Good	Moderate	Invali d
Edaphology	Fluvisols, Regosols	Leptosols, Arenosols, Cambisols	Acrisols, Luvisols, Anthrosols	-
Lithology	Gravel	Arkose, Conglomerates	Granite, Slate, Limestone	-
Land Coverage	Dryland crops, grasslands	Scrublands, natural meadows	-	-
Slope (%)	0–1,5	1,5–3	3–6	>6

3. Results and discussion

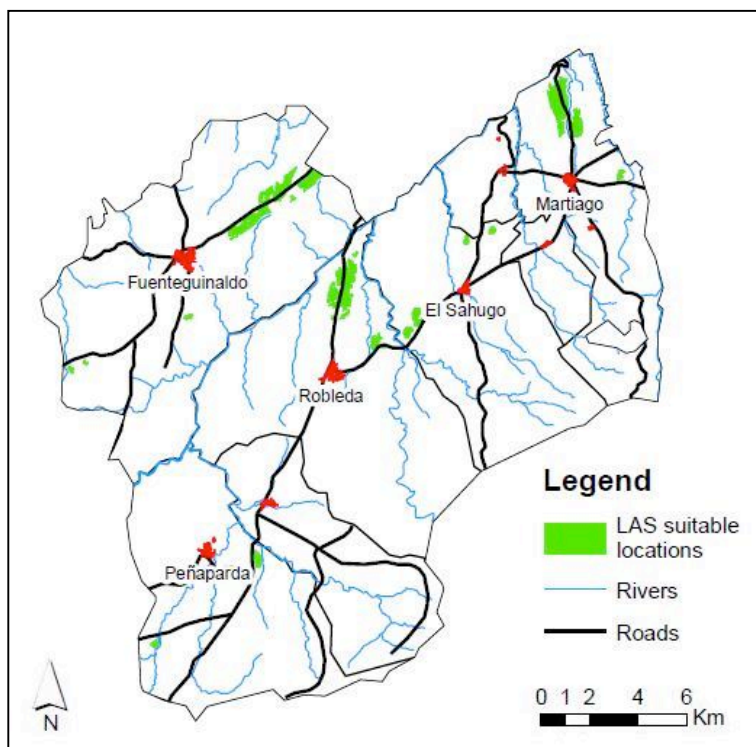


Figure 2 shows the optimal size locations of the LAS for the municipalities analysed, once applied the cartographic analysis. The number of sites is limited because of the several restrictive conditions imposed.

Table 2 displays the main design variables needed in the implementation of the land application system. The biggest surface corresponds to Fuenteguinaldo (383 inhabitants), with a total of 15,000 m², divided in two different areas: one with arboreal vegetation (poplar forest) of 10,000 m² and another one with

a meadow of 5,000 m². The smallest municipality is El Sahugo (262 inhabitants) with a surface of

Figure 2. LAS suitable locations

4,500 m² (3,000 m² and 1,500 m² respectively in each area).

We propose the use of the system in the two areas, so when higher evapotranspiration the arboreal area will be used (summer); whereas when evapotranspiration is reduced we will extend the treatment surface to the grass area. The total recharge is around 76.500 m³ per year for all the villages.

Table 2. . Main design variables using the methodology of multi-stage land application systems. (De Bustamante, et al. 1998; 2001;2009).

Municipality	Population (Inhabitant)	Inflow (m ³)	l.e	Poplar Stage Surface (m ²)	Meadow Stage Surface (m ²)	Total Surface (m ²)	Total Recharge (m ³ /año)
Fuenteguinaldo	803	38.121	383	10.000	5.000	15.000	28.280
Robleda	521	15.534	156	4.000	2.000	6.000	11.204
Peñaparda	431	20.461	206	4.500	2.000	6.500	15.976
Martiago	329	15.619	157	4.000	2.000	6.000	11.669
El Sahúgo	262	12.438	125	3.000	1.500	4.500	9.420

4. Conclusions

The proposed system adapts easily to the characteristics of the studied municipalities because it requires a small surface, less than 1 hectare per 350 inhabitants. In some cases even 450 inhabitants per hectare (Fuenteguinaldo). It is an effective system but low maintenance is need, non-qualified workers could do it. In addition, it is able to hold the increases in the volume flow experienced during the summer time. This system allows the reusability of wastewater for the highly economic valued biomass production, improving the landscape and the environment by capturing CO₂ emissions, as well as for the aquifers recharge with quality water (more than 76,500 m³ per year among all the municipalities).

5. Acknowledgement

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TRAGUA Project. Spanish Science and Innovation Ministry (CSD2006-00044).

6. References

- Blaney H F and Cridle W D (1950). Determining water requirements in irrigated areas from climatological and irrigation data. U. S. S. C. Service. 96.
- De Bustamante I, Alpuente J, Sanz García J M, López Espí P, Dorado Valiño M, López Ferreras F, Roquero E (2001). "Nueva metodología de diseño, control y gestión de filtros verdes. Aplicación a sistemas en funcionamiento." *Hidrogeología y Recursos Hidráulico*, XXIV: 585-594.

De Bustamante I, Dorado M, Vera S, Oliveros C (1998). "Filtros verdes. Un sistema para la depuración y reutilización de aguas re-siduales." *Tecnoambiente* 79: 73-75.

De Bustamante I, Lillo J, García E, De Miguel A, Martínez F, Sanz García J M, Corvea J L, (2009). A comparison of different method-ologies for land application systems: application to Redueña's WWTP. *Desalination and Water Treatment* 4: 98-102.

INE (2009). *Censo Municipal*, National Statistical Institute, Spain