Land Application Systems and its Assessment on Financial and Economic Criteria: The Experience of CENTA in Sothern Spain

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1 Introduction

The main objective of financial analysis is to assess the feasibility of using this technique given its costs and the existing financial incentives. Land application systems (LAS), or plant based purification systems, are low cost technologies applicable to rural areas where it is impossible to achieve the scale economies that are common in conventional treatment systems.

Apart from overcoming the cost barriers of water treatments at low scales, to be financially acceptable small treatment projects need to generate sub products or other ancillary benefits with the ability to produce alternative earnings. In this case those benefits might come from two main outputs obtained in the application of the effluent obtained from the system. The first potential output is an alternative amount of water with a renewed quality that makes it suitable for its application to different alternative uses including the one considered in this project which consist in the restoration of an aquifer. The second potential output results from a valuable production of biomass in the form of wood or other commodity with the potential to produce market revenues. Moreover, in the design of the system, the tradeoff between the two kinds of potential outputs would need to be carefully considered as the consumption of water for commodities reduces the potential for environmental restoration and vice versa.

This above mentioned analysis including the overall financial assessment and the trade offs between environmental and commercial subproducts of the water can be illustrated with the information obtained from the Experimental Plant of Carrión de los Céspedes.

2. The LAS of Carrión de los Céspedes

Land application system with forest mass (LAS) is a plot of land, determined by the influent to treat, where arboreal vegetation is planted and irrigated with treated wastewater. This system is considering like an extensive wastewater treatment system. The purification takes place through the action of the ground, the microorganisms and the plants, through physical, chemical and biological mechanisms. For its design is necessary to estimate the surface requirement, in relation with the influent (quality and quantity) and with climatic variables (De Bustamante, et al. 1998; 2001; 2009). A recent change in current Spanish legislation (RD 1620/2007) has had to modify this treatment, introducing a primary

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treatment system to reduce some of the pollutants. LAS are beyond a simple wastewater treatment system, since they produce the highly economic valued biomass and if the quality allows, recharge the aquifer.

The "Experimental Wastewater Treatment Plant of Carrión de los Céspedes" is located in the municipality of Carrión de los Céspedes, Seville. It has a total surface of 41,000 m^2, where different wastewater technologies are being tested (also intensive and extensive technologies). The LAS of Carrión is operating since 2005. The system has a total surface of 2.000 m^2, divided in two plots. The first one, with 945 m^2 is divided in 5 parcels of 5 x 35 m and the specie used is *Populus euroamericana*. The second one, where the forest is composed of *Eucalyptus camaldulensis*, has a total surface of 1.045 m^2, divided in 10 parcels of 3 x 35 m. The wastewater is distributed to each parcel by a system of tubes with 15 valves. Flood irrigation is carried out independently in each parcel by cycles of 4-10 days. For sampling purposes, the system includes 3 piezometers of 10 m depth. The irrigation water comes from a maturation pond. Table 1 shows the effluent (maturation pond) and groundwater quality obtained after soil infiltration. In case of COD, TOC and HPO_4-^{2} there are an important reduction, around 80-95 %. In case of Nitrogen, the pollutions levels are very height, due to the tillage and weed control (removal of herbaceous vegetation which is responsible of the desnitrification process). Nowadays, we have changed the management of herbaceous vegetation, so that the last groundwater values show a reduction trend of Nitrogen in aquifer quality.

Table 1: Groundwater and treatment plant effluent parameters (mg/l)

	Treatment Plant Effluent	Groundwater
COD mg/l	125	4,5– 30
TOC ppm	28	4 – 9
N_{Total} mg/l	31,5	30
HPO_4^{-2} mg/l	11	0

3- Financial and economic analysis

As a first step, we can estimate the cost of production and obtain comparative indicators with other technologies and treatment systems The Carrión de los Céspedes' LAS occupies an area of 2,000 m^2 with an investment about € 16,362. Annual maintenance costs amount to about € 865. Extending this data to an exploitation 30 years of the useful life of the plant and using an standard rate of discount of 4% we can obtain an equivalent annual cost that rounds € 1,811.

From the other side, experimental observations allow us to deduce that green filter has the capacity to pass through an amount of 3,420 m^3/yr of water received from a secondary wastewater treatment plant. The net flow obtained from the green filter to the underground has been estimated in 502 m^3/yr giving a technical effectiveness of the system of about 15%. The rest of the water is "used" by the system in the whole process of regeneration and in the production of biomass. As a first approximation to the financial analysis we can obtain some indicators in order to compare with other technical treatments. The average cost of the water regenerated (considering 502 m^3/yr) is 3.61 €/m^3. This relatively high financial cost can only be compensated by the financial value of some subproducts or by other economic benefits not included in the financial analysis.

In the first kind on additional benefits we can mention the commercial value of the biomass obtained. The annual average production of biomass has been estimated in 1.32 cubic meters of elm (*Populus euroamericana*) and 2.04 cubic meters of eucalyptus (*Eucalyptus camaldulensis Dehnh*). The logging produces an annual average income of € 119. Considering the water consumption of about 2,900 m^3/yr in the process of water regeneration and biomass production we can estimate the productivity of the water used this way in only 4 eurocents per cubic meter. Taking into account the revenue from the logging, the average financial cost of reused water eventually amount to 3.27 €/m^3. Another data from water productivity in the agricultural sector in Spain suggest there still are important opportunities to compensate for the high cost of this treatment system by increasing the commercial value of the associated crops.

From the other side, the low water productivity and the relatively high water consumption might be explained by climate conditions in Carrión de los Céspedes where the relatively dry conditions increase the agronomic needs of the associated crops reducing its technical efficiency and decreasing the potential collateral market revenue. A reduction in 20% in the agronomic requirements of water make result in doubling the technical effectiveness of the system from the current 15% to 32% (transferring 1.100 cubic meters to underground instead of 502) and reducing the cost from 3,61€ per cubic meter to only 1,64. The challenge of optimizing the system requires finding the best combination of suitable places and crops with low water requirements with respect to the commercial value of the commodities obtained from the system.

The financial cost of the land application systems is strongly affected in two ways. Firstly, by water shrinkage (consumption to produce biomass, which can require up to 75% of the flows), despite being able to have a source of additional income in the exploitation of timber and biomass. In addition, there is a lack of economies of scale that produce an increase in the average cost, even when the technology is simple and not expensive.

Although these costs might seem high compared with the standard figures used in the literature for tertiary treatments suggest, any comparison will need to be aware of the scale of the project. Evidently the financial information from other technical treatments, based in direct irradiation by ultraviolet (UV) light or similar, used in large treatment plants, displays better results. The average financial cost for a 2.5 million meter cubic plant is about 0.3591 €/m^3, not including distribution network cost. But no reference can be found for systems as the one considered in this project which still work at an experimental scale.

Apart from the financial direct costs and direct and indirect benefits part of the costs can be compensated by some external benefits that can not be converted into financial revenues for the project. At this respect one important external benefit is the one associated with carbon capture. Considering the volume of wood produced and its density the amount of CO2 captured can be estimated in 6.3 tonnes at a market price (September 09 2010) of 15.55 €/ton. Gives a total benefit of 98 €, or the equivalent of 6% of the equivalent annual cost. Although this figure seems modest there is also a wide scope to increase this additional benefit by improving the choice of the associated crops by using the physical productivity of the applied water as a criterion.

In addition to that, there are two important external economic benefits that need to be considered to appraise the project on a collective welfare perspective. First, if tertiary treatment is mandatory, as happens in nitrate sensible areas across Europe, the LAS system avoid the cost of installing a plant for this purpose and this saving will be higher as lower is the scale of production. Cost avoided this way may be considerable in small places. For example, even considering a low tertiary cost of 30 cents per cubic meter (which is not available at small scale plants) the avoided cost of the LAS system amounts to 1,020 Euros per year (equivalent to the cost of treating the 3,400 cubic meters). This amount is enough to compensate for the 56% of the annual equivalent financial cost, and for substantially reducing the gap between this cost and the commercial benefits. The second important benefit comes from the increase in the water stored underground which value depends on many factors including the potential saving in the extraction costs (resulting from a higher level of the water table), the improvements in the quality of the water in the aquifer (as it is now mixed with a better quality water coming from the LAS system), the reduced risk of future water supply (as the water buffered is higher) and even from the reduction in the risk of irreversible damages (when the aquifer is exposed to the risk of salt intrusion).

3. Conclusions

Taking into account the financial and the economic benefits, and the still relevant scope to optimize Land Application Systems such as the one analyzed in this project we can conclude that this is a technology with the prospect to become a real suitable and economically sound alternative for small places, without the option to benefit from scale economies, provided the right choice of the places and the associated crops is made in order to optimize the effectiveness of the treatment, the internal and external environmental benefits and the value of the tradable byproducts.

REFERENCES

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 residuales." 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 methodologies for land application systems: application to Redueña`s WWTP. Desalination and Water Treatment 4: 98–102.