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Wastewater treatment in small urban areas in Andalusia (Spain)

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ABSTRACT

Andalusia has about 2,300 small urban areas with less than 2,000 inhabitants, with a total population of roughly 741,000 inhabitants, which represents 9% of the Andalusian total population. Currently, a population equivalent of about 211,000 inhabitants from those small communities is served by 256 plants, using a varied range of technologies, both non-conventional (mainly peat filters), and conventional (essentially extended aeration). In the near future, in order to comply with the European Directives on water treatment, the sewage generated by a population of approximately 500,000 population equivalent (p.e.) will have to be treated. Most of that population is not served yet.

Keywords: Non-conventional technology; Wastewater treatment; Small urban areas; Inhabitant equivalent

1. Introduction

Andalusia has about 2,300 agglomerations with less than 2,000 inhabitants, accounting for an overall population of 741,000 inhabitants, roughly 9% of the total Andalusian population.

The treatment of wastewater generated by small urban areas has been one of the objectives of the Regional Government of Andalusia in the field of sanitation and water purification. To this end, in 1987 a research and development (R&D) plan on non-conventional technologies was promulgated. The aim of that R&D plan was the development of alternative solutions for the treatment of wastewater generated in those small villages, where treatment systems are very conditioned by technical and financial resources.

Under the R&D Plan, the creation of the Carrión de los Céspedes Experimental Plant —PECC (Seville) (Fig. 1) in 1990, and all the research works developed there since its creation, has contributed to a better knowledge and dissemination of the technologies to be applied in small urban areas. Moreover, since 1995 not only non-conventional technologies but also a wide range of conventional technologies have being studied and assessed at the PECC (extended aeration, RBC, SBR, BMR, etc.). Research is completed through the study of possible combinations between different technologies, looking for synergies.

Twenty years after the promulgation of the R&D plan, this study analyzes the current situation of urban wastewater treatment in the small urban areas of Andalusia.

2. Methodology

For the purpose of this study, a deep review of the studies carried out and coordinated at the experimental plant from 1990 to 2006 [1–5] was done. The inventory of existing small wastewater treatment plants (WWTP) in Andalusia and their operation over time has also been used as a source of information.

The information has been divided into three categories, in order to carry out a more detailed study.

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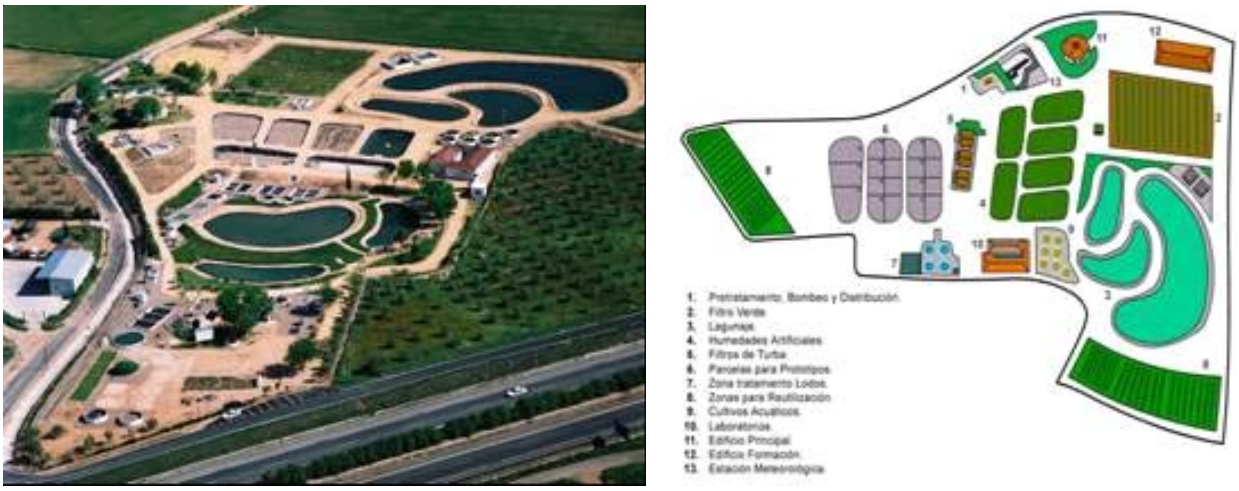

Fig. 1. Aerial view and diagram of the Carrión de los Céspedes Experimental Plant —PECC (Seville).

1) Number, type and capacity of the treatment facilities.
2) Water treatment performance.
3) Investment, operation and maintenance costs.

3. Results and discussion

3.1. Number, type and capacity of the treatment facilities

Table 1 shows the different technologies applied for wastewater treatment from small Andalusian towns (<2,000 p.e.), the number of plants in operation and the population equivalent served.

From Table 1 it can be concluded that a large number of small agglomerations, mainly under 500 p.e., only have primary treatment (settling-digestion in septic or Imhoff tanks), and require further treatment to improve the quality of the treated effluents.

Table 1
Breakdown of water treatment systems used in Andalusia for population under 2,000 p.e.

Technologies	Number of plants	Pop. equiv. treated
Settling-digestion	48	27,600
Settling-digestion + biological filter	72	32,000
Green filter	2	1,500
Constructed wetlands	4	1,500
Stabilisation ponds	5	8,300
Peat filters	30	33,600
Anaerobic ponds + peat filter	23	23,300
Trickling filters	2	2,800
Settling-digestion + trickling filters	2	1,400
Anaerobic ponds + trickling filters	5	7,600
Rotating biological contactor (RBC)	11	14,700
Settling-digestion & RBC	3	2,900
Physical-chemical treatment	5	6,800
Extended aeration	44	46,700
Total	256	210,700

The settling-digestion + biological filter systems, which are basically applied for agglomerations under 500 p.e., are the most extended system. Although they improve the performance of settling and digesting tanks, they do not achieve the level of quality supposed to a secondary treatment.

Out of the 26 stabilisation ponds existing in Andalusia, covering a population of 1,000 -35,000 p.e., only 5 of them are implemented in agglomerations under 2,000 p.e.

Green filters and constructed wetlands are hardly used in Andalusia. In the case of constructed wetlands, a natural system which is highly developed and widely used worldwide, the Andalusian Water Agency (Regional Ministry of the Environment, Regional Government of Andalusia), has recently put into practice the Andalusian Constructed Wetland Plan to foster the use of this technology in the region.

Peat filter is the most widely used technology in small agglomerations, with 53 facilities accounting for 56% of all the peat filters in operation in Andalusia. In 40% of the cases, an anaerobic pond system is used as a preliminary treatment to improve the elimination rate of solids in suspension, thereby prolonging the lifetime of the operational cycles of the filters.

The widespread use of peat filter technology is due to the numerous black peat beds in the province of Granada, and to the fact that less land is required to implement it compared to other non-conventional technologies (green filters, stabilization ponds).

About the bio-film systems, the rotating biological contactors are much more extended than the trickling filters, although the latter have become more widely used in the past few years. Commonly, settling-digesting tanks

or anaerobic ponds are implemented before the trickling filters in order to simplify and reduce the cost of the management of the sludge generated. The sludge is recirculated from the secondary clarifier to the previous systems.

Extended aeration systems serve a larger population equivalent (46.700 p.e.). In very small agglomerations prefabricated extended aeration systems are typically applied.

3.2. Water treatment efficiency

Table 2 shows the average efficiency of the different technologies applied for the treatment of wastewater in small urban areas of Andalusia.

It has been observed that the operational simplicity of non-conventional technologies (stabilisation ponds, peat filters) is quite often mistaken with the design and construction simplicity. As a result, the design of those systems is incorrectly and the plants implemented do not always work as well as they should. Following some examples are exposed:

- In stabilisation pond systems, the size of the facilities for the maturation stage is calculated according only to the retention time; consequently, many of these lagoons operate with an organic overload.
- Some stabilisation pond facilities do not even have a maturation stage, which reduces the efficiency of the elimination of solids in suspension.
- The selection of the filtering material is often incorrect (granulometry, physical-chemical characteristics), even though this is essential to the efficient operation of peat filters.

3.3. Installation, operation and maintenance costs

Tables 3 and 4 show the investment, operation and maintenance costs of the different treatment technologies. They have been obtained from real data in Andalusian plants.

As these costs, defined by the population equivalent treated, vary widely in small urban areas, the next table is specific for population equivalents in the range of 500 and 2,000 p.e.

In reference to the installation of WWTP in small towns, we should point out that local councils sometimes find it difficult to provide the necessary land. Consequently, it is not always easy to get the most adequate plot to the implementation of the treatment plant.

We can observe that differences in costs between the diverse technologies are greater for operation and maintenance than for installation.

Frequently, the management of the WWTP in small urban areas is not adequate, which can be deduced from the poor results achieved by many of them, especially those which are run directly by local town councils. In this respect, the sludge management is a very important step which is not being properly taken into account when designing the plant. Currently, 48% of all the WWTP set up in small urban areas in Andalusia are maintained and operated by local town councils themselves. Utility companies run 33% of the plants and the remaining 19% are managed by private companies. Combined settling-digestion + biological filter facilities are run by local town councils in 70% of cases.

Table 2
Efficiency of the technologies applied in the small urban areas of Andalusia

	Efficiency (%)				
	Suspended solids	BOD_5	COD	N_t	P_t
Stabilization ponds*	60	75	70	51	51
Peat filters	79	78	72	45	38
Trickling filters	82	80	78	35	18
RBC	82	78	75	36	20
Extended aeration	85	82	79	37	19

* Efficiency from unfiltered samples

Table 3
Investment costs for the different treatment technologies applied in Andalusian urban areas with less than 2,000 p.e.

	Installation costs (€/inhab. eq.)	
	500 inhab. eq.	2.000 inhab. eq.
Stabilization ponds	340	210
Peat filters	470	320
Trickling filters	560	370
RBC	620	410
Extended aeration	610	400

Table 4
Operation and maintenance costs for the different treatment technologies applied in Andalusian urban areas with less than 2,000 p.e.

	Operation costs (€/p.e. year)	
	500 p.e.	2.000 p.e
Stabilization ponds	7	4
Peat filters	9	6
Trickling filters	14	7
RBC	16	9
Extended aeration	21	14

It has been observed that the operational deficiencies found in plants are more frequent among those which are managed directly by local councils, especially in the smaller villages.

4. Conclusions

Today, Andalusia has over 250 facilities for the treatment of wastewater generated in urban areas of less than 2,000 i.e. This figure accounts for about a third of all the existing plants in the region. The population served is 211,000 inhabitant equivalents, which is only 2.3% of the population equivalent currently served in Andalusia.

In respect of the technologies, a wide range is used going from non-conventional technologies (essentially peat filters) to conventional technologies (particularly extended aeration).

The management of the WWTP located in small urban areas is a priority matter which must be addressed in order to improve the situation and meet the treatment objectives laid down in this field.

Despite all the efforts made in Andalusia in wastewater treatment in small urban areas, a population equivalent of 500,000 p.e. remains to be served in this sector. Therefore, in forthcoming years, it will be necessary to cover this gap, in accordance with the objectives set forth by the new Water Quality Plan: Sanitation and Water Treatment, in order to comply with European regulations (Directive 91/271 and the Water Framework Directive).

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