3

WSP Usage in Mediterranean Europe

3.1 PORTUGAL

There are 44 WSP systems in Portugal treating municipal wastewaters (Marecos do Monte, 1997; INAG, 1998), and a further 20 treating piggery wastes (Bicudo and Alberquerque, 1995).

The municipal WSP systems serve populations of 500-40,000. They mostly comprise anaerobic, facultative and a single maturation pond, although some do not have anaerobic ponds, some have more than one maturation pond, and some have no maturation ponds. A typical system, that at Vidigueira in Alentejo, is shown in Figure 3.1. It serves a population of 6000 and comprises an anaerobic pond (0.7 ha, 3 m deep) and a facultative pond (2.4 ha, 1.5 m deep). BOD removal is approximately 85 percent. The effluent is used to irrigate orange trees (Marecos do Monte, 1985).

There are 23 WSP systems in the tourist areas of the Algarve (Rodrigues, 1997). The largest is that at Portimão: it comprises two series, each with an anaerobic pond (0.83 ha, 3 m deep) and a facultative pond (7.2 ha, 1-1.4 m deep), which discharge into a common maturation pond (4.9 ha, 1.3-1.5 m deep). The design population and flow are 39,400 and 131,300 m^3/day, respectively. Unfiltered BOD removal is approximately 85-95 percent in winter, falling to 60 percent in summer due to a higher concentration of algae. Faecal coliform numbers in the final effluent are around 100-1000 per 100 ml.

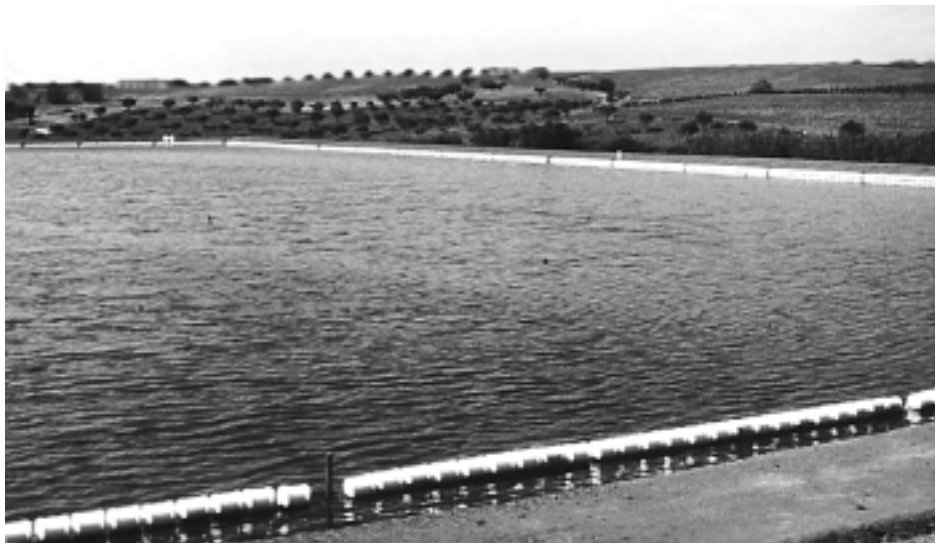

Figure 3.1 Facultative WSP at Vidigueira (the plastic floats adjacent to the embankment are for protection against wave-induced erosion – see Section 7.2)

The WSP treating piggery wastes generally comprise four ponds in series (range: 3-5, occasionally more). These are all anaerobic, although facultative conditions occur in the fifth pond. Few data are available on their performance: BOD removal is around 85 percent, but the effluent BOD is still high – around 1600 mg/l (range: 200-3000 mg/1). Effluent disposal is generally to agricultural land.

3.2 SPAIN

Most of the WSP systems in Spain are in the southeast of the country, especially in the provinces of Murcia, Alicante and Almería. Many of these systems have odour problems due to high organic loadings and/or high sulphate concentrations in the wastewater. The former arise as a result of seasonal fluctuations in organic load, mainly agro-industrial wastewaters (from fruit processing plants, other food factories), but also due to high tourist populations in summer. The high sulphate concentrations occur as a result of salt water intrusion into the sewers in many coastal towns, but also because the drinking waters have very high sulphate concentrations, generally in the range 350-1200 mg SO_4/1 (i.e. well in excess of the EU requirement of 250 mg/1: see CEC, 1980). One municipality, Vera, in Almería, has even installed a reverse osmosis unit at its water treatment plant to reduce the high sulphate concentration in its raw water, and this automatically cured the odour problem in its WSP.

Table 3.1 details the nine WSP systems in Almería. Odour apart, most of these systems perform well and in some cases the effluent is used for crop irrigation. Effluent quality data are limited, but all systems produce effluents with < 200 mg unfiltered COD/1 (see Section 6.1). Figure 3.2 shows the WSP at Vera.

Table 3.1 WSP systems in the province of Almería, Spain

Location	Population Flow (m^3/d), BOD (mg/l)	Number of WSP[a]	Remarks
Carboneras	6,700 1,100, 250	2A + F + M	Odour.[b]
Cuevas del Almanzora	5,500 960, 300	2A + 4B + M	Odour.[b] Effluent COD ~ 190mg/1; reused for crop irrigation
Huércal Overa	10,000 1,600, 350	2A + 8B + M	Odour.[b] Effluent COD ~ 140 mg/1
Los Gallardos	1,500 100, 300	A + P + M	Odour.[b] Effluent COD ~ 190 mg/1
Mojacar-Garrucha-Turre	15,000 3,200, 350	4A + 3F + 2M	Odour.[b] Effluent COD ~ 100 mg/1
Pulpí	2,800 350, 300	3A + F + M	Odour.[b] Effluent COD ~ 140 mg/l
San Juan de los Terreros	2,300 460, 300	A + F + M	Odour.[b] Effluent COD ~ 90mg/1
Vera	6,700 1,100, 350	3A + 3F + M	Effluent COD ~ 100 mg/1
Zurgena	800 110, 300	2A + F + 2M	Odour.[b] Effluent COD ~ 140 mg/1

a A, anaerobic; F, facultative; M, maturation. In two cases the facultative ponds have been replaced by biodiscs (B) and in one case by peat filters (P).
b Odour due in all cases to high sulphate concentration in the raw wastewater (generally 600–1,200 mg/1), and exacerbated in some cases by sea water intrusion and/or high organic loads.
Source: GALASA (1997).

Figure 3.2 Partial view of the WSP at Vera, Almería

Data on two WSP systems in Murcia are given in Soler *et al.* (1995), one of which is the WSP system that jointly serves the municipalities of Lorquí and Ceutí. These ponds were designed for a population equivalent of 27,500, but fruit processing wastewaters seasonally increase this to 95,000. The organic load and sulphate concentrations are both high: 3,500-5,600 kg BOD/d (the design value was 1,650), and 400-1,100 mg SO_4/1. Odour is consequently a problem and effluent quality is poor, although this overloaded system still achieves a BOD removal of 75 percent in winter and 84 percent in summer.

Microbiological performance data on the WSP system serving Guardamer del Segura in Alicante, which has problems due to both salt water intrusion and an excessive organic loading due to a high tourist population in summer (five times the resident winter population), can be found in Emparanza-Knörr and Torrella (1995). The winter and summer design flows were 1,200 and 4,400 m^3/day, respectively; it currently receives over 7,000 m^3/day in summer. The WSP system comprises three anaerobic ponds in parallel (total volume: 10,000 m^3) which discharge into two facultative ponds (70,000 m^3). Faecal coliform removal is much higher in the anaerobic ponds than in the anoxic facultative ponds, but the whole system only reduced faecal coliform numbers by two orders of magnitude. Numbers of salmonellae and coliphage were reduced by 1 and 1-2 orders of magnitude, respectively.

3.3 FRANCE

France is the country in Mediterranean Europe where WSP are most widely used, with around 2,500 systems (Boutin *et al.,* 1987; Racault *et al.,* 1995; CEMAGREF *et al.,* 1997). Interestingly, some of the early WSP systems in France (installed in the mid-1970s) replaced malfunctioning activated sludge units serving small communities (under 2000 population). WSP generally serve small rural communities: 77 percent are for populations under 1000, and only a few serve large communities – the largest WSP system in France is at Rochefort sur Mer: it covers an area of 40 ha and serves a peak summer population of

50,000. Many of the WSP systems in the south of France have high seasonal loads: the population served in July and August is often 2- 20 times that served in winter (see Drakides and Calignon, 1983).

A large-scale research WSP system is at Mèze in the department of Hérault, near Montpellier on the south coast. This system, which treats the wastewater from the towns of Mèze and Loupian (population 14,000), originally comprised three ponds in series – a primary facultative pond (3.9 ha, 1.2 m deep) and two maturation ponds (2.4 and 1.9 ha, both 1.2 m deep) (Figure 3.3). In 1997 two additional maturation ponds (1.5 and 1.9 ha, both 1.2 m deep) were built and in 1998 the complex has been enlarged by the addition of two anaerobic ponds (each 2000 m^2 and 3.5 m deep) in parallel. Final effluent quality is very important as the effluent is discharged into the Bassin de Thau, a salt-water lagoon in which there is large-scale commercial production of oysters – in the European Union shellfish eaten raw, such as oysters, are not permitted to contain more than 300 faecal coliform bacteria per 100 g fresh weight (Council of the European Communities, 1991), generally interpreted as no more than 10 faecal coliforms per 100 ml of the water in which the shellfish are grown.

Early recommendations for WSP design in France (ABLB/CTGREF, 1979) were for three ponds in series, a primary facultative pond (5 m^2 per person, 1-1.5 m deep) and two maturation ponds (each 2.5 m^2 per person, 1-1.5 m deep), i.e. a total pond area of 10 m^2 per person and equivalent to a surface BOD loading on the facultative pond of 100 kg/ha day (see Section 6.4). Often the second maturation pond was wholly or partially planted with reeds, but in the south of France this encouraged the prolific breeding of mosquitoes (especially *Mansonia* spp.) (Ringuelet, 1983). This practice is not now recommended (CEMAGREF *et al.*, 1997). Current WSP design recommendations are for the facultative pond to have an area of 6 m^2 per person (CEMAGREF *et al.,* 1997), equivalent to a BOD loading of 83 kg/ha day (see Section 6.4) and a total pond area of 11 m^2 per person.

WSP construction costs in France are FFR 600-3,000 (90-450 ecu) per person served, with a mean of FFR 800 (120 ecu). Operation and maintenance costs are FFR 30-50 (4.5-7.5 ecu) per person served; of this FFR 10-20 (1.5-3 ecu) is for sludge removal (CEMAGREF *et al.,* 1997).

The performance of WSP in France is generally good. In a survey of 178 WSP systems conducted in 1992 (Racault *et al.,* 1995), average filtered effluent BOD

Figure 3.3 The WSP at Mèze, near Montpellier

and COD concentrations were 23 and 99 mg/1, respectively, and the average suspended solids concentration was 60 mg/1 (Table 3.2). These values compare well with the French pond effluent requirements of ⊁ 40 mg filtered BOD/1, ⊁ 120 mg filtered COD/1 and ⊁ 120 mg suspended solids/1 (Circulaire Interministérielle, 1980) (cf. Section 6.1). Little variation in performance between summer and winter was found (Table 3.3).

Wastewater reuse is not widely practised in France as freshwater resources are normally sufficient for irrigation. However, over 2000 ha of vegetables are irrigated with treated wastewater near Paris, and nearly 600 ha near Reims; these are both reuse practices dating back over 100 years. A more recent example is the reuse of treated wastewater from Clermont-Ferrand. Treatment is by activated sludge supplemented by WSP, and up to 700 ha will be irrigated with 25,000 m^3/day of treated wastewater. The crops grown are alfalfa, maize, sugar beet, peas and sunflower (Bontoux and Courtois, 1996). In some tourist areas in the south of France treated wastewater is used for landscape irrigation and for the irrigation of golf courses. The microbiological quality of treated wastewater used for crop irrigation in France has to comply with the WHO guidelines (see Section 12.1) (Conseil Supérieur d'Hygiène Publique, 1991).

Table 3.2 Average performance of 178 WSP systems in France

Parameter	Raw wastewater (mg/l)	WSP effluent (mg/l)
BOD	277	23[a]
COD	657	99[a]
Suspended solids	256	60
Total Kjeldahl nitrogen	70	22
Ammoniacal nitrogen	48	14
Total phosphorus	21	8.5

[a] Filtered. Unfiltered values: BOD, 43; COD, 162.
Source: Racault *et al.* (1995).

Table 3.3 Seasonal variation of WSP effluent quality in France

Parameter (mg/l)	Spring	Summer	Autumn	Winter
Filtered BOD	18	28	25	26
Filtered COD	89	113	102	85
Suspended solids	49	57	57	54
TKN	22	16	21	29
NH_4-N	16	7	14	21
Total P	10	7	9	9

Source: Racault *et al.* (1995).

3.4 GREECE

There are only a few WSP systems in Greece: out of 241 municipal wastewater treatment plants, 13 are WSP and these are all located in the northern prefectures of Seres and Kavala, serving communities of 500 - 3000 population (Tsagarakis *et al.,* 1996). They comprise a primary facultative pond (2.5 m deep) followed

by 1-3 maturation ponds (~ 1.5 m deep), the last of which often has a rock filter surrounding its outlet (see Section 10.3) (Figures 3.4 and 3.5). Operation and maintenance are generally poor: rooted macrophytes (even trees) are present in the ponds, and mosquito breeding occurs at some locations. Almost no operational data exist (COD removal is reported to be around 60 percent) (Tsagarakis, 1997).

Recently an experimental/demonstration WSP facility has been installed adjacent to the wastewater treatment plant at Thessaloniki in northern Greece. The complex (Figure 3.6) comprises three lines:

(a) an anaerobic pond (570 m^2, 4 m deep), a facultative and two maturation ponds (each 1380 m^2, 1.75 m deep); the maturation ponds can be operated at variable depths in the range 1.25 - 1.75 m;
(b) as (a), except that (i) the anaerobic pond is replaced by a covered circular "anaerobic tank" to permit biogas generation and composition to be studied; and (ii) the final effluent can be recirculated to the inlet of the facultative pond; and
(c) as (a) but without the anaerobic pond.

The treated effluent can be returned to the main treatment plant, or retained in a 4 m deep reservoir (see Section 11). The WSP effluent and/or reservoir contents can be further treated in a slow-sand filter prior to reuse for crop irrigation in an adjacent field or in a greenhouse. This experimental complex will serve as a demonstration unit for villages and small towns with populations up to around 10,000.

Wastewater reuse for crop irrigation is not common in Greece, despite a high demand for irrigation water in summer (Tchobanoglous and Angelakis, 1996). The effluents of only four wastewater treatment plants are used for direct crop irrigation; and effluents from a further 17 plants are used for crop irrigation after dilution with freshwater (Tsagarakis, 1997).

Figure 3.4 Secondary maturation pond at Sitochori

Figure 3.5 Rock filter in the secondary maturation pond at Kokinixoma

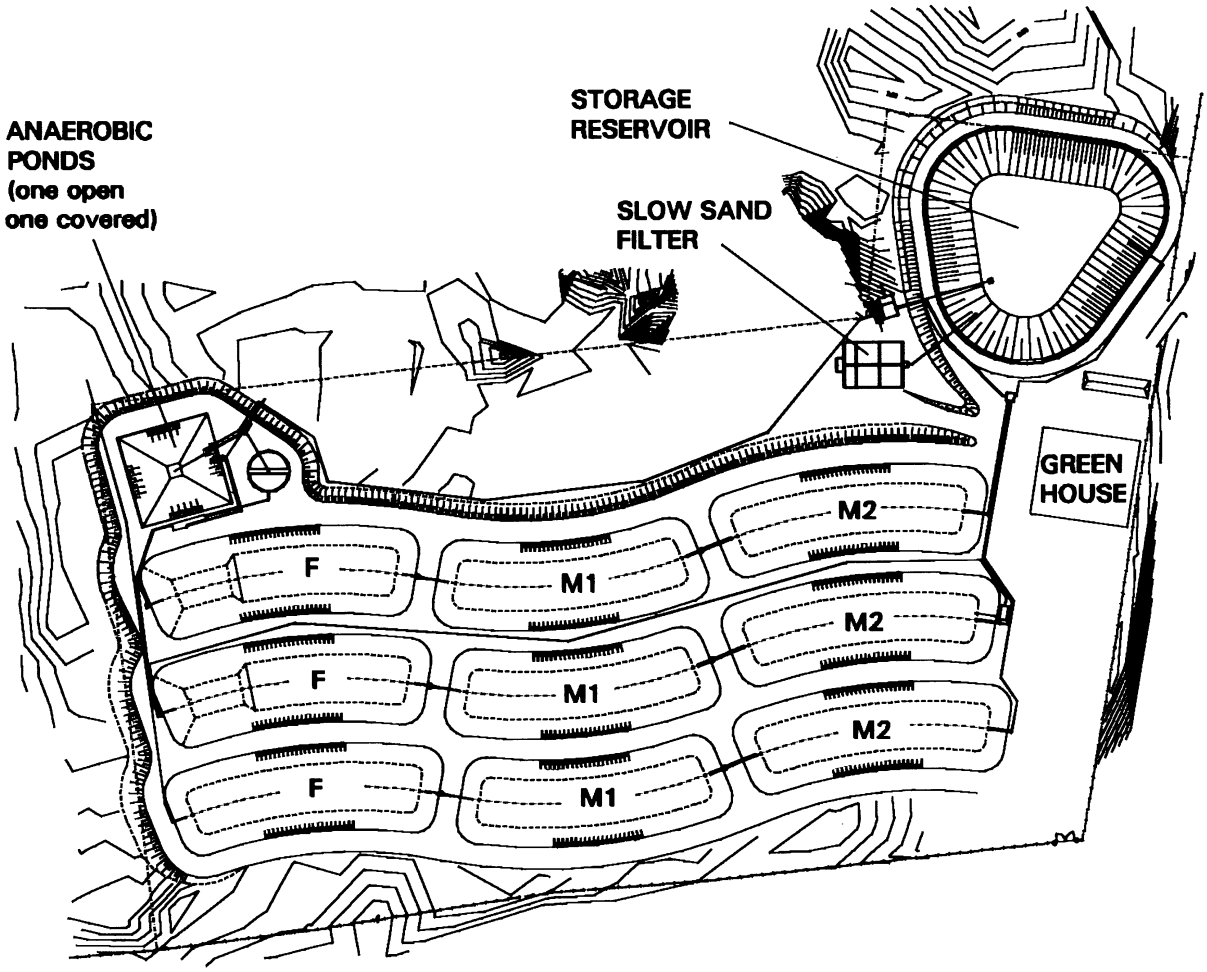

Figure 3.6 Layout of experimental/demonstration WSP at Thessaloniki