5

WSP Usage in North Africa

5.1 EGYPT

There are a few WSP systems in Egypt, although aerated lagoons are slightly preferred to facultative ponds in the Nile Delta area as they require less land (El-Gohary *et al.*, 1993). However, as noted by Shereif *et al.* (1995), "in a country where 95% of the land is desert, it is surprising that WSP treatment systems have not been widely used in Egypt."

Shereif *et al.* (1995), Shereif and Mancy (1995) and Easa *et al.* (1995) report on the experimental WSP system at Suez. This receives a flow of 150 m^3/day and comprises two anaerobic ponds in parallel (one day retention time, 3.5 m deep), operated alternately every nine months, followed by a facultative pond (10 days, 1.5 m deep) and two maturation ponds (each 5 days, 1.5 m deep). BOD removal is from 290 mg/l in the raw wastewater to 30 mg/l in the effluent of the second maturation pond (90 percent). Total nitrogen and phosphorus removal is from 40 to 17 mg/l (58 percent) and from 7.4 to 4.3 mg/l (42 percent), respectively. Faecal coliform numbers are reduced from 2.8×10^7 to 25 per 100 ml (i.e. a removal of 99.9999 percent). The WSP effluent is discharged into two fishponds in series, in which Nile tilapia (*Oreochromis niloticus*) and grey mullet (*Mugil sehli*) are grown. Fish yields are 5-7 tonnes/ha year. After passage through two freshwater depuration ponds, the fish were found to be microbiologically safe for human consumption and with very low heavy metal and pesticide levels. The fishpond effluent is used to irrigate trees and crops such as barley, maize, beets and ornamental plants.

A recent full-scale WSP system is at Edfu in Upper Egypt (Figure 5.1). Designed for a population of 50,000, the system comprises two series of ponds, each with an anaerobic pond (0.26 ha, 3 m deep, 2.5 days retention time), a facultative pond (4.5 ha, 2 m deep, 28 days) and a single maturation pond (3 ha, 1.5 m, 14 days). The ponds are surrounded by a treebelt (Figure 5.2; see Section 7.9). The effluent is used for unrestricted irrigation during April-October.

Figure 5.1 Facultative WSP at Edfu

Figure 5.2 Treebelt to protect the Edfu WSP from wind-blown sand (one year after planting)

5.2 TUNISIA

Of the 48 wastewater treatment plants in operation in Tunisia in 1995, only three are WSP systems: Cotière Nord in Greater Tunis (commissioned in 1981), Gafsa (1985) and Moknine (1986) (Ministère de l'Environnement, 1995). There is also a recently rehabilitated experimental WSP complex at Rades in Greater Tunis, and at Sidi Mehrez on the island of Jerba a series of four maturation ponds is used to polish activated sludge effluent.

The pond system at Cotière Nord, situated 20 km to the north of Tunis in the area of Gammarth, consists of two series of three ponds, each comprising a facultative pond (20 ha, 2 m deep, 50 d retention time), a primary maturation pond (9 ha, 1.5 m, 17 d) and a secondary maturation pond (8 ha, 1.5 m, 15 d). Both series discharge into a common tertiary maturation pond (10 ha, 1.5 m, 10 d). The total pond area is 84 ha. The facultative ponds are provided with standby surface aerators (Figure 5.3). The system was designed to treat a mean daily flow of 15,750m^3/d and a BOD load of 5,000kg/d which gives an acceptable loading of 122 kg BOD/ha d on the primary facultative ponds. Pond performance is summarised in Table 5.1. Saline intrusion into the sewer system means that the final effluent has a high conductivity (7,000 μS/cm) (Strauss and Blumenthal, 1990) and it is not therefore suitable for general agricultural reuse without dilution.

Figure 5.3 Primary facultative pond at Cotière Nord (one of the standby aerators, left, has been removed for repair)

The WSP system at Gafsa comprises two primary facultative ponds in parallel (each 3 ha, 2 m deep, 43 d retention time in winter, 24 d in summer) which discharge into a series of three maturation ponds (each 2 ha, 1.5 m, 11 d in winter, 6 d in summer). The design BOD was 1340 kg/d. However, the system is now greatly overloaded, with a BOD loading on the facultative ponds of around 350 kg/ha d, which is nearly four times higher than the permissible

Table 5.1 Performance of the Cotière Nord WSP in 1993

Sample	Unfiltered BOD (mg/l)	Faecal coliforms (per 100 ml)	Helminth eggs (per l)
Raw wastewater	319	7×10^6	4.3
Effluent from:			
Facultative pond	89	-	-
1st maturation pond	76	-	-
2nd maturation pond	61	-	-
3rd maturation pond	48	1,000	0
Cumulative removal (%)	85	99.998	100

design loading for January (mean temperature: 9ºC) (see Section 6.4). It is not surprising therefore that effluent quality is poor, although performance in terms of BOD and COD removal is good (Table 5.2). The ponds are pink for most of the time, and only the final pond is green. This is due to the high sulphate concentration of the raw wastewater (400-600 mg SO_4/l) and a consequently high generation of sulphide, which promotes the growth of purple and green photosynthetic bacteria. Despite the high organic overloading on the ponds, the final effluent always had < 1000 faecal coliforms per 100 ml during June - December, representing a 5 log reduction in faecal coliforms through the system.

In a detailed comparative study undertaken in 1992-94, the microbiological quality of the final effluents from the four WSP systems at Cotière Nord, Gafsa, Moknine and Rades was generally much better than that from the aerated lagoons at Houmt Souk, Lella Meriem and Sfax (Lagoon Technology International, 1994). The final effluents from the Cotière Nord and Gafsa WSP consistently satisfied the WHO guidelines for unrestricted irrigation at least during the irrigation season (see Section 12.1).

Table 5.2 Unfiltered BOD and COD removal in the Gafsa WSP in 1993

Sample	BOD (mg/l)	COD (mg/l)
Raw wastewater	561	1,517
Effluent from:		
Facultative pond	148	465
1st maturation pond	140	430
2nd maturation pond	109	329
3rd maturation pond	101	312
Cumulative removal (%)	82	79

Figure 5.4 Maturation pond at Gafsa

All the WSP lagoon systems in Tunisia are very well maintained and there are few operational problems. Detailed records on influent and effluent load, operational problems and costs are also kept for each system and results reported in Annual Reports for each works.

The Tunisian standard for the agricultural reuse of treated wastewater (INNPI, 1989) adopts the WHO guideline of ≯1 helminth egg/l for restricted irrigation, but does not include a faecal coliform standard as unrestricted irrigation is not currently permitted in Tunisia. Restricted irrigation with treated wastewater is not uncommon in Tunisia. In Greater Tunis, for example, around 1,800 ha of citrus trees are irrigated with activated sludge effluent, and the Cotière Nord WSP effluent, together with activated sludge effluent, is used to irrigate nearly 3,000 ha of cereal and forage crops (Strauss and Blumenthal, 1990).

5.3 ALGERIA

There is one functioning WSP system in Algeria, serving the coastal city of Annaba (Lehtihet, 1997). The Salines de Annaba WSP, which were commissioned in 1985, serve a population of 350,000. The wastewater flow is 65,700 m^3/day and the BOD is 280 mg/l. There are three series of four ponds which are preceded by preliminary treatment (automatic screening, grit and grease removal) and followed by a "homogenization" pond prior to pumped discharge to the sea via a oued (wadi). Each series of WSP comprises an anaerobic pond (8.3 ha, 4 m deep), a facultative pond (16.2 ha, 2 m deep) and two maturation ponds (18 ha, 0.9 m deep; and 8.8 ha, 0.9 m deep). The total pond area is 160 ha. Effluent quality is 10-30 mg unfiltered BOD/l. Operation and maintenance has been poor, and currently the WSP are being rehabilitated. Consideration is also being given to effluent reuse in agriculture and/or industry.

5.4 MOROCCO

In 1994 there were 47 wastewater treatment plants in Morocco, of which 18 were in service (ONEP, 1994). WSP systems served nine towns, but only five were in operation and three of these were experimental systems (Ben Sergao, Marrakesh and Ouarzazate; see El Hamouri *et al.*, 1995; Ouazzani *et al.*, 1995; and Administration du Génie Rural, 1994).

The WSP system at Bouznika comprises two series each with a facultative pond and two maturation ponds (total area 3.1 ha). The design population was 12,000 and the design flow 1500 m^3/day. In 1994, the flow and BOD load were 800 m^3/day and 200 kg/day, respectively, and BOD removal was 80 percent and faecal coliform removal 5 $\log_{10}$ units. Ammonia and total phosphorus removal were both 50 percent (ONEP, 1994).

The WSP at Boujaad are described by Niedrum *et al.* (1991) and in ONEP (1994). There are two series: one comprises an anaerobic, a facultative and two maturation ponds, and the other has only an anaerobic and facultative pond (Figure 5.5). Up to 84 percent of the effluent flow from the latter series can be discharged in summer into the maturation ponds of the first series, to produce as much effluent as possible for unrestricted irrigation (up to 92 percent of the

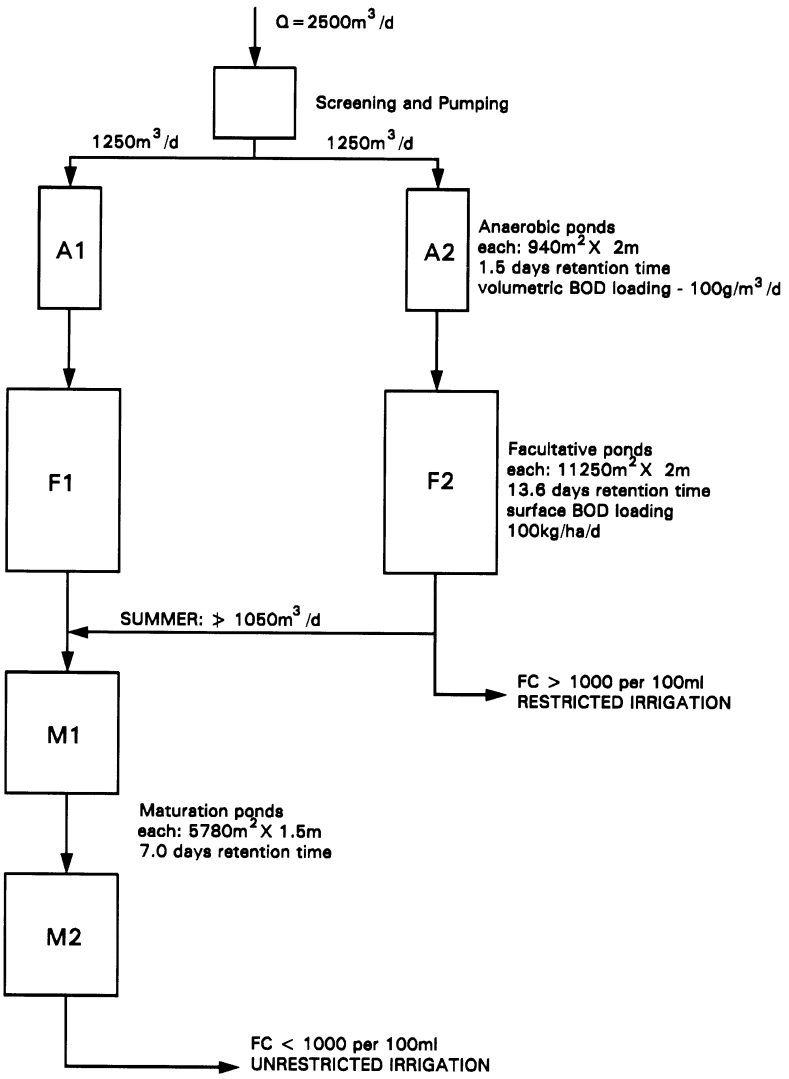

Figure 5.5 Layout of the WSP at Boujaad

design flow of 2,500 m^3/day). In 1992 BOD removal was 85 percent, and effluent BOD values were 45 mg/l unfiltered and 20 mg/l filtered, and the faecal coliform count was 2,000 per 100 ml (ONEP, 1994). The effluent is used by local farmers for crop irrigation, mainly vegetables and fruit trees (olives, figs and citrus).

A WSP system was commissioned in March 1997 at Ben Slimane (Figures 5.6 and 5.7). There are four series of ponds, each comprising an anaerobic pond (3,600 m^3, 5 m deep), an aerated lagoon (5,000 m^2, 4 m deep), a facultative pond (two are 1 ha and two are 1.5 ha in area; each 1.4 m deep) and an effluent storage reservoir (75,000 m^3, 4 m deep, 3-4 months retention time). There is a fifth anaerobic pond to provide operational flexibility during sludge removal. Each aerated lagoon has a 11.2 kW aerator and two 5.6 kW turbine mixers. The operation of the WSP is fully automated: the pumps and aerators are computer controlled. The design population and flow were 36,000 and 5,600 m^3/day respectively. In October 1997, when the flow was 4,080 m^3/day, the BOD was reduced from 300 mg/l in the raw wastewater to 40-50 mg/l in the facultative ponds, and to 7-8 mg/l in the storage reservoirs. The faecal coliform count in the

Figure 5.6 Anaerobic ponds at Ben Slimane

Figure 5.7 Storage reservoirs at Ben Slimane

reservoirs was zero. The reservoir effluent, which can be chlorinated as required, is reused for golf course irrigation.

The Ben Slimane WSP occupy 25 ha on a 36 ha site. They cost DH 98 millions (8.9 million ecu) (the Canadian International Development Agency provided a grant of C$ 3.75 million (2.2 million ecu), and the balance of the cost was shared equally between the municipality and the Office National de l'Eau Potable). The WSP complex is let on a 25-year design-build-operate contract, the first concession of this kind in Morocco.

5.5 CONCLUDING REMARKS ON WSP USAGE IN MEDITERRANEAN COUNTRIES

From the overview of WSP usage in Mediterranean countries given in Sections 3-5, certain key observations can be made:

(a) WSP currently serve a wide range of populations – from small rural communities of less than 1,000 in France, for example, to large urban centres of 360,000 in Turkey and 1.4 million in Jordan;

(b) few of the more recently constructed WSP systems appear to take account of recent advances in WSP technology, in terms of both process and physical design (see Sections 6 and 7, respectively); this includes a continuing lack of the use of anaerobic ponds, despite their high efficiency (and consequent reduction in land area requirements) and potential for energy recovery (Section 2.1.1);

(c) anaerobic ponds should be avoided in situations when the sulphate concentration of the wastewater exceeds 300 mg SO_4/l due either to a high concentration in the drinking water or to the intrusion of saline groundwater into the sewers in coastal areas (of course, drinking waters should not contain more than 250 mg SO_4/l; and good workmanship in sewer jointing can obviate groundwater intrusion);

(d) there are many examples of very poorly operated and maintained WSP, even though WSP O&M is simple (Section 8); in some cases the system has been allowed to deteriorate to point where originally well-designed and constructed WSP have become almost "lost" (and are thus in need of rehabilitation – see Section 10), although in others reasonable treatment efficiency is achieved despite O&M abuse and/or serious overloading (and this could not be achieved by most conventional treatment plants); and

(e) despite the particular suitability for crop irrigation of effluents from WSP and wastewater storage and treatment reservoirs (see Sections 11 and 12), there is currently only limited effluent reuse for agriculture in the Region outside of Israel and Jordan; yet it is important that this potential for reuse be fully exploited, given the water deficit in most parts of the Region.