2.

WSP applicability and usage in India

2.1 APPLICABILITY

Waste stabilization ponds are, as noted in Section 1, a low-cost, low-energy, low-maintenance and, above all, a *sustainable* method of wastewater treatment. They are highly appropriate under many conditions in India – not all, of course, but in the majority of cases an honest appraisal (see Box on pages 4–6) of wastewater treatment alternatives will undoubtedly indicate that WSP are the best option. Well designed WSP, provided they are constructed and maintained properly and not overloaded, will provide a high level of wastewater treatment for very many years. Other wastewater treatment processes can do this as well, of course, but not at the low cost of WSP, nor with their simplicity. This is an extremely important consideration in India, where there is a paucity of wastewater treatment plants, with most wastewater being discharged untreated into a surface watercourse. Effective treatment in low-cost WSP is thus a good way to improve the environment in general and environmental health in particular.

The climate in India, with the possible exception of that in the Northern mountainous areas, is very favourable for the efficient operation of WSP. The intense rainfall occurring during the monsoon is not a factor militating against the use of ponds, for it can easily be taken into account in both the process and the physical design of WSP (Sections 4 and 5). The high temperatures that occur throughout the year in much of India are especially favourable for anaerobic ponds.

2.1.1 Anaerobic ponds

Design engineers are often reluctant to use anaerobic ponds because of a fear that they will cause a significant level of odour nuisance. As noted in Section 3, this is *not* the case if they are properly designed. Anaerobic ponds are so efficient in removing BOD (see Sections 3 and 4) that really there should be no excuse for not using them. They are also very effective in removing heavy metals, which are precipitated as insoluble metal sulphides, and in degrading certain organic compounds (such as phenols) that would otherwise be toxic to the algae in the receiving facultative pond (see Mara and Mills, 1994). Yet in the past aerated lagoons have been favoured over anaerobic ponds, and current fashion is to consider UASBs as a preferable alternative to both aerated lagoons and anaerobic ponds.

Anaerobic ponds or UASBs?

Upflow anaerobic sludge blanket (UASB) reactors are an extremely efficient process for the treatment of high-strength industrial, including agro-industrial, wastewaters: BOD removals of >90 percent are achieved at very short retention times (<10 hours). A full description of UASBs in hot-climate countries is given by van Haandel and Lettinga (1994).

However, UASBs are less suitable for the treatment of domestic and municipal wastewaters, although nearly 20 such plants are presently under construction in India under the Yamuna Action Plan (R.P Sharma, pers. comm.). A common design assumption is that they achieve a 70 percent BOD removal at a retention time of 8 hours, and this has been realised in practice by the full-scale UASBs operating at Kanpur and Mirzapur (Hammad, 1996). An anaerobic pond in a hot climate can also achieve a 70 percent reduction in BOD, but at a retention time of 1 day, rather than 8 hours (see Section 4.3). It may therefore appear that an UASB is "better" than an anaerobic pond. However, when costs are taken into account this is not the case: it will always be less expensive to construct (essentially, excavate) a 1-day anaerobic pond, rather than to construct an UASB in reinforced concrete. Construction costs of the 5 Mld UASB at Kanpur were Rs 3.6 crore (including post-treatment in a 1-day "polishing pond", but excluding land costs) (Hammad, 1994).

Average UASB construction costs in India are Rs. 35 lakh per Mld, excluding land costs (R P Sharma, pers. comm.).

Anaerobic ponds or aerated lagoons?

It is not uncommon to see domestic and municipal wastewaters being treated in aerated lagoons prior to treatment in facultative and maturation ponds (although the current popularity of UASBs means that this is less common now than it was 10-20 years ago). As noted in Section 1.2, the local sewerage authority often finds that it cannot afford the energy costs of the aerated lagoon, and the unaerated lagoon functions as an anaerobic pond.

Aerated lagoons are designed to achieve a BOD reduction of 70-85 percent at a retention time of 2-6 days (Mara, 1976). Anaerobic ponds in hot climates will achieve a 70 percent BOD removal at a retention time of 1 day (see Section 4.3). Thus they are rather more efficient than aerated lagoons, and they achieve this efficiency at zero energy cost.

2.2 USAGE

Waste stabilization ponds are not a new technology in India. The then Central Public Health Engineering Research Institute organised a Symposium on WSP over 30 years ago (CPHERI, 1963), and published a WSP guidance manual over 20 years ago (Arceivala *et al*., 1972). Nevertheless, and certainly in recent years, little work on WSP in India has been published, as evidenced by the contents lists of such journals as the *Indian Journal of Environmental Health*. Many of the existing WSP systems in India are old, often poorly maintained and overloaded, and sometimes abandoned. They generally did not include anaerobic ponds.

One State where WSP are favoured is West Bengal. Four modern WSP systems have been installed in the Calcutta region (three within the metropolitan area, at Titagarh, Panihati and Ballay North Howrah, and one just outside, at Nabadwip); two of these are described below. Calcutta is also the site of the largest wastewater-fed fisheries in the world, and a brief description of the 3000 ha Calcutta East fishponds is also given.

2.2.1 Titagarh WSP

The WSP system at Titagarh, which was commissioned in 1995, comprises two series of anaerobic, facultative and a single maturation pond (Figure 2.1). The design flow was 14 Mld, raw wastewater BOD 200 mg/l and faecal coliform numbers 1×10^7 per 100 ml. The retention times at the design flow, the mid-depth pond areas and depths are:

Anaerobic ponds:	1 day	
	0.7 ha	2 m
Facultative ponds:	5 days	
	4.8 ha	1.5 m
Maturation ponds:	4 days	
	3.8 ha	1.5 m

The WSP were designed to produce an effluent suitable for aquaculture reuse, i.e. with a faecal coliform count below 10^4 per 100 ml. In fact, in accordance with the recommendations made by Ghosh (1996), fish culture is currently practised in both the facultative and maturation ponds (rather than in a dedicated fishpond, as recommended in Section 10). This is essentially an interim measure as the wastewater flow is currently around one-third of the design flow. Fish yields are approximately 7 tonnes per ha per year.

The Titagarh WSP are rented out to a local fish-farmer who pays Rs 50,000 p.a. to the local panchayat and Rs 120,000 p.a. to

Figure 2.1 View of WSP at Titagarh in the metropolitan Calcutta area.

the Calcutta Metropolitan Water and Sanitation Authority. This fish culture enterprise is an excellent example of low-cost sustainable wastewater treatment and reuse which not only provides employment for 50 people, but also produces much high-quality animal protein for the local low-income community.

2.2.2 Ballay and North Howrah

The WSP system at Ballay and North Howrah (Figure 2.2), which was commissioned in 1996, is similar to that at Titagarh. The design flow was 30 Mld, and the BOD and FC numbers 150 mg/l and 1×10^7 per 100 ml, respectively. The system comprises three series of anaerobic and facultative ponds, which discharge into two maturation ponds in parallel. Retention times, areas and depths are:

Anaerobic ponds:	1 day	
	1.5 ha	2 m
Facultative ponds:	4 days	
	7.8 ha	1.5 m
Maturation ponds:	3 days	
	6.0 ha	1.5m

As at Titagarh, the Ballay and North Howrah WSP are currently receiving only a third of their design flow, and fish culture is

Figure 2.2 View of WSP at Ballay North Howrah in the metropolitan Calcutta area.

practised in the facultative and maturation ponds. However, there is one important difference: fish culture is practised not by a local entrepreneur but by a co-operative of local farmers. Thus at these two WSP sites, CMWSA is investigating two different management systems for aquacultural reuse. This will permit the appropriate replication to be made in future projects of this kind.

2.2.3 Calcutta East wastewater-fed fishponds

The Calcutta East wastewater-fed fisheries (Figure 2.3) are the largest example of wastewater-based aquaculture in the world. Some 3000 ha of fishponds are fed with approximately 550,000 m^3/d of untreated wastewater by the local fisherman. They produce around 13,000 tonnes of fish (mainly Indian major carp, with some tilapia) per year. This represents 16 percent of the local demand for fish. Average yields are just over 4 tonnes of fish per ha per year, although some of the better managed fishponds produce over 7 tonnes per ha per year.

Currently Indian major carp (catla, *Catla catla*; mrigal, *Cirrhina mrigala*; and rohu, *Labeo rohita*) are stocked at around 3 fingerlings (weighing about 20 g) per m^2. The ponds are drained only very infrequently (once every 3-4 years), but fish of about 150-250 g (which is the size most commonly consumed by low-income communities) are harvested by siening each pond 2-4 times per week, some 3 months after stocking. As noted above, yields from the better managed ponds are up to 7 tonnes of fish per ha per year, but this is probably the upper limit using current practices.

These Calcutta East fishponds were developed by the local fishermen some 80 years ago to produce fish, rather than to treat the wastewater. It is a highly successful local enterprise, employing some 4,000 people. As it happens the practice is safe from the point of view of public health, since there are no locally endemic trematode infections, and faecal coliform levels in the fishponds are usually around 1000 per 100 ml (see Section 10.1). Further health protection is given by the local practice of cooking the fish by simmering it for 2-3 hours.

Detailed descriptions of the Calcutta East wastewater-fed fisheries are given by Edwards and Pullin (1990), Edwards (1992), Furedy and Ghosh (1983), Ghosh and Sen (1987, 1992) and Ghosh (1996).

Figure 2.3 The Calcutta East wastewater-fed fishponds: general views (top). The effluent from the fishponds is used partly for crop irrigation but mainly for the cultivation of rice (bottom).