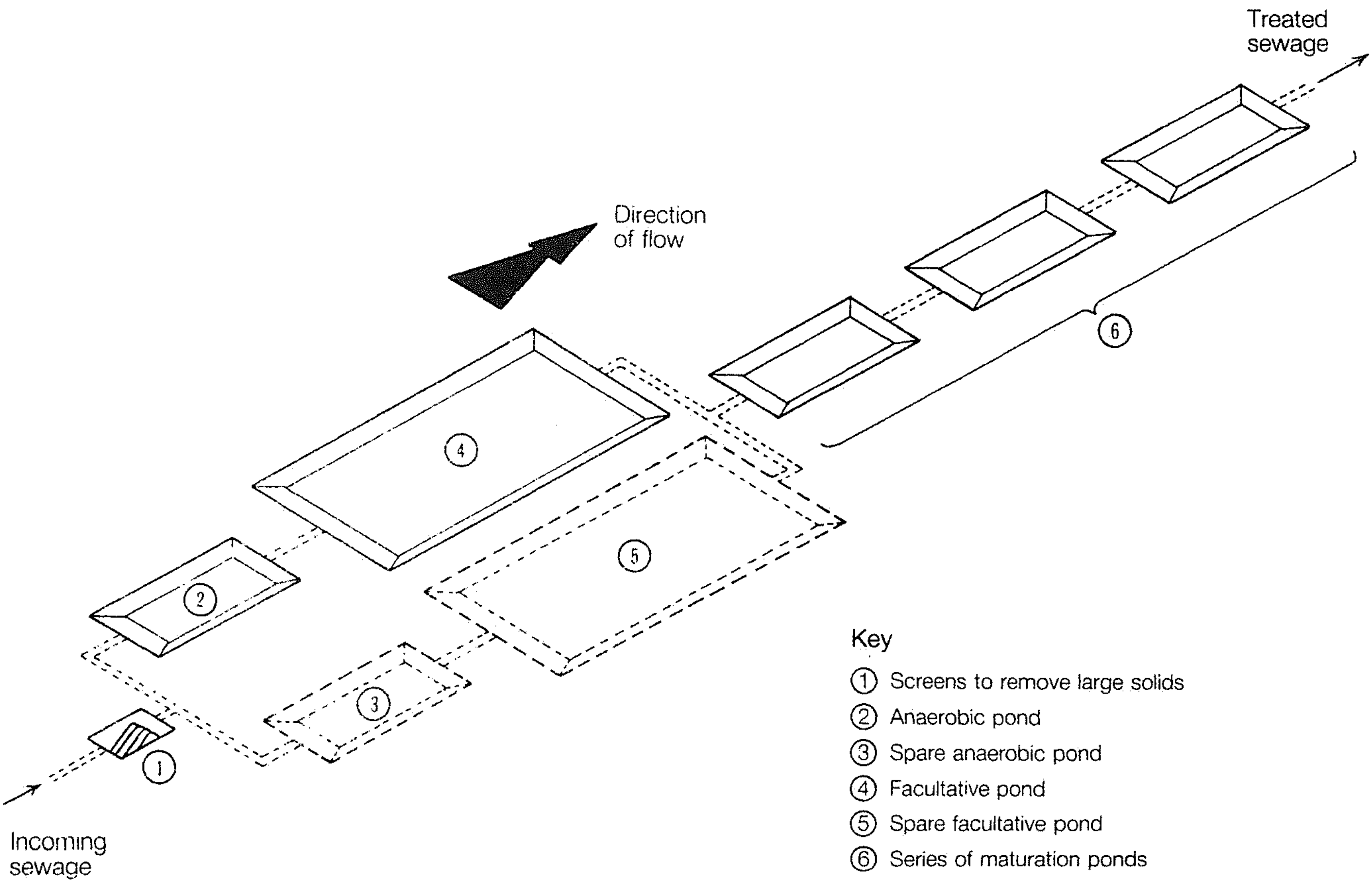
10. Waste stabilisation ponds

Waste Stabilisation Ponds (WSPs) are large, shallow, man-made lakes in which bacteria help to purify raw sewage.

A possible system of waste stabilisation ponds using several types of pond might look like this:



So that any pond may be isolated for maintenance work or to allow sludge to be removed, at least one extra pond of each type should be provided.

This system is suitable for treating sewage (household wastewater and excreta) from quite large communities.
Possible applications are:

1. Treatment of sewage collected by a network of sewers,
2. Treatment of sewage collected in small-bore sewers,
3. Treatment of nightsoil collected from a community.

WSPs take up large areas of land and so are suitable only where land is easily available.

Waste stabilisation ponds

Suggested design methods

1. Anaerobic ponds

Volumetric BOD loading rate (grams O_2/m^3. day)	$= \lambda_v$
Influent BOD strength (mg. O_2/litre)	$= L_i$
Influent flow rate (m³/day)	$= Q$
Pond volume (m³)	$= V$
Mean temperature of the coldest month (°C)	$= T$

$$\lambda_v = \frac{L_i Q}{V}$$

Find the appropriate value of λ_v from the following and calculate V.

$$T < 10°C, \quad \lambda_v = 100 \text{ grams } O_2/m^3\text{. day}$$
$$20°C > T > 10°C, \quad \lambda_v = (20T—100) \text{ grams } O_2/m^3\text{.day}$$
$$T > 20°C, \quad \lambda_v = 300 \text{ grams } O_2/m^3\text{.day}$$

2. Facultative ponds

Surface BOD loading (kg O_2/ha. day)	$= \lambda_s$
Mid-depth plan area of pond (ha)	$= A_f$
Influent BOD strength (mg. O_2/litre)	$= L_i$
Influent flow rate (m³/day)	$= Q$
Mean depth of pond (m)	$= D_f$
Mean retention time (days)	$= t_f$
Mean temperature of the coldest month (°C)	$= T$

Calculate λ_s from

$$\lambda_s = 350\ (1.107 — 0.002T)^{(T-25)}$$

Calculate $A_f = \dfrac{10L_iQ}{\lambda_s}$ or $t_f = \dfrac{10L_iD_f}{\lambda_s}$

3. Maturation ponds

No of faecal coliforms in effluent (No/100ml)	$= N_e$
No of faecal coliforms in influent (No/100ml)	$= N_i$
First order faecal coliform removal constant (days^{-1})	$= K_b$
Mean retention time in a pond (days)	$= t$
Mean temperature of coldest month (°C)	$= T$

$$N_e = \frac{N_i}{\text{(Product of } (1 + K_bt) \text{ for } all \text{ ponds in series)}}$$

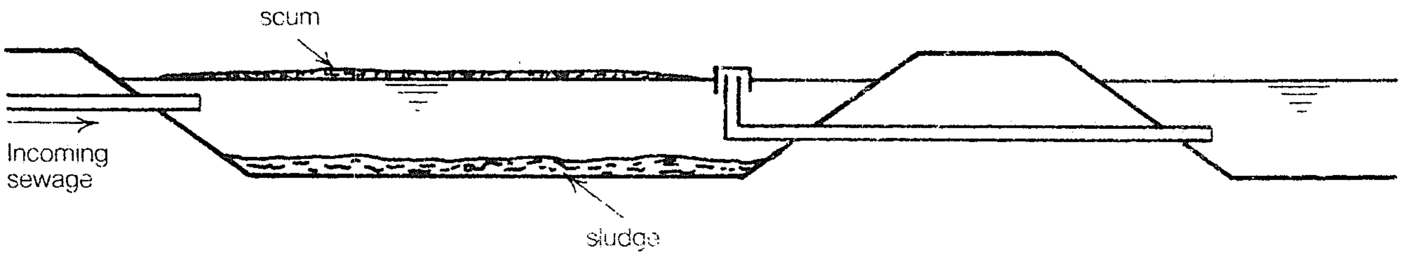
(Note: Anaerobic, facultative and maturation ponds are all considered in calculating the product of $(1 + K_bt)$.

$$K_b = 2.6\ (1.9)^{(T-20)}$$

Pond type	Typical Depth	Typical Retention Time
Anaerobic	2-5 metres	3-5 days
Facultative	1-2 metres	20-40 days
Maturation	1-2 metres	4-6 days for each of three or more ponds

The purification process

In very simple terms, incoming sewage which has usually been passed through metal screens to remove large solids, enters a system of ponds. Some of the wastes float to the surface as scum, while other wastes sink to the bottom as sludge. The first pond in a series would look like this, in section:



Over a period of time, bacteria living in the ponds feed on the wastes, partially treating them.

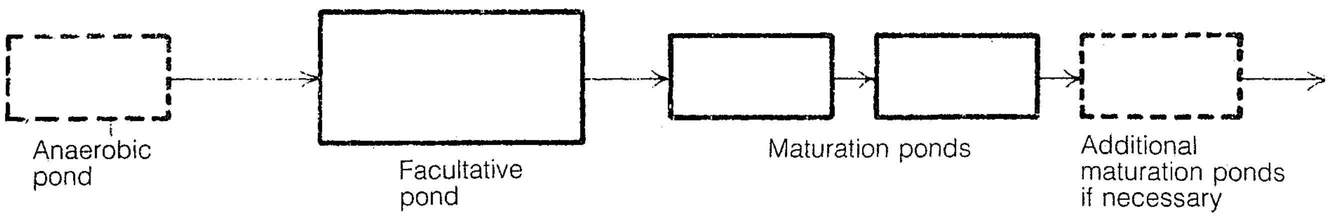
Sunlight is needed to encourage the growth of algae which are essential to the purification process in facultative ponds. Warm temperatures accelerate the treatment of wastes, and wind is important to ensure good mixing of the pond contents. WSPs work well in hot climates.

Pond form and layout

Ponds are often rectangular in plan, with depths varying from 1 to 6 metres. There are three types of pond which may be used:

1. Anaerobic ponds – used to pre-treat strong wastewaters (not always needed).
2. Facultative ponds – used to break down the organic matter in the sewage.
3. Maturation ponds – used to destroy faecal pathogens.

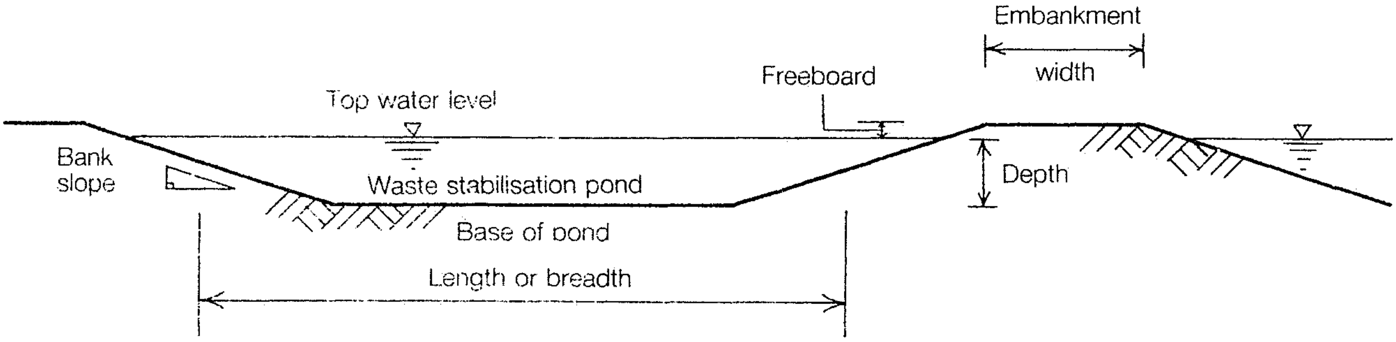
A typical System might be:



Anaerobic ponds perform the same function as septic tanks, so are not necessary if the sewage comes from septic tanks along small-bore sewers.

Waste stabilisation ponds

Design features



Depth: Typical ranges for pond depths are:

Anaerobic ponds	2.0 to 5.0 metres
Facultative ponds	1.0 to 2.0 metres
Maturation ponds	1.0 to 2.0 metres

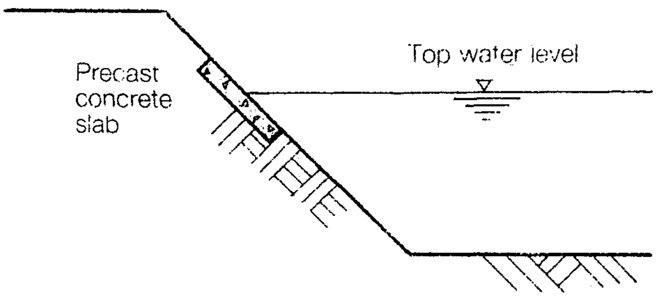
Length or breadth: It should be assumed that the length and breadth of a pond are measured at half depth.

Freeboard: A clear height of 0.5 metres should be provided between the top water level and the top of the embankment.

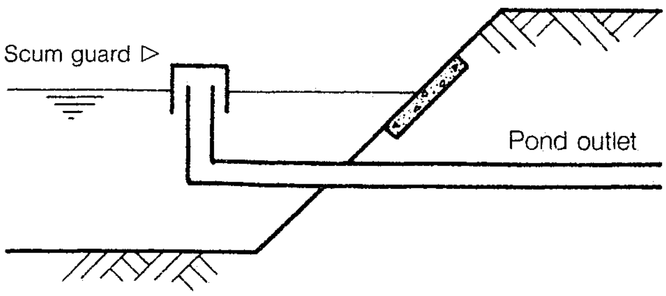
Bank slope: Embankment slopes should be at about 1:3.

Embankment width: Maintenance vehicles should be able to have access between adjacent ponds.

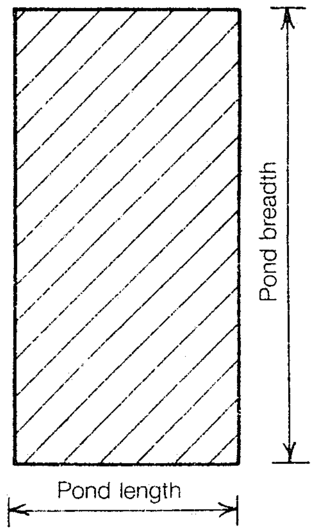
Base of pond: Pond bases should be impermeable, lined with clay, plastic, rubber or concrete, to prevent leakage and groundwater contamination.



Pre-cast concrete slabs should be laid at top water level around each pond to discourage growth of weeds and to prevent bank erosion caused by wave action.

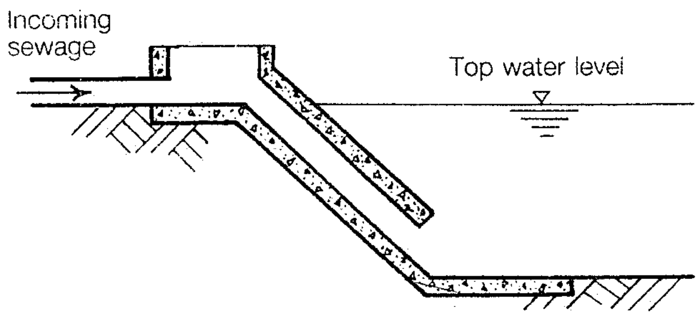


Scum guards should be provided around outlets from all ponds to prevent floating material from entering and possibly blocking the pipes.



In order to ensure that the pond contents are well mixed by winds the ratio of breadth to length should be in the range 1:2 or 1:3.

The inlet to a series of ponds should be constructed in concrete to prevent bank erosion, and should be designed so that sewage enters below top water level.



Maintenance

1. Any scum that collects on the pond surfaces should be removed and either buried or burned.
2. If screens or grit traps are used to collect the easily separated solid materials at the inlet to the ponds, the materials collected should be buried.
3. Grass around the ponds must be cut regularly.
4. Anaerobic and facultative ponds will require desludging every few years as necessary. (Anaerobic ponds every 3 to 5 years; facultative ponds every 10 to 15 years).
5. Some bird scaring may be necessary in order to reduce the likelihood of bird droppings polluting the partially treated sewage and also to reduce cross-pollution between ponds.

For further information:

Horan N.J. *Biological Wastewater Treatment Systems: Theory and operation,* John Wiley & Sons, Chichester, England, 1990.

Lumbers J. and Andoh B. *Waste stabilisation pond design,* Waterlines Vol. 3 No. 4, 1985.

Mara D.D. *Sewage treatment in hot climates,* English Language Book Society/John Wiley & Sons, Chichester, England, 1977.

Mara O.D. *Sewage treatment in hot climates,* Overseas Building Note No. 174, Building Research Station, Watford, England, 1977.

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