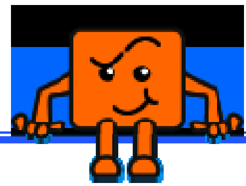
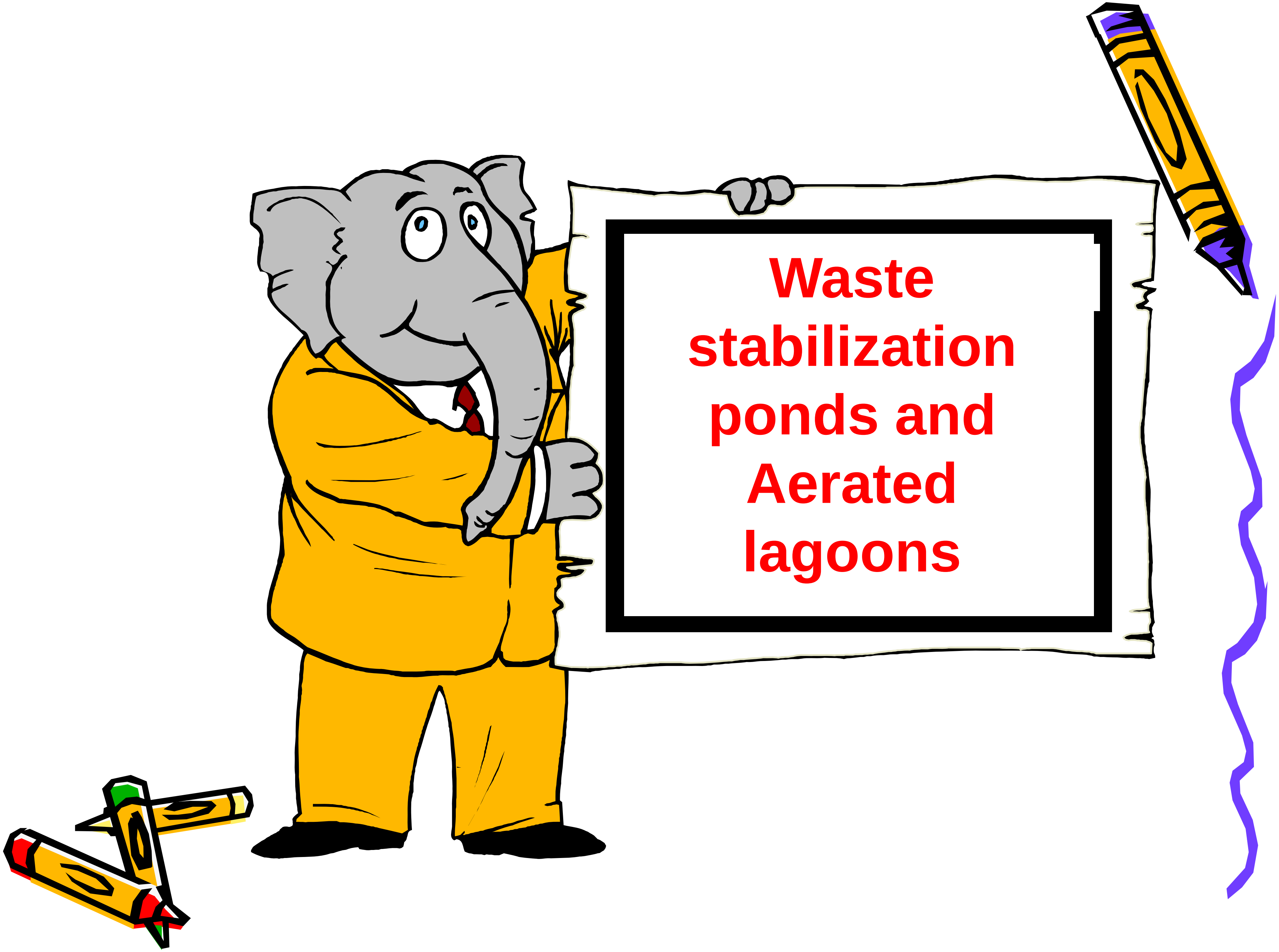
# Chapter-5-

Prof. Dr. Samir Afifi

## Waste Stabilization pond




Waste stabilization ponds and Aerated lagoons

# Waste Stabilization System

- Conventional treatment system have aerobic condition and designed to speed up the process of natural aeration and bio-oxidation by forced aeration

- Such systems require energy together with regular maintenance

- This system provides cheap alternative to conventional

## Cont. Waste Stabilization System

- In case where energy and maintenance not possible or not requirements, a waste stabilization pond system (SPS) can be apply
- SPS is Simplest forms of wastewater treatment system
- In the system , A complex biological ecosystem will be developed
- This system provides a cheap alternative to conventional processes

# What is Waste stabilization pond?

- **Requires only simple maintenance**

- **A large land requirement is needed**

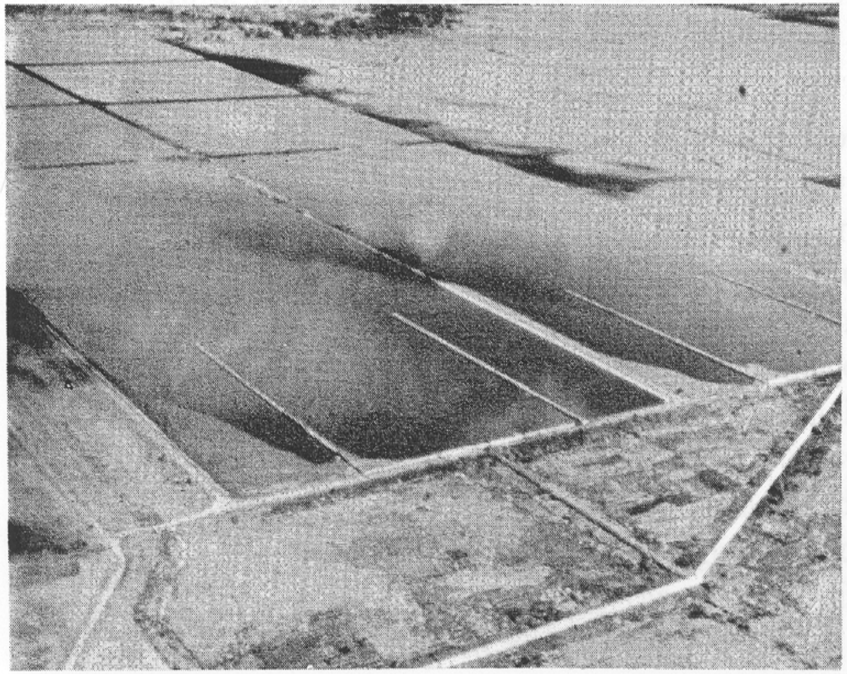


**Figure 10.1** Aerial view of the Dandora pond system in Nairobi, Kenya. The photograph shows two series of a facultative and three maturation ponds. The facultative ponds each measure $700 \times 300\,m^2$ and the maturation ponds are $300 \times 300\,m^2$, giving a total area of 96 ha. The ponds were designed to treat a flow of $30\,000\,m^3$/day with a design temperature of 17 °C. (Photograph courtesy of D.D. Mara.)

# What is Waste stabilization pond?

- **Waste stabilization pond is a shallow excavation**

- **Receives a continues flow of wastewater**

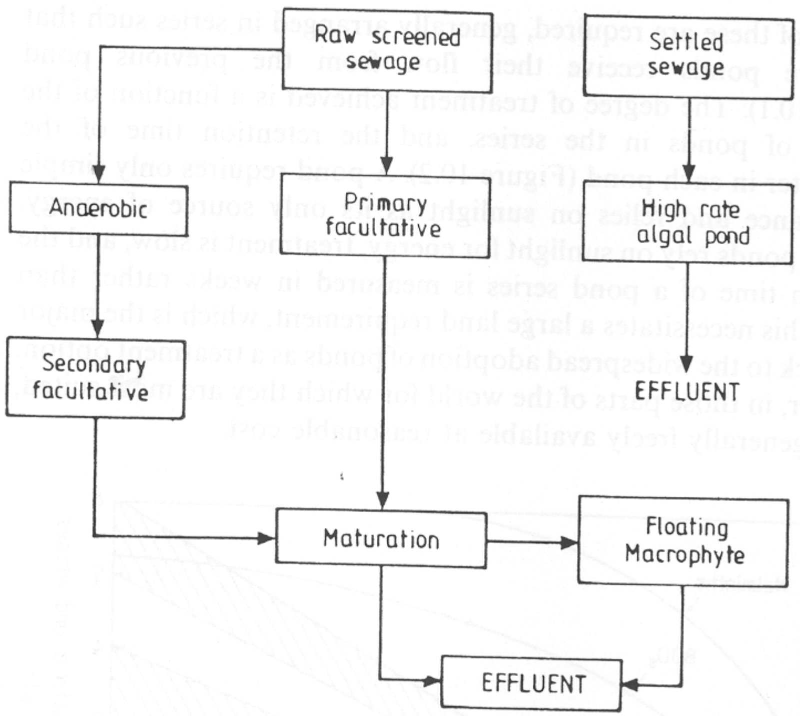
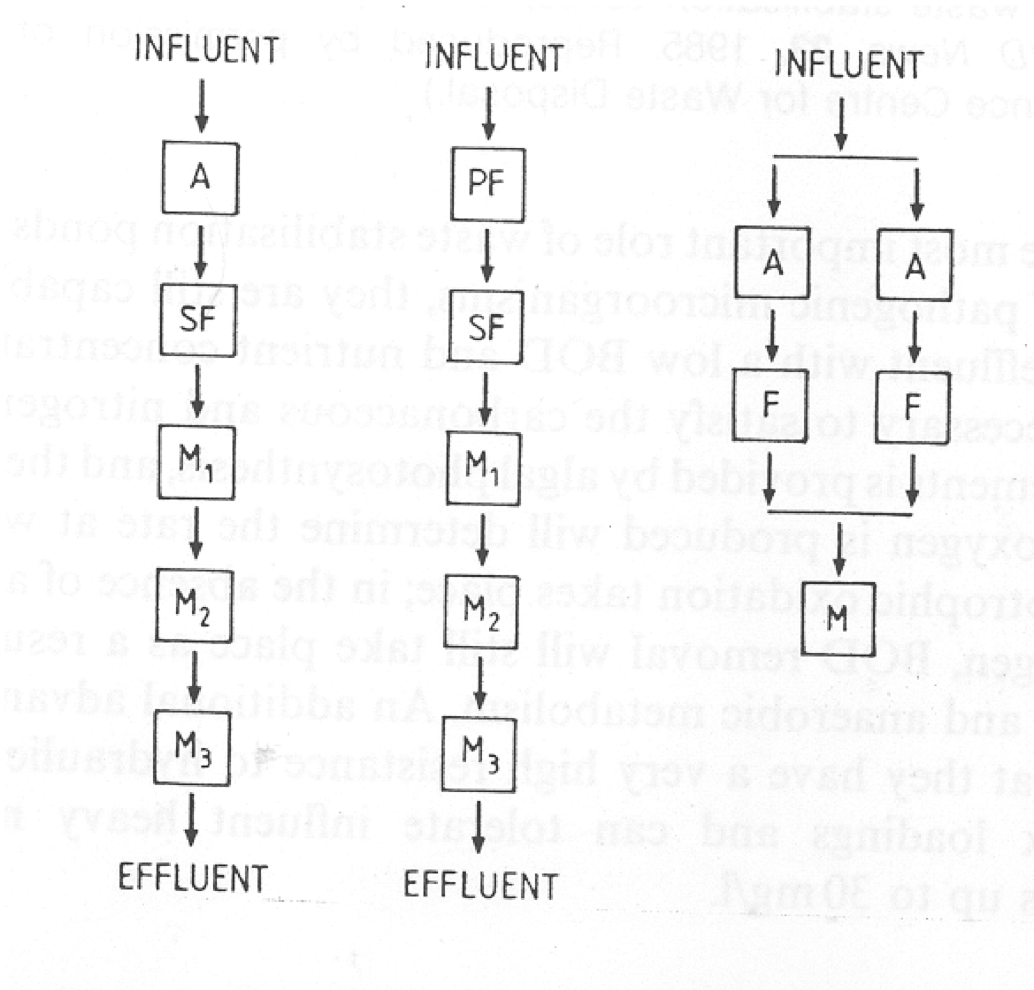



**Figure 10.3** A simple classification of the major pond types based on the influents they receive.

# What is Waste stabilization pond?

- A number of these arranged in series one receive their flow from the previous



# What is Waste stabilization pond?

- Treatment degree is a function of the number of ponds in the series

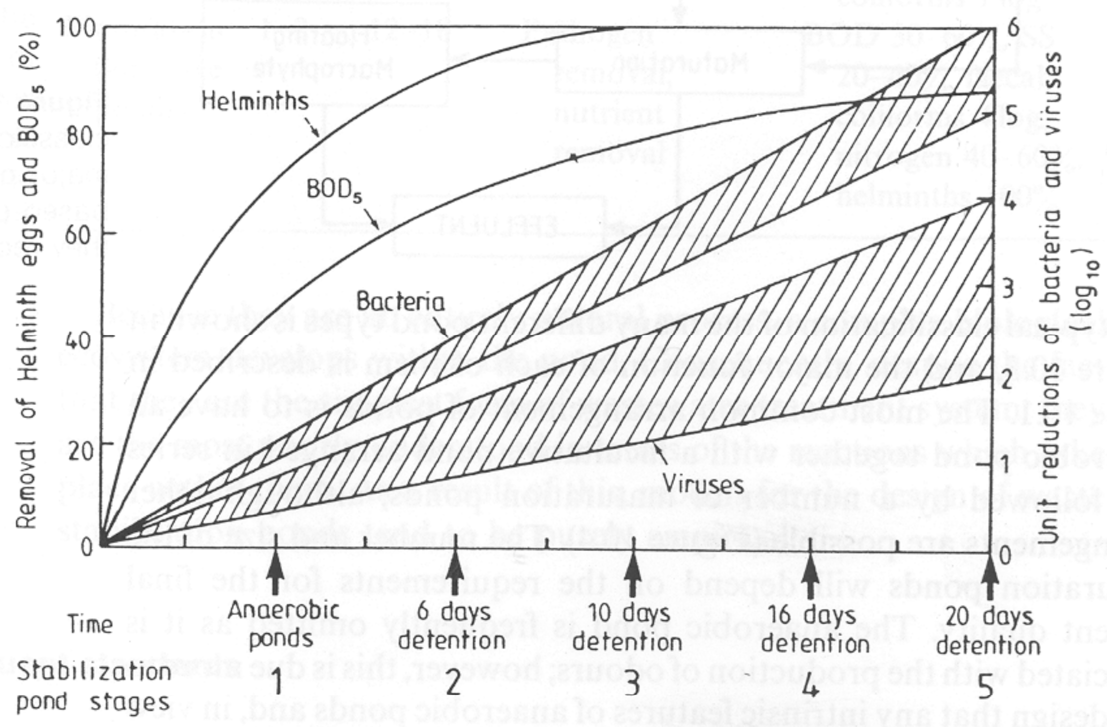



**Figure 10.2** Generalised curve for the removal of organic material and excreted pathogens across a waste stabilisation series, for temperatures in excess of 20 °C. (From *IRCWD News*, **23**, 1985. Reproduced by permission of the International Reference Centre for Waste Disposal.)

- The most important role of the system to remove pathogenic micro-organisms

# What is Waste stabilization pond?

- The most important role of the system to remove pathogenic micro-organisms

**Table 10.1** The principal functions of the main pond types and their typical performance and operating data.

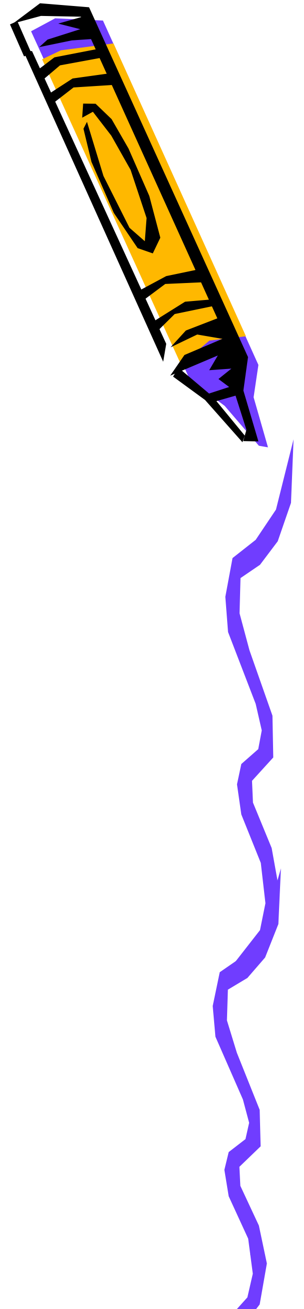
| Pond type | Depth (m) | Retention time (d) | Major role | Typical removal efficiencies |
|---|---|---|---|---|
| Anaerobic | 2–5 | 3–5 | Sedimentation of solids, BOD removal, stabilization of influent, removal of helminths | BOD 40–60%, SS 50–70%, faecal coliforms 1 log, helminths 70% |
| Facultative | 1–2 | 4–6 | BOD removal | BOD 50–70%, SS increases due to algae, faecal coliforms 1 log |
| Maturation (for three ponds) | 1–2 | 12–18 | Pathogen removal, nutrient removal | BOD 30–60%, SS 20–40%, faecal coliforms 4 log, nitrogen 40–60%, helminths 100% |

## Cont. What is Waste stabilization pond?

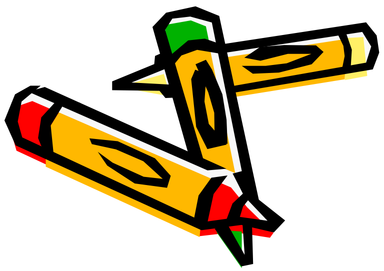
- The system producing an effluent with a low BOD and nutrient concentration
- Oxygen source natural, atmosphere and alga
- The system has a very high resistance to hydraulic and organic shock loading
- <u>BOD removal:</u>
    - Aerobic heterotrophic oxidation
    - Sedimentation and
    - Anaerobic metabolism

# Waste stabilization pond

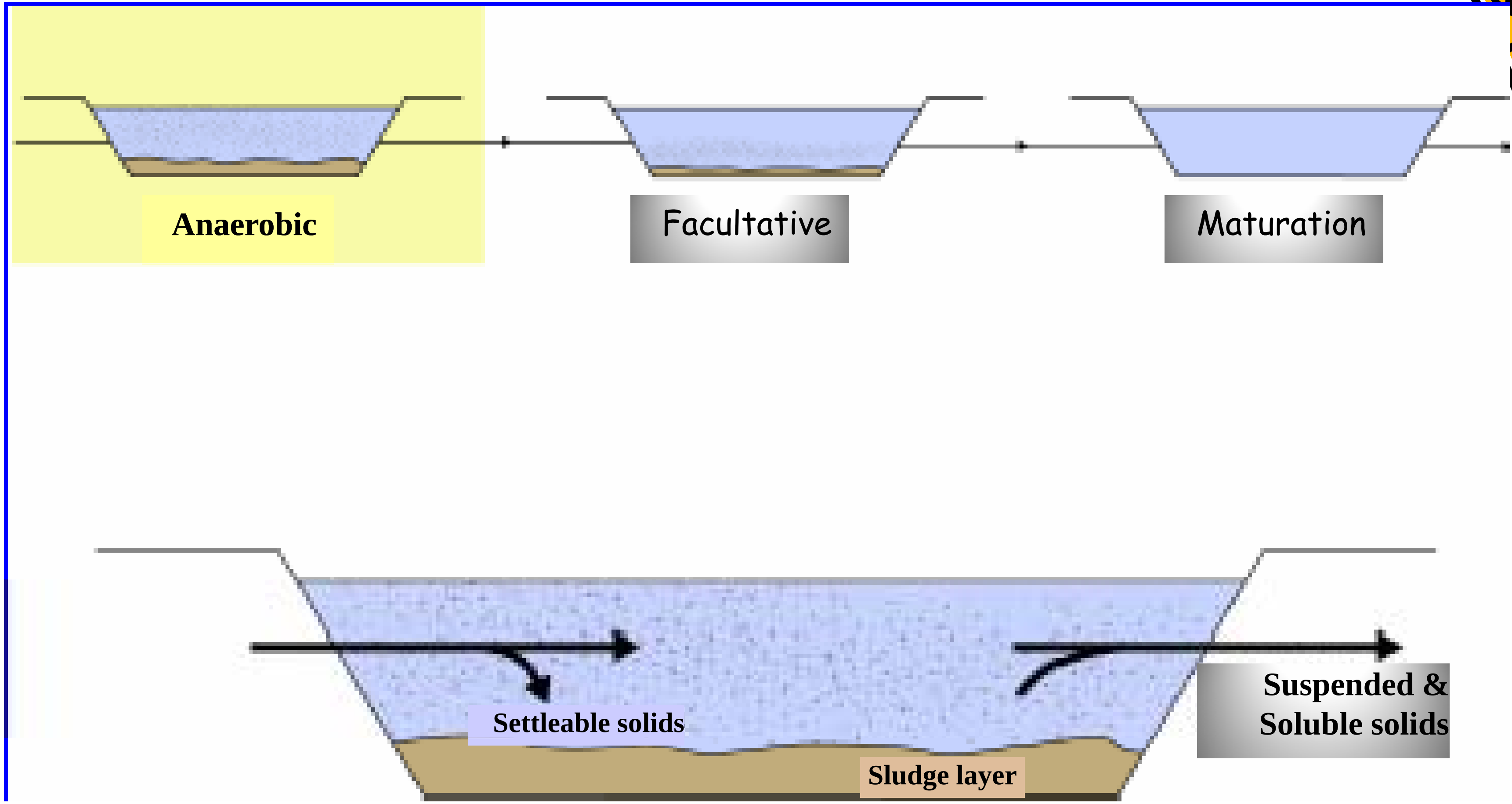
# The Main Ponds Types



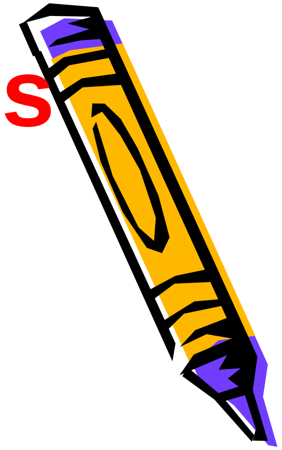
- Anaerobic Ponds
- Facultative Ponds
- Maturation Ponds



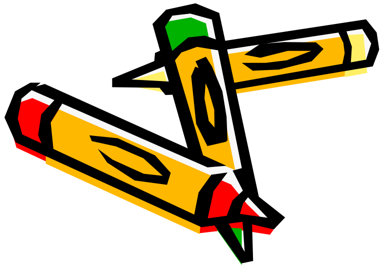
# Three processes of stabilization: anaerobic



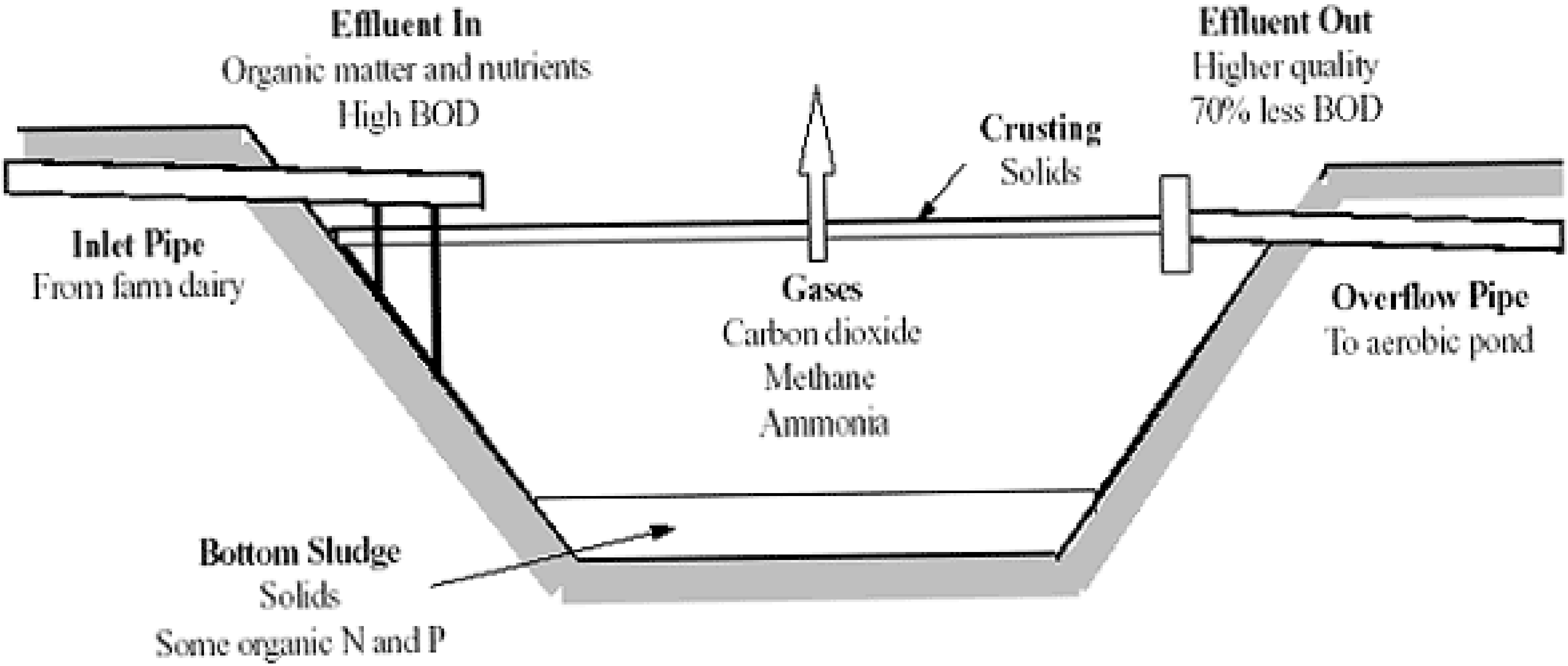
# Characteristics of Anaerobic ponds



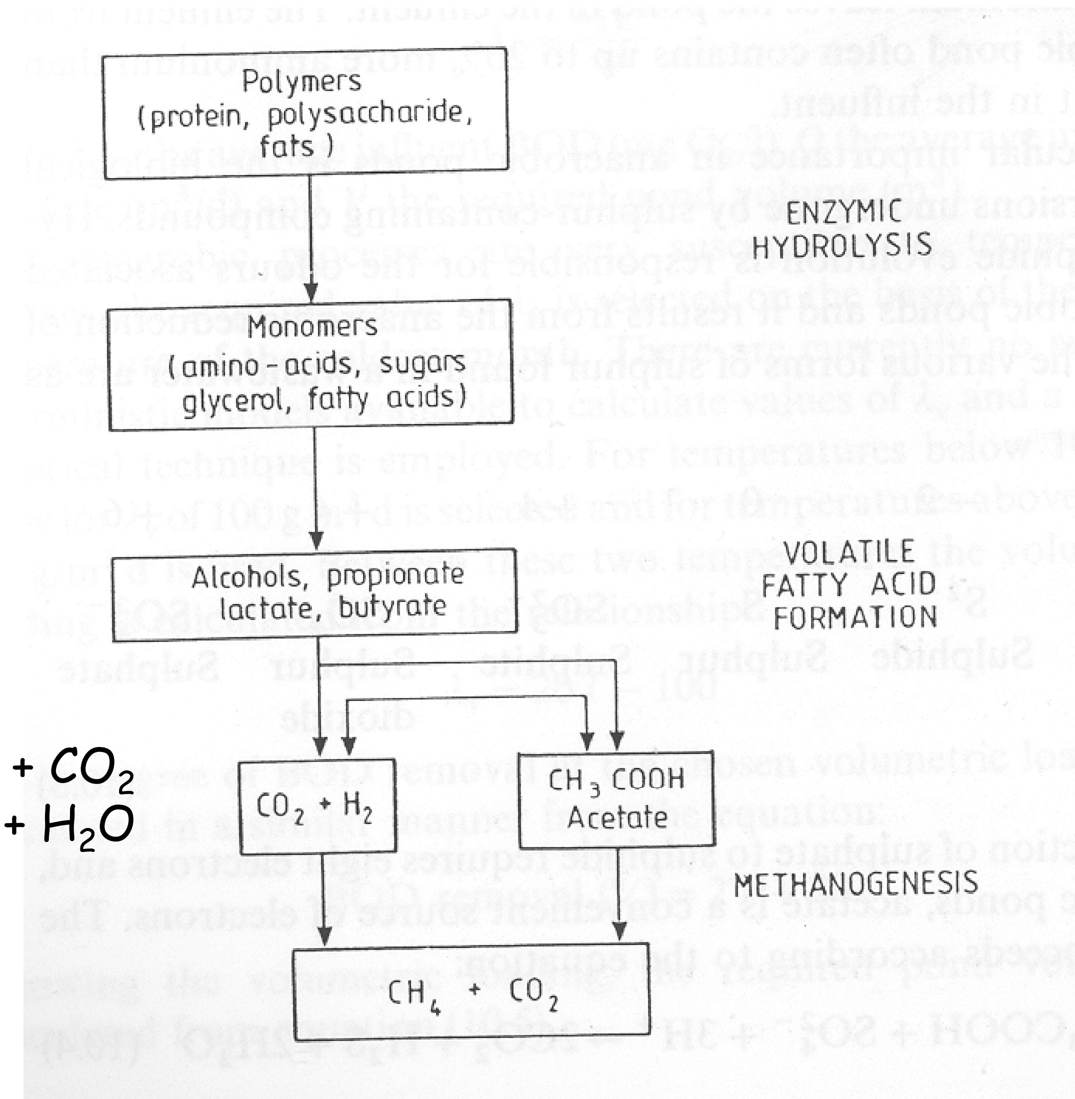
- ✓ **Lack of dissolved oxygen**
- ✓ **Micro-organism (facultative and strictly anaerobic)**
- ✓ **Degradation of organic matter by fermentation**
- ✓ **Production of volatile acids (putrefaction acids)**
- ✓ **BOD removal through methanogens**



# Characteristics of Anaerobic ponds



# The Fermentation Pathway of Organic Material Degradation




$$CH_3COOH \rightarrow CH_4 + CO_2$$

$$CO2 + 4H_2 \rightarrow CH_4 + H_2O$$

## Factors Effects Role of Methanogens in the Anaerobic Ponds

- **PH (6.2-8)**
- **Temperature**

***Both parameter used to calculate the organic loading***

# Operation:

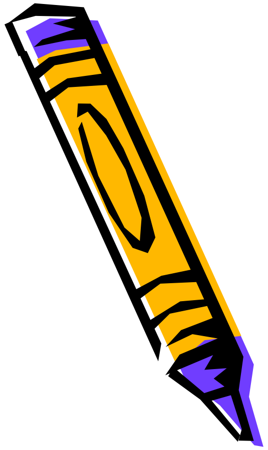
1- **BOD-Removal (60%)**

- **Sedimentation**
- **Anaerobic organic matter degradation**

2- **N-Removal**

- **No Nitrification**
- **Ammonification**

# Operation:



## 3- SULPHUR

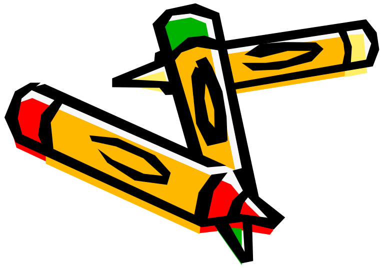
***The various forms of sulphur found in a wastewater are as follows:***

| | | | | | |
|---|---|---|---|---|---|
| ***Oxidation Number*** | ***-2*** | ***0*** | ***+4*** | ***+4*** | ***+6*** |
| ***Formula*** | $S^{2-}$ | $S$ | $SO_3^{2-}$ | $SO_2$ | $SO_4^{2-}$ |
| ***Name*** | ***Sulphide*** | ***Sulphur*** | ***Sulphite*** | ***Sulphur Dioxide*** | ***Sulphate*** |

***Oxidation*** →

← ***Reduction***

Hydrogen sulphide evolution is responsible for the odorous associated with anaerobic ponds



## Odour problems :

- Very high loadings, up to 1000g $BOD_5/m^3d$, with wastewater containing sulphate concentrations in excess of 500 mg/l, the production of $H_2S$ is likely to cause odour problems.
- In the case of typical municipal sewage, it is generally accepted that a maximum anaerobic pond loading of 400g $BOD_5/m^3d$ will prevent odour nuisance

# Design

## 1- Volumetric Organic Loading ($\lambda$) {g BOD/m$^3$.d} is:

$$\lambda = L_i\,Q/V$$

**where:**

**$L_i$ = Influent $BOD_5$, mg/l,**

**Q = Influent flow rate, m$^3$/d, and**

**V = Pond volume, m$^3$**

***since $V/Q = t_{an}$, the retention time:***

$$\lambda = L_i/t_{an}$$

# Design

## 2- Temperature

$$\lambda \text{ (g BOD/m}^3\text{.d)} = 20T - 100$$

$$BOD\% = 2T + 20$$

***Organic loading & % Removal is function of temperature***

***Removals of $BOD_5$ in anaerobic ponds will be in the range 40% below 10°C, at a design loading, $\lambda$ of 100 g/m$^3$d, and 60% above 20°C, at a design loading of 300 g/m$^3$d,***

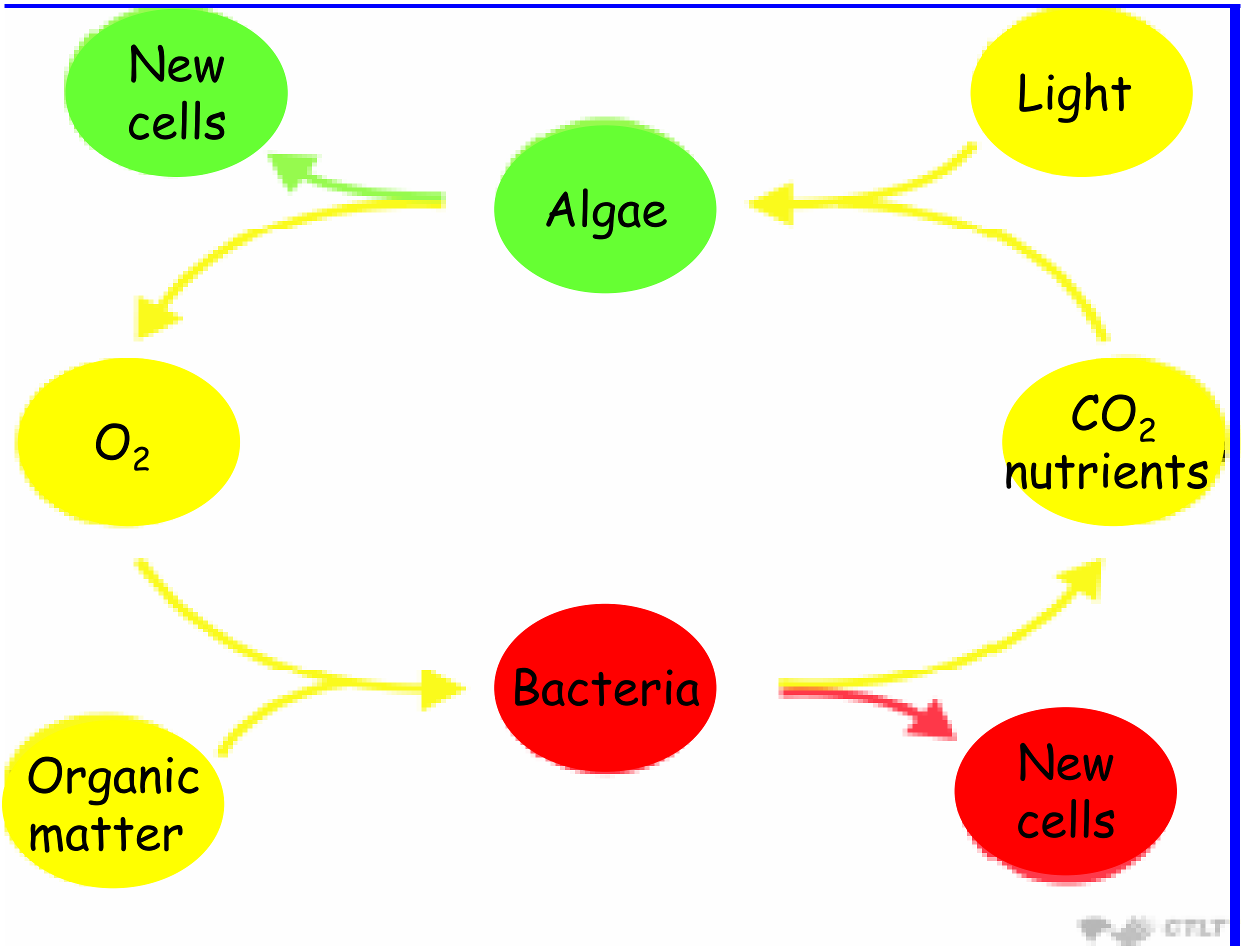
***pH is the other environmental conditions in the ponds pH, must be suitable for the anaerobic microorganisms bringing about the breakdown of BOD.***

# Facultative ponds

- **Major Role: BOD removal**

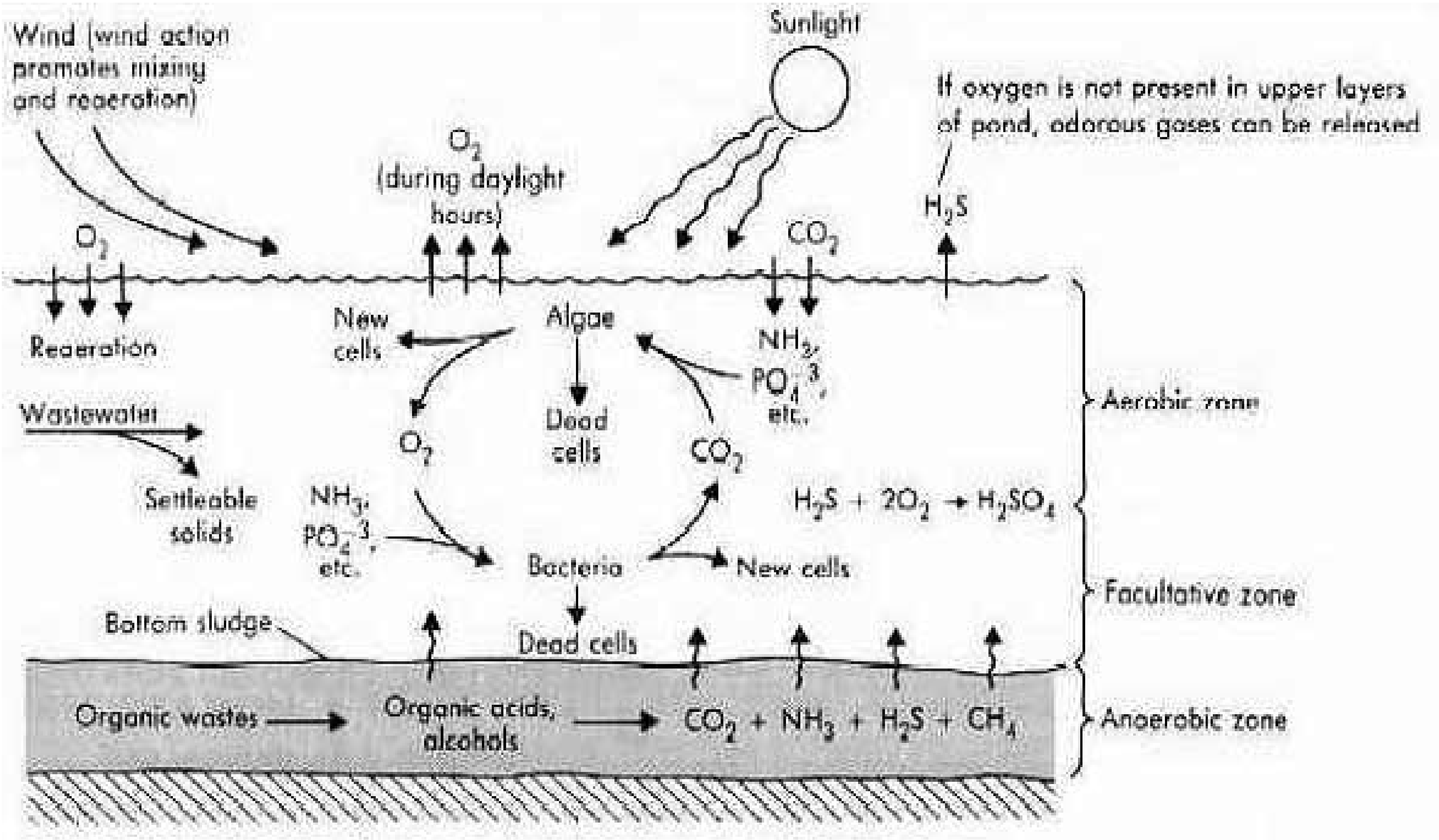
- **Aerobic and anaerobi n**
- **Nutrient cycling**

# Oxygen supplied

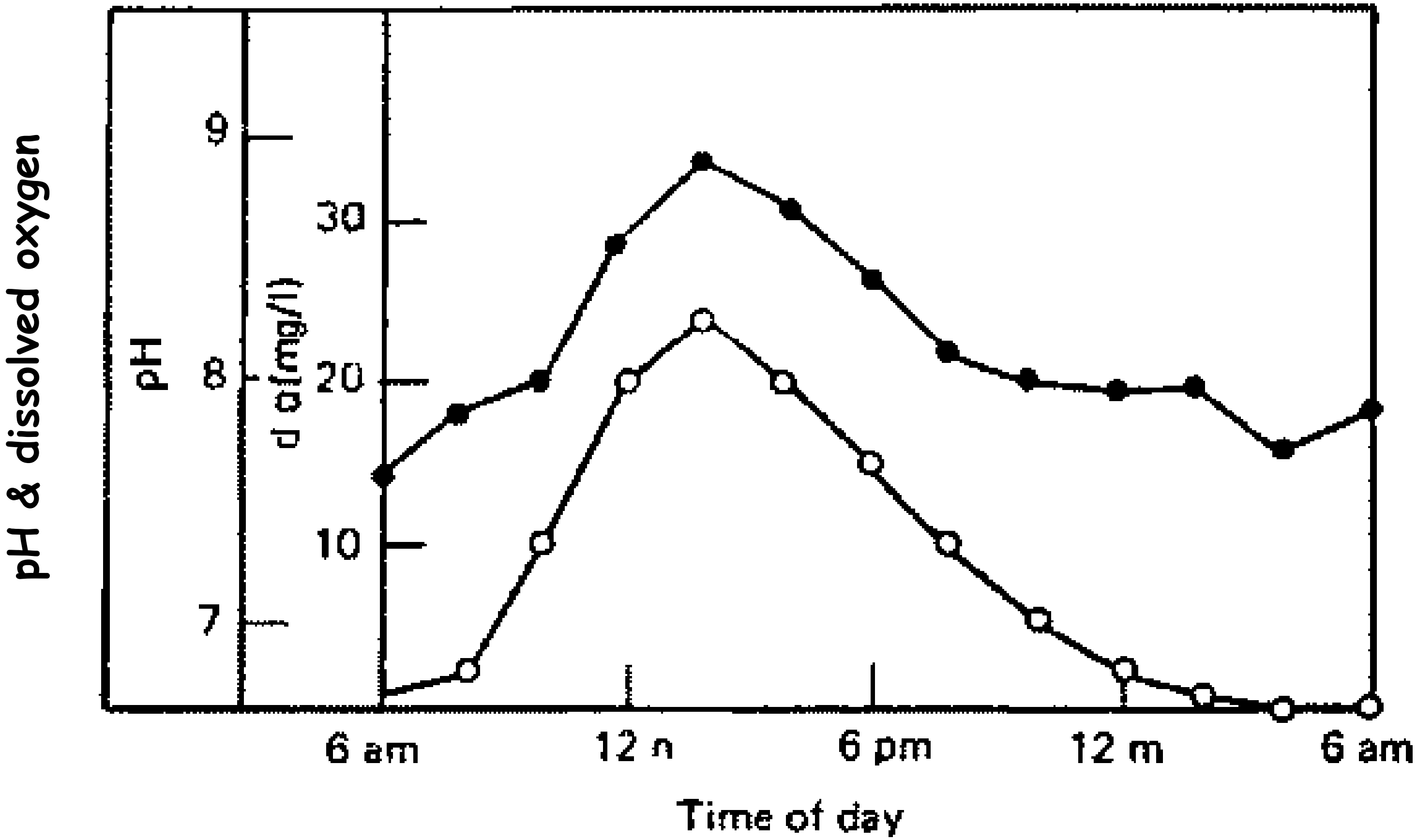


**The amount of oxygen present in the pond depends upon the following factors:**

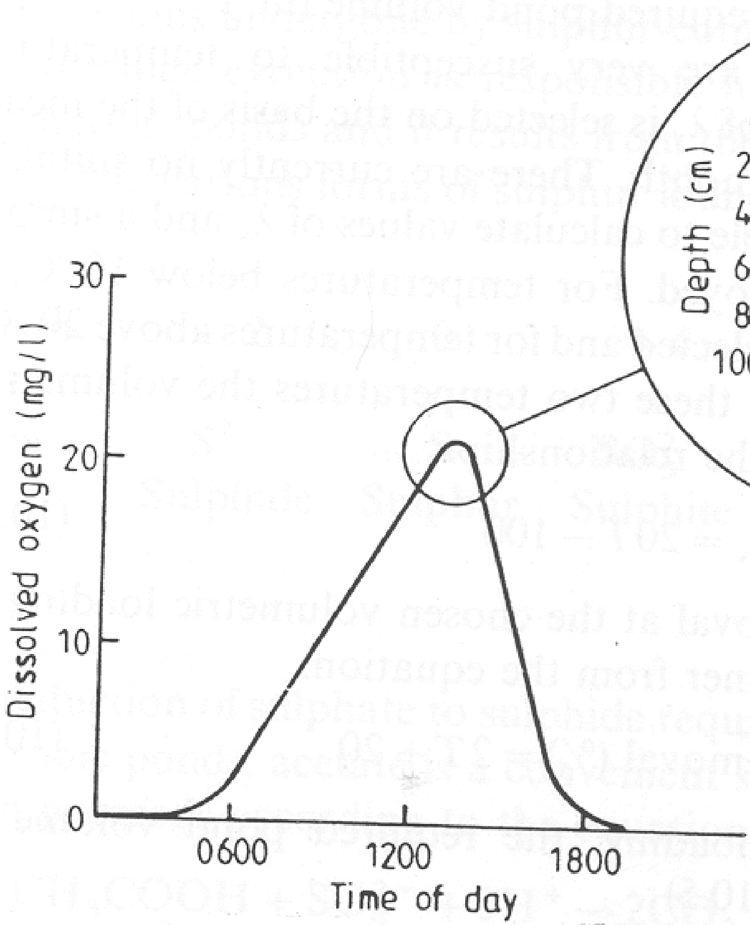
- ***Temperature***
- ***Organic loading***
- ***Sunlight***



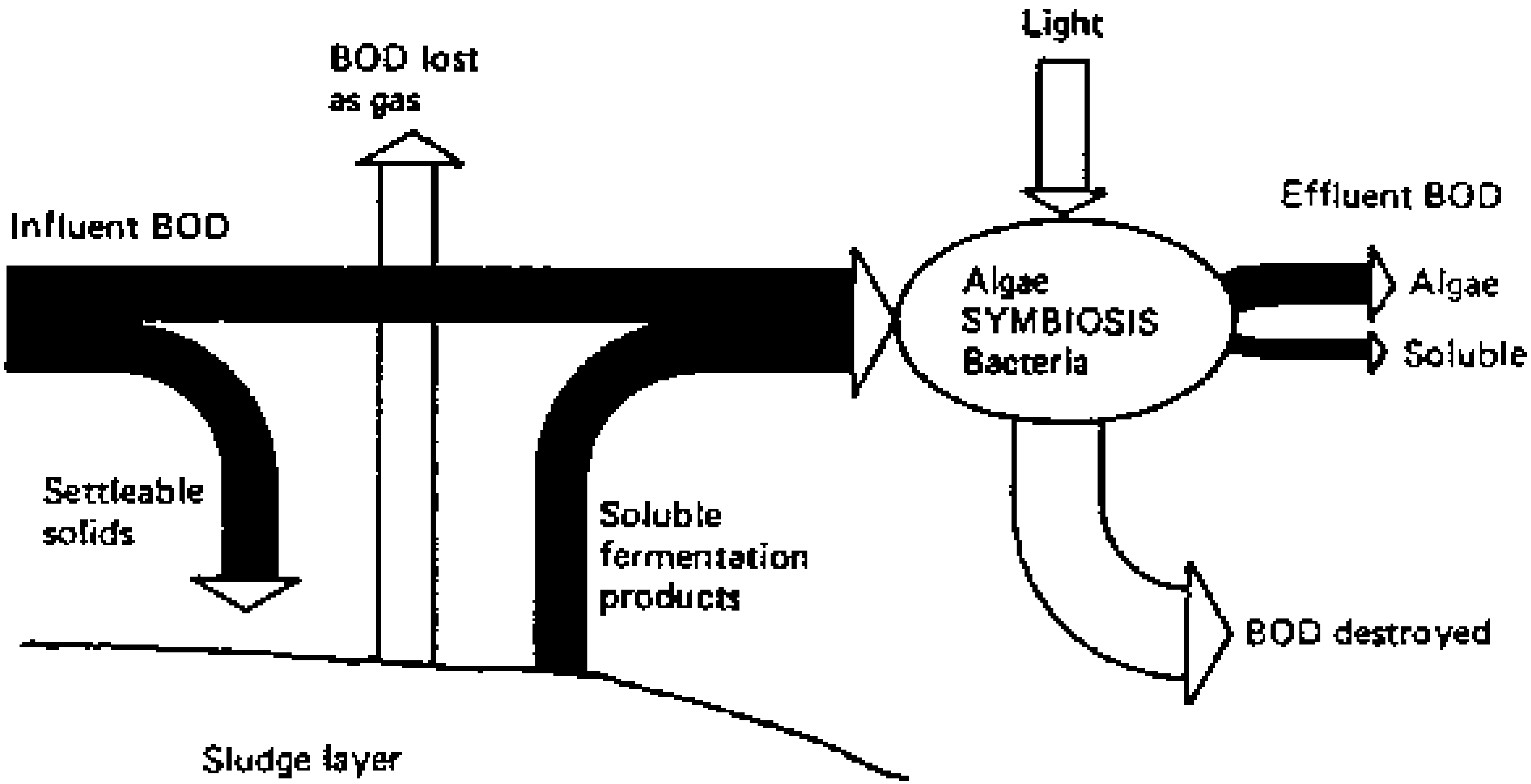
## Variation of dissolved oxygen and pH in facultative pond (*pH: ·, dissolved oxygen: o*)



# Variation of dissolved oxygen



# *Energy flows in facultative stabilization ponds*



- **NOD-Removal**
  - **Sedimentation**
  - **Aerobic anaerobic**
  - **Gaseous ammonia (volatilization)**

$$NH_4 + OH^- \rightleftharpoons NH_3 + H_2O$$

- **Sulphur Removal**
  - **In sedimentation layer**

$$CH_3\text{-}COOH + SO_4^{-2} + H^+ \xrightarrow{\textit{(Anaerobic)}} CO_2 + H_2S + H_2O$$

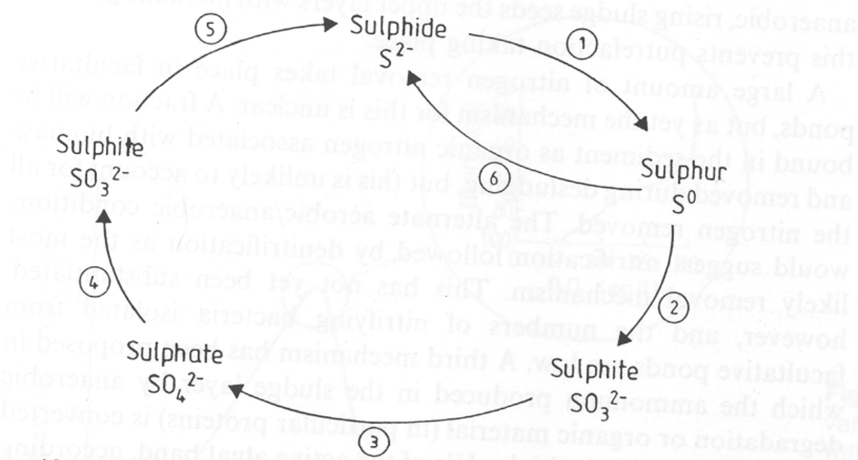



**Figure 10.7** A simplified sulphur cycle which operates in a facultatively anaerobic pond. Reactions 1–6 are carried out by the following representa-ive organisms: (1) *Beggiatoa, Thiobacilli*, photosynthetic sulphur bacteria; 2) *Thiobacilli*; (3) *Desulfovibrio, Thiobacilli*, (4) sulphate-reducing bacteria *Desulfovibrio, Desulfotomaculum*); (5) sulphate-reducing bacteria (*Desul-ovibrio, Desulfotomaculum*); (6) *Desulfuromonas, Campylobacter*.

- **In aerobic layer**

  $H2S \longrightarrow S$ (colorless S.B)

- **In anaerobic**

  $H2S \longrightarrow S$ (purple and green)

**Concentration of $H_2S$ (8ms)**

Reduction

| Oxidation numper | formula | Name |
|---|---|---|
| -2 | $S^{-2}$ | Sulphide |
| 0 | S | Sulpher |
| +4 | $SO_3^{-2}$ | Sulphate |
| +4 | $SO_2$ | Sulpher dioxide |
| +6 | $SO_4^{-2}$ | sulphate |

Oxidation

# Maturation Ponds

- **Removal of pathogenic (viruses, Bacteria, and Helminthes).**

- **Long retention time**

- **Sedimentation is the mechanism of Helminthes**

✓ **Scares eggs (20-70um)**

✓ **Protozoa cysts (Giaradia) 14um**

- The major mechanism for viruses removal is Adsorption on organic material fallowed by sedimentation

- Mechanism for facial coli form removal

✓ **Nutrient starvation**

✓ **Enhanced pH**

✓ **High dissolved oxygen**

✓ **Health UV radiation**

✓ **Protozoa predation**

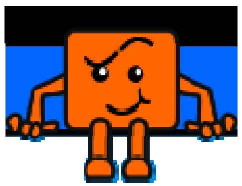
- **Nutrient Removal**

✓ **Up-take through algae and sedimentation**

✓ **Chemical precipitation of P**

# Considerations in pond Design

**Mixing**
**and**
**short-circuiting**



# Mixing

- Facilitate wind-induced mixing
- Chose the site
- Anaerobic pond  1000m
- Facultative pond 500m

## Short-circuiting

- Stagnate zones reduce the pond volume
- Inlet and outlet
- Formation of sludge banks
- Plug-flow mixing by baffles placed
- Elevated inlet pipes

# *Specialized pond types*

## 1- Macrophyte ponds

- **Floating Macrophyte**
- **Attached or rooted Macrophyte**

# Specialized pond types

## 2-High-rate algal ponds (HRAP)

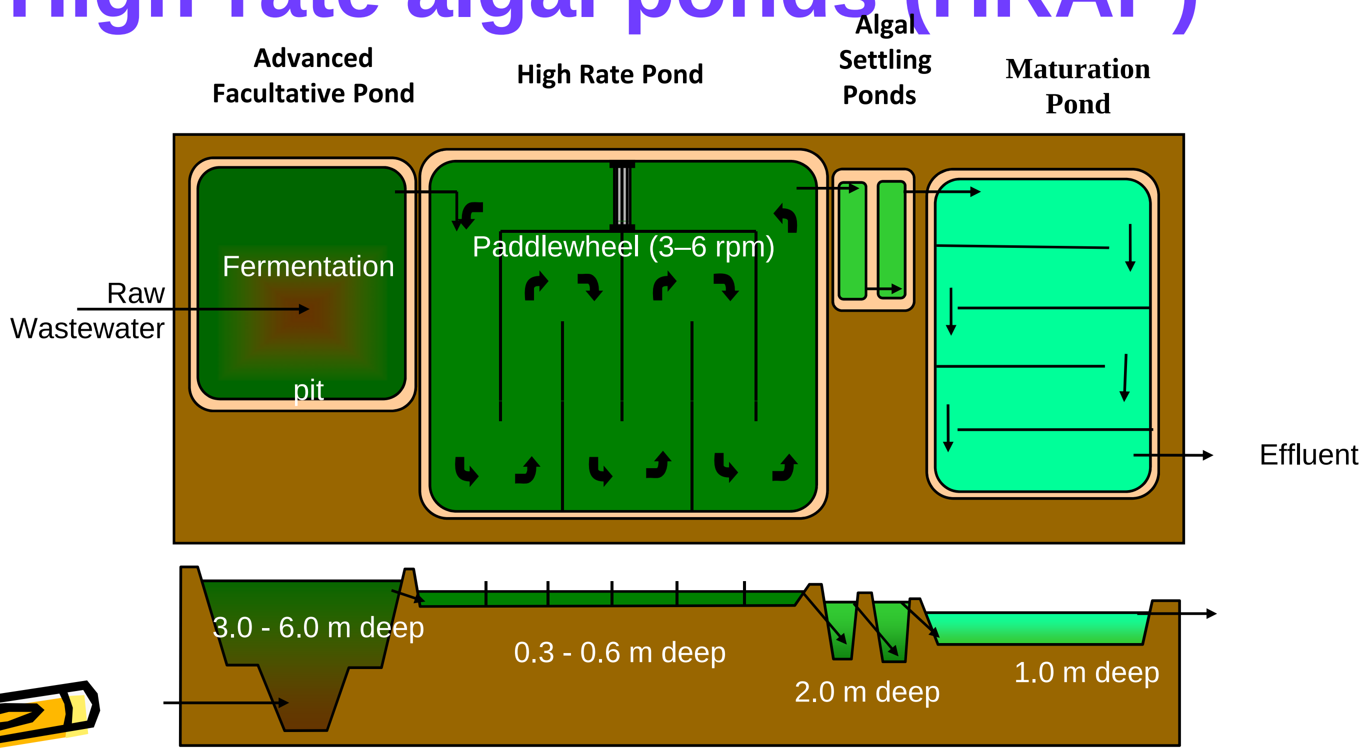
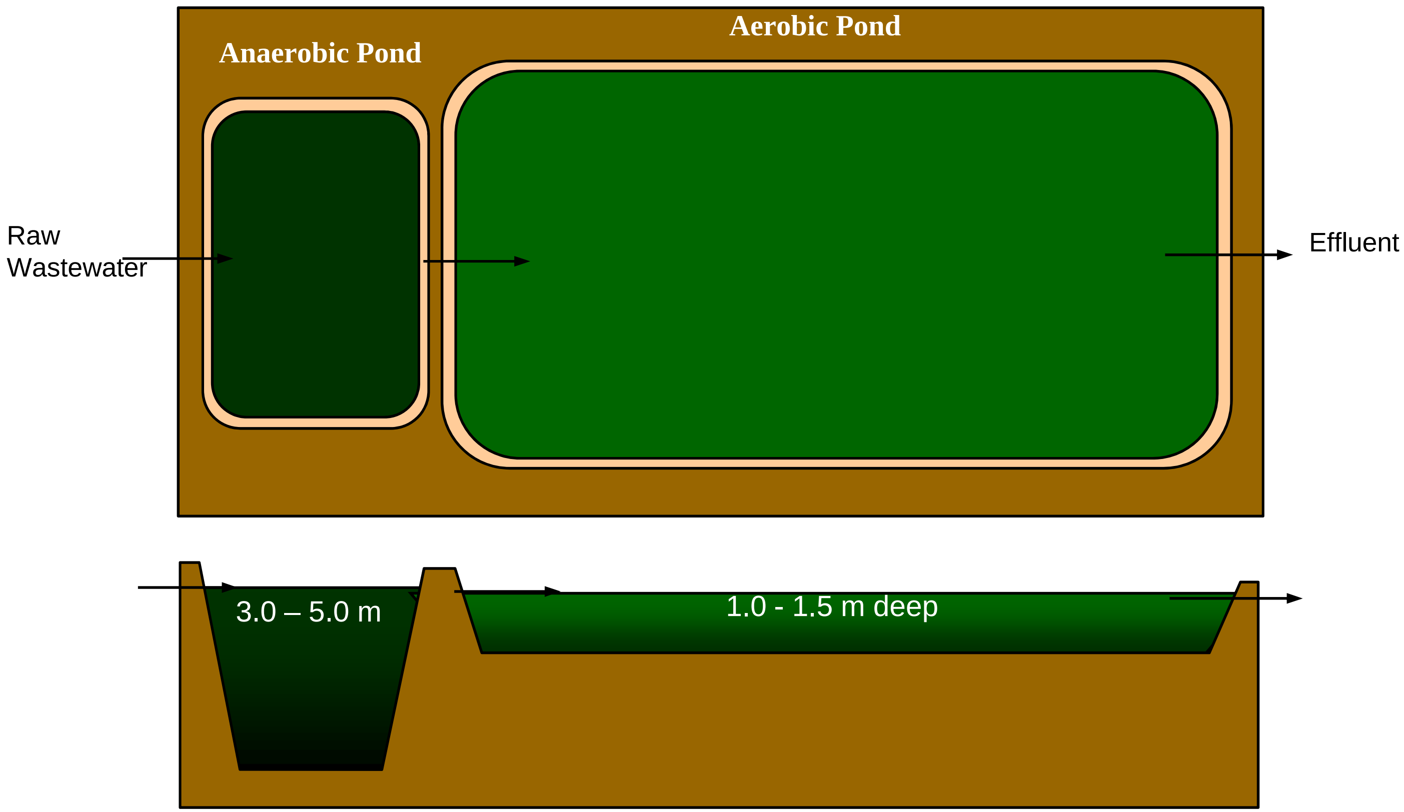



**Figure 2:** Schematic diagram of an Advanced Pond System (APS).

# Aerobic ponds

# Aerobic ponds



# QUIZ

# True or false:

1) Stabilization pond provides a cheap alternative to conventional processes

2) Waste stabilization pond Receives a continues flow of wastewater

3) Degradation of organic matter by fermentation  in aerobic bond

4. **short retention time must be in maturation pond**

5. **Considerations in maturation pond Design Mixing and long-circuiting**