University of Zambia

School of Engineering

Department of Civil and Environmental Engineering

CEE 4412: Environmental Engineering I

NON-CONVENTIONAL TREATMENT METHODS

JMT

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UNZA

Non Convention Methods

OBJECTIVES

- To equip students to design, operational and maintenance aspects of non-conventional wastewater treatment systems-Wastewater Stabilisation Ponds

TYPES

- Oxidation ditches
- Aerated lagoons
- Waste stabilisation ponds

Non- Conventional Methods

- Both Oxidation ditches and aerated lagoons are modifications of the conventional systems. Details pg 241-245

Wastewater Stabilisation Ponds

- Natural treatment of wastewater

Layout

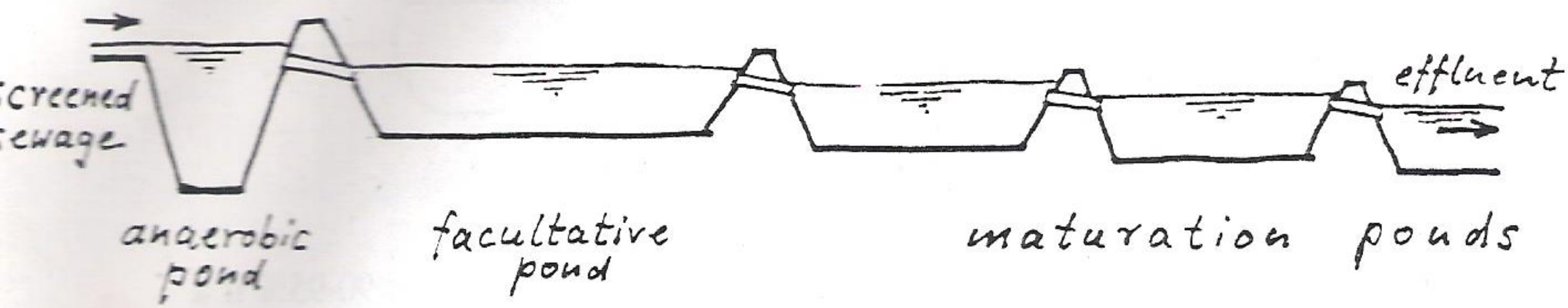

Figure 64. Waste stabilization ponds system.

- Important factors to look out for in order to have effective performance include: Retention time; layout-Short circuiting-Multiple inlets

Types of Ponds in WWSP System

- The anaerobic ponds
- The facultative ponds and
- The maturation ponds

Anaerobic Ponds

- Open unmixed basins designed to enhance the settling and biodegradation of particulate organic solids by anaerobic digestion.
- Usually 3 to 5 m deep
- Hydraulic retention time typically 1-3days.
- Reduce strength of raw sewage going to facultative ponds.

Anaerobic Ponds –What goes on?

- Removal of suspended solids
- Anaerobic digestion of solid
- Microbiological treatment- i.e. removal of helminth's eggs and cysts through sedimentation
- Removal of SS including oil and grease –Retention
- Gases are released (methane and CO_2) and are dispersed into the atmosphere.
- Sludge drying and de-sludging at least once every 3-5 years.

Treatment Mechanism

Anaerobic ponds aim at removing settleable solids. However, based on their functions, they are comparable to

- ❖ Screens and grit chambers
- ❖ Primary settling tanks
- ❖ Sludge thickeners
- ❖ Anaerobic sludge digesters
- ❖ Sludge drying facilities

Treatment Mechanism Cont'

- TSS removal = 50 - 70%.
- BOD removal temperature and retention time dependent and varies from 40 - 60%.

Design

- The most common approach in the design of anaerobic ponds is to calculate the volumetric organic loading rate based on the lowest monthly average sewage temperature measured as in the table below

Design Table

Minimum monthly ambient temperature (^{0}C)	Volumetric organic loading rate λ_v (in g $BOD_5/m^3.d$)	BOD_5 removal (%)
< 10	100	40
10 - 20	20T - 100	2T + 20
> 20	300	60

Design Cont'

Calculating Pond Area

$$A = \frac{S_i Q}{\lambda_v D}$$

Area = Load/Depth*Volumetric Organic Loading Rate

Design Cont'

- where
- Q = hydraulic loading (m^3/d)
- Si = influent BOD_5 concentration (mg/l)
- λv = Volumetric organic loading rate (g BOD5/m^3.d)
- D = Average pond depth (m)
- A = Surface area of anaerobic pond (m^2)

Other Design Considerations

- Pond depth = 3 -5m.
- The minimum HRT = 1- 3 days.
- The l/W ratio of the ponds = 2-3.
- At least two ponds in parallel arrangement

* In anaerobic ponds, FC removal is about 1 log unit achieved through the settling

Facultative Ponds

- Largest ponds in the system
- Can be receptors of raw sewage if the sewage is not very strong

- Why Facultative: Utilises both aerobic and anaerobic processes

Treatment Mechanism

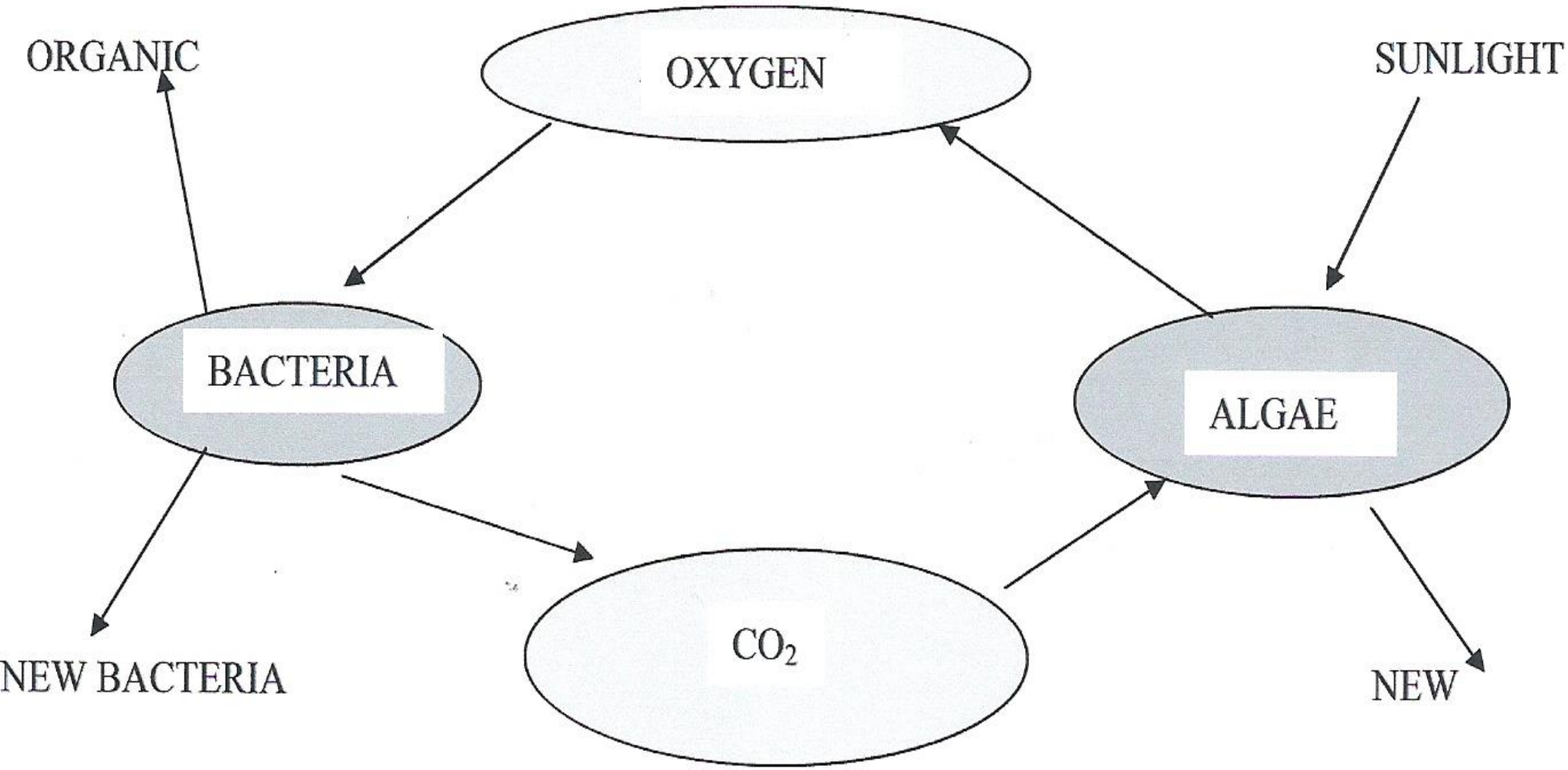

Figure: Symbiosis between Bacteria and Algae in Facultative Ponds

Treatment Mechanism

Design

- Based on empirical formulae of which one based on organic surface loading rate is given below

$$\lambda_s = \frac{LQ(g/m^3 * m^3/d}{A(m^2)} = BOD(g/m^2.d$$

Organic Surface Loading Rate = Load/Surface Area

Design Cont'

Where

- L = BOD influent (mg/l)
- Q = Sewage flow (m^3/day)
- A = Pond area (m^2)

Design Cont'

- Temperature plays a very significant role in the processes taking place in facultative pond. Empirical relationship between temperature and the organic surface Loading is given below:

- $\lambda_s = 2T - 12$

Design Cont'

- The area of the facultative pond can be expressed in terms of λs as

$$A = \frac{L*Q}{\lambda_s} = \frac{L*Q}{2T-12}\, m^2$$

Design Cont'

For Hydraulic Retention Time

$$t = \frac{V}{Q} = \frac{Ah}{Q} = \frac{Lh}{2T - 12}$$

Note: h is the depth of the pond

Design Cont'

OTHER DESIGN CONSIDERATIONS

- The minimum hydraulic retention time in a set of facultative ponds should be 5 days whether one pond is used or several ponds in series (Ideally 2-3 weeks).
- Ponds, if not in parallel should be provided with bypass lines to allow for desludging (Primary Facultative Ponds)
- To design facultative ponds, a depth of 1 - 2.5m has to be adopted. Mostly 1.2m is used

Maturation Ponds

- Polishing stage (tertiary treatment)
- BOD and Nutrient removal accomplished by the algal biomass and the bacteria

Treatment Mechanism

- BOD reduction is achieved through processes described under facultative ponds.
- Nutrient removal is through algal uptake
- Pathogen reduction as follows:-
  - **Light-induced mortality**: Through UV irradiation from the sun. However, in WSPs, light is normally restricted to the top 15-20cm.
  - **pH -induced mortality**: During periods of photosynthesis, pond pH can rise to 9 - 11 which pH enhances pathogen die-off.

Treatment Mechanism

- **Starvation-induced mortality**: There is low concentration of organic (i.e. <20mg BOD/l).

- **Adsorption/Sedimentation**: As ponds serve as sedimentation tanks, micro-organisms tend to form clusters and attach to particulate matter and settle to the bottom of the ponds.

- **Preditation**: Bacteria in WSPs are part of the biological food chain. A large number of these bacteria are consumed by protozoa which are a higher animal life.

Design

- Based on impirical formulae

$$\frac{N_e}{N_i} = \frac{1}{\left[1 + K_b \frac{\tau}{n}\right]^n}$$

Design Cont'

Where

- Ni and Ne = No. of FC CFU in the influent and effluent respectively
- τ = hydraulic retention time
- K_b = Die off rate coefficient (in day-1) which is temperature dependent and is given by

$$K_b = 2.6(1.19)^{(T-20)}$$

- Where T is temperature in ^{O}C.

Factors that may affect performance

‘Weed Infestation of the Chama Secondary School Ponds’

Challenges

‘Weed Infestation of the Petauke Ponds’

Factors that may affect performance

‘Vandalism’

Challenges

The Reason

‘Starved Ponds in Katete’

The Consequence

Challenges

Benefits?

Challenges

Encroachment

THANK YOU