IBK412: Environmental Bioprocess Technology

By
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What moment you have the smile in your face, but honestly you don’t like that photo at all? Mind to share what was the situation and why it happened?

Go to www.menti.com and use the code 65 75 593


Moment where I missed my smile.. huhu

Moment where I missed my smile.. huhu

Section Break

WASTEWATER

- DOMESTIC WASTE
- INDUSTRIAL WASTE

ASSIGNMENT (Due Date 5 NOv 5am)

Part A

- State the percentage (%) composition inside the sludge for these following elements:

  - Macronutrient
  - Micronutrient
  - Trace element

*Need to mention your type of wastewater and cite the source of your finding (Endnote/Mendelley).

Part B

State the recent function of sludge from WWTP:

- Brick
- soil conditioner / fertilizer
- Soil reclamation

Part C

- Two other relevant application
- *cite the source of your finding (Endnote/Mendelley)

Allocation Marks (52/52 marks ~ 100 %)

Part A

- Table for different type of wastewater (state the source of the sludge):
  - macro (4 marks) , micronutrient (4 marks) and trace element(4 marks)

Part B (12 marks x 3 application = 36 marks)

- Well elaborate the application in each sludge application(2)

- the techniques used ; mechanism (6 marks)
- the impacts toward yield/aims/ the efficiency (4 marks).

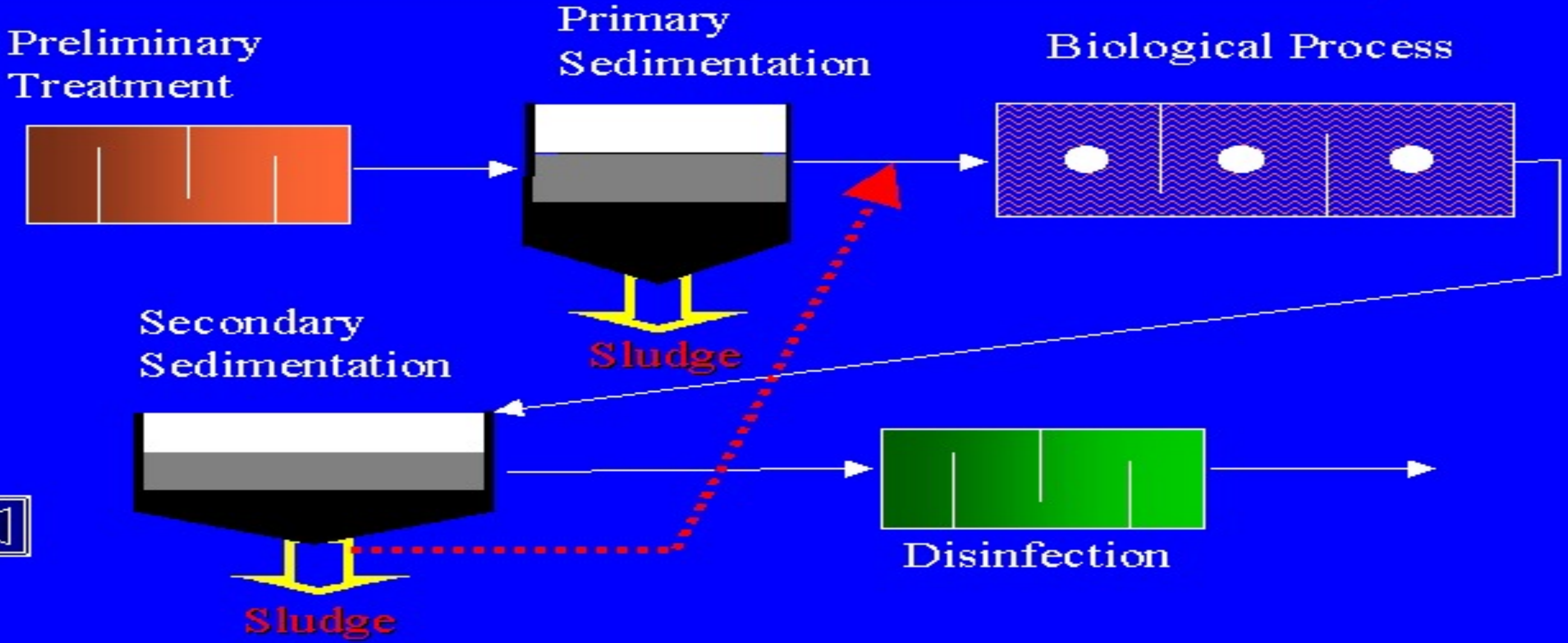
Part C

- The 'others' application (2 marks)

**Usage of endnote/ mendelley (2 marks)

REFRESH OF WASTEWATER TREATMENT

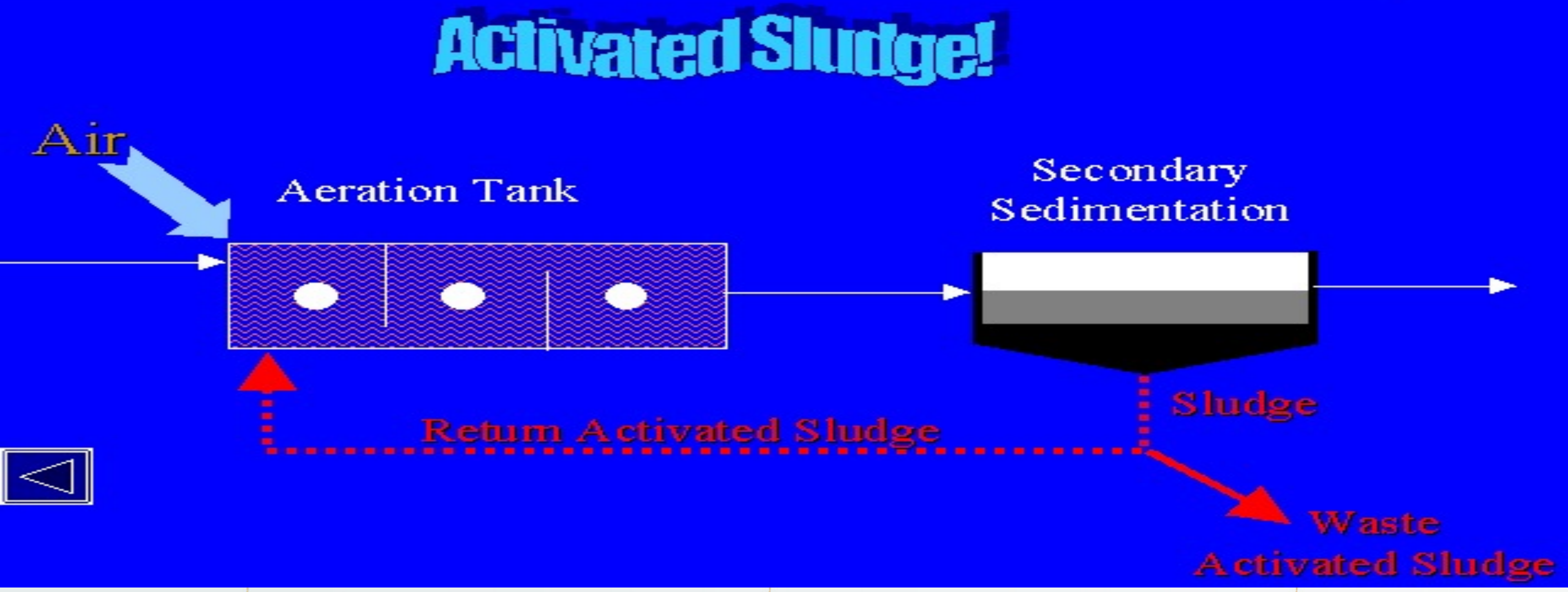
Conventional WW Treatment



Primary Sedimentation

- Purpose: to remove suspended solids (smaller than grit, and less harmful)
- Typical efficiency
  - 67% TSS removal
  - 33% BOD removal
- Design parameters
  - overflow rate
  - weir loading rate
  - detention time

Suspended Growth Systems



Sludge Disposal

- Thickening
  - gravity, flotation
- Digestion
  - aerobic, anaerobic
- Mechanical Dewatering
  - Vacuum filtration, centrifugation, pressure filtr.
- Disposal
  - land application, burial, incineration

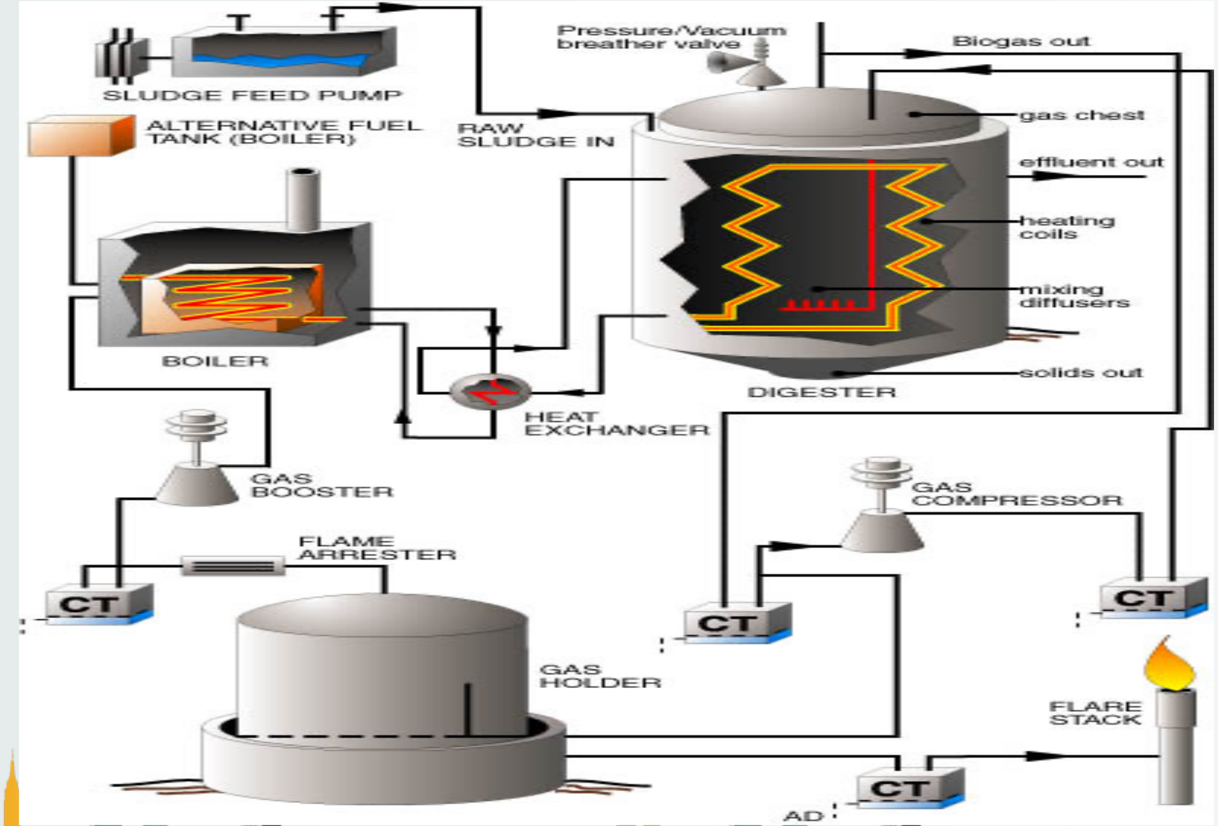
Sludge Characteristic

Source	Typical Concentration, percent
Primary sludge, without thickening	2 - 7
Waste activated sludge	0.5 -1.5
Waste trickling filter sludge	1 - 5
Digested sludge	4 - 10
Dewatered sludge	12 - 50

Value of Sludge Composition

Constituent	kg/ton	Gross value $A/ton
Protein	320	130
Fat	150	60
N	50	25
P	15	18
B_{12}	0.0025	20
Oil	30	10
Energy		70-150
Metals	3	35
		$300

Sludge Digestion: Anaerobic



Sludge drying bed: preparation

Filling the drying bed with sludge

Starting the drying process


Waste is Wealth

Advance Method in wastewater Treatment

- In 1910, a botany professor from University of Durham, UK, had proposed the idea of ca talytic activity and conversion of microbes ca n generate electricity .
- Then early in 1990s Allen and Bennetto repo rted that fuel cell became more attractive an d the investigation on MFCs began to start

Microbes Story

A mysterious forest in the distance...

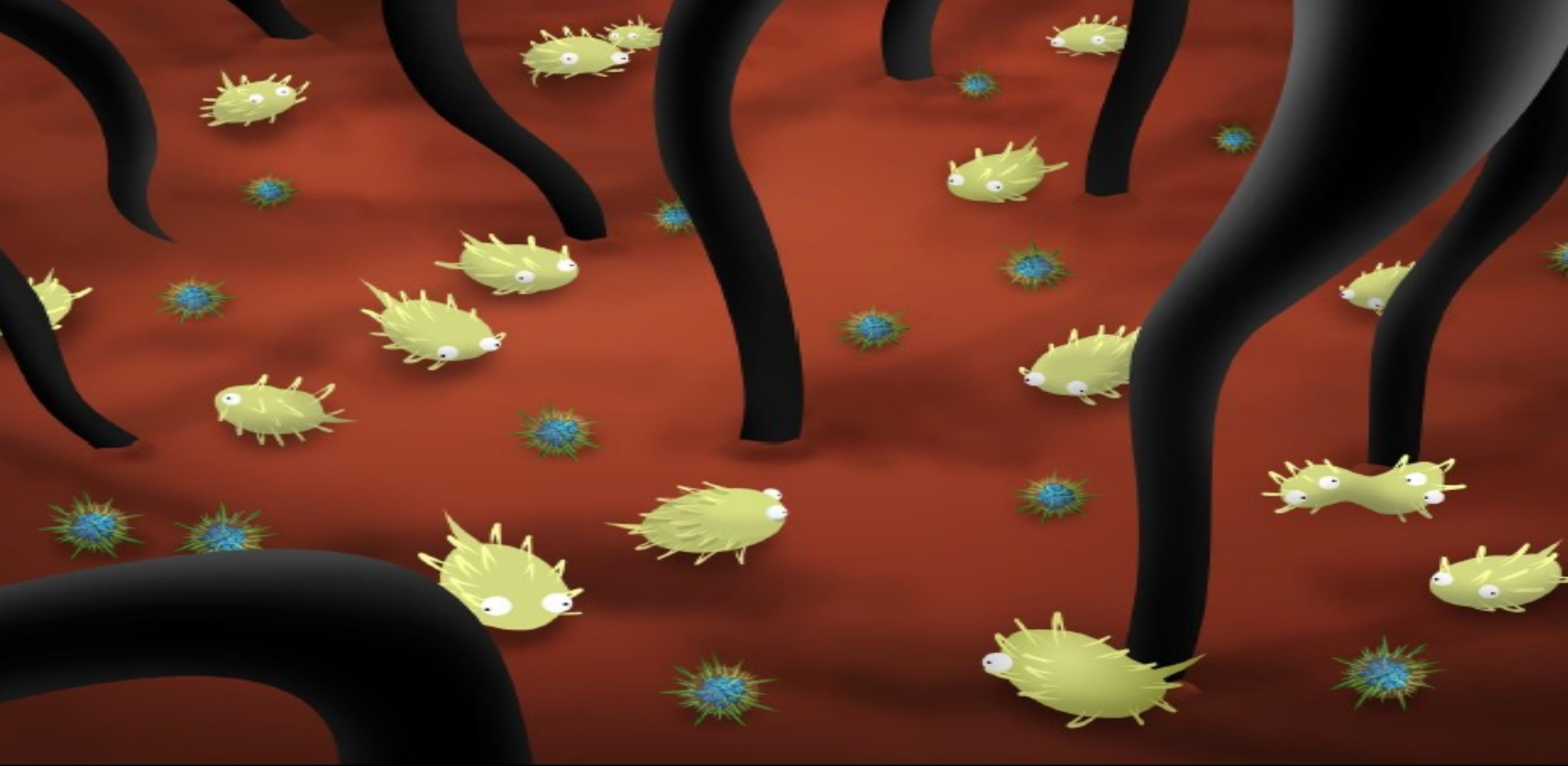
A fiber forest full of nutrients!

A glorious feast to power up!

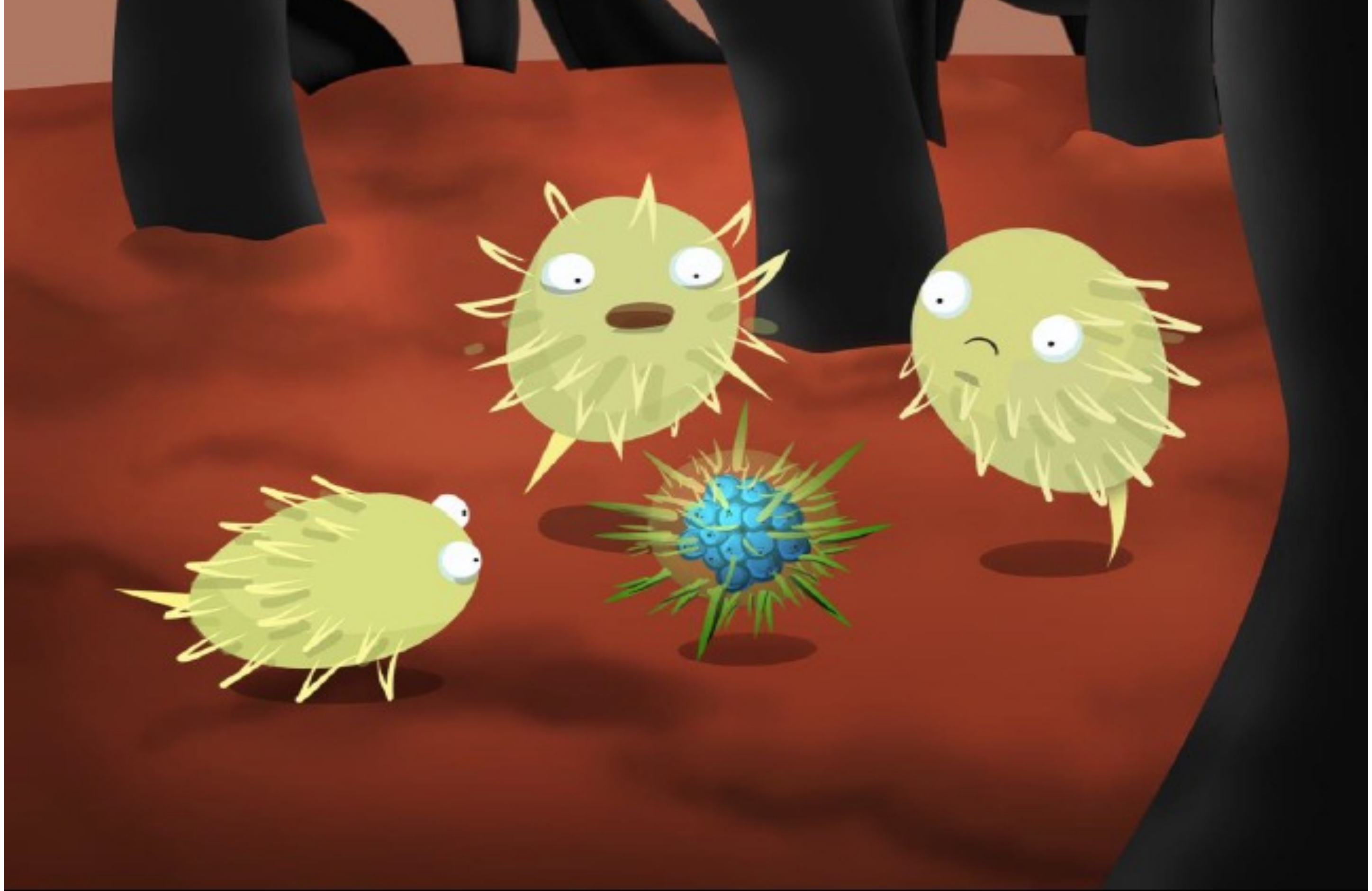
Zap! An electrical charge bursts to a nearby fiber!

With the microbe's ability to replicate, one becomes two.

Two becomes four. Four becomes eight. Soon there are millions!



Simple foods are eaten first. Now only complex, inedible nutrients remain



The microbes can't digest these complex foods.
What will they do?

A fungi clan arrives. Are they friends or foes?

The fungi munch up the complex foods, freeing
the simple nutrients inside.

Symbiosis saves the day!

A shocking development! The microbes grow electron-shuttling nanowires!

Even distant microbes can discharge to a
fiber by linking nanowires!

A connected community flourishes –
the power of working together!

Theoretical calculation

- Let say
  IWK Sdn Bhd produces 500 L/d AD, 600 mg/L of COD, 14.7 kJ/g –COD (basis waste water)

  The power would be:

- $$P = \left(600\ \frac{mg\ COD}{L}\right)\left(\frac{500\ L}{d}\right)\left(\frac{g}{10^3 mg}\right)\left(\frac{14.7}{g\text{–}COD}\right)\left(\frac{1kWh}{3600kJ}\right)\left(\frac{1d}{24h}\right)$$
  $$= 0.051\ kW$$

Let say tariff Tenaga Nasional Berhad RM0.44/kW-h, how much IWK Sdn Bhd save the c ost a year by having power at 0.51 kW/day?

$$Value = 0.051\ kW\ \left(\frac{RM0.44}{kWh}\right)\left(\frac{24 \times 365\ h}{yr}\right)$$

$$= RM196.57$$

**these calculation all assume 100 % energy recovery, not reasonable. As a goal, it is hope t o recover 20 – 30 % of the energy.

How to visualize the power we have instead you see the small amount of RM we managed to save?

We try to show in term of the application.

A wastewater company light their waste pond during night 7 pm to 7 am (12 h) using 3 W LED lamp. So how many LED lamp can be lighted?

$$0.051\ kW \quad = 51\ Watt$$

1 LED lamp = 3 Watt

LED can be lighted up $= \left(\frac{51 Watt}{3\ Watt}\right)$

= 17 LED throughout a year!

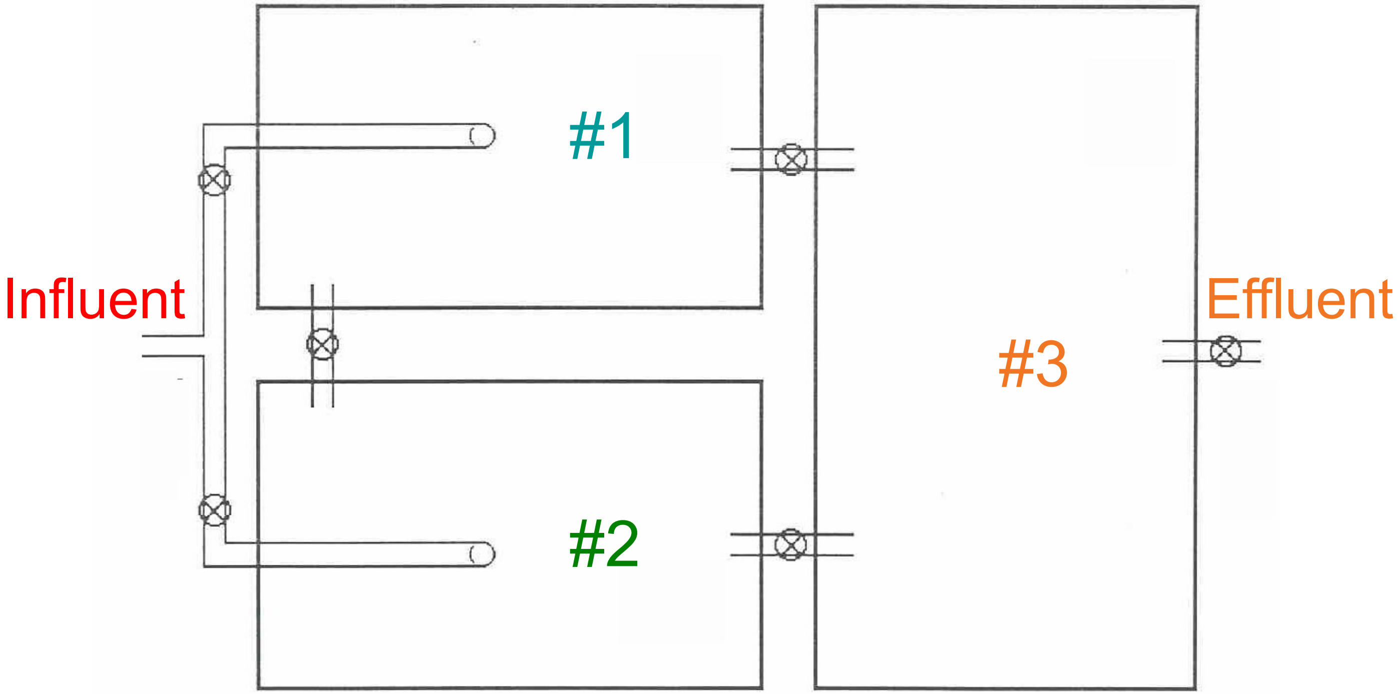
Lagoons

Waste Stabilization Lagoons

A carefully designed structure constructed to contain and to facilitate the operation and control of a complex process of treating or stabilizing wastewater.



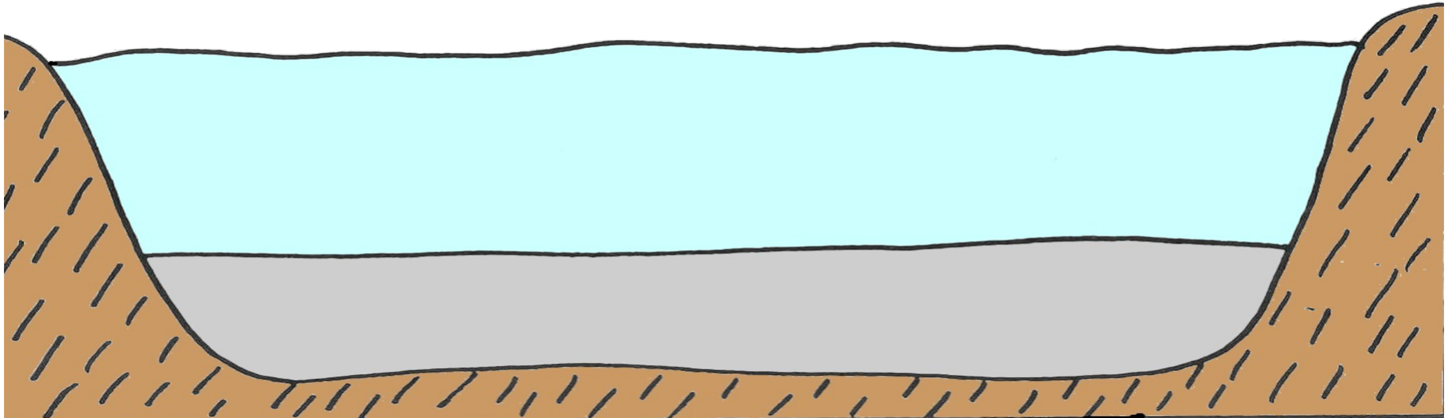

Typical Lagoon System



WASTEWATER

Water used to carry waste products aw
ay from homes, schools, commercial e
stablishments, and industrial enterprise
s.

TREATMENT PROCESS



Waste Stabilization Lagoons
"Treatment" Process

Natural Process

Same Process Which Occurs in a Natural P
ond or Lake

Under Controlled Conditions

Waste Stabilization Lagoons

Natural Process

Same as Mechanical Plants

Carefully Designed and Constructed

Must Be Operated Properly

Must Be Understood

Waste Stabilization Lagoons

“The Process” Involves:

Physical Processes

Chemical Processes

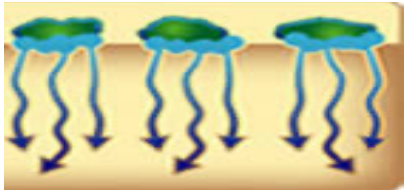
and

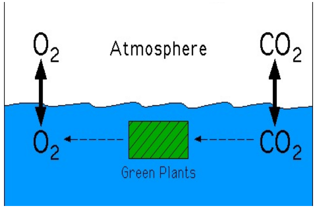
Biological Processes

Physical Processes

Evaporation

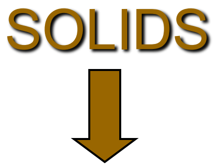
Seepage

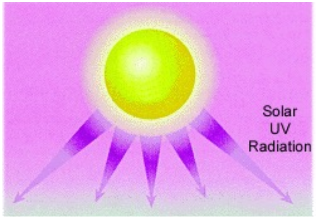




Gas Exchange

Sedimentation



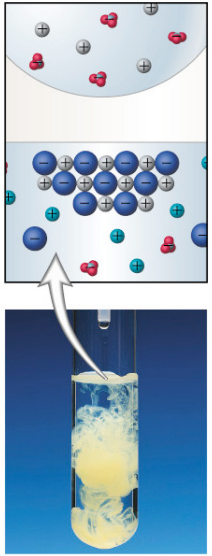


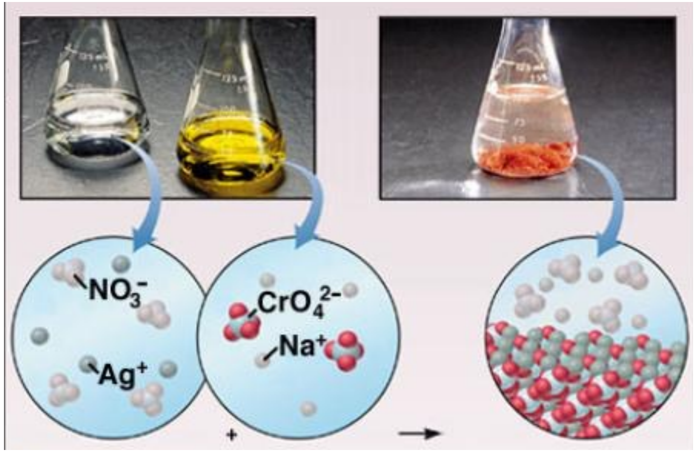
U.V. Radiation

Chemical Processes

Inorganic Activity

Precipitation Formation

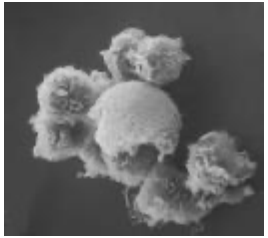




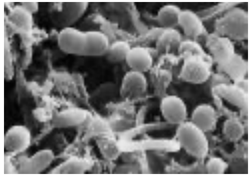
Wastewater “Treatment” Process

Mostly

BIOLOGICAL



BACTERIA



BACTERIA
Types

Aerobic

Bacteria that can use only oxygen that is “free” or not chemically combined.

Anaerobic

Bacteria that can live in the absence of “free” oxygen.

Facultative

Bacteria that use either “free” or combined oxygen.

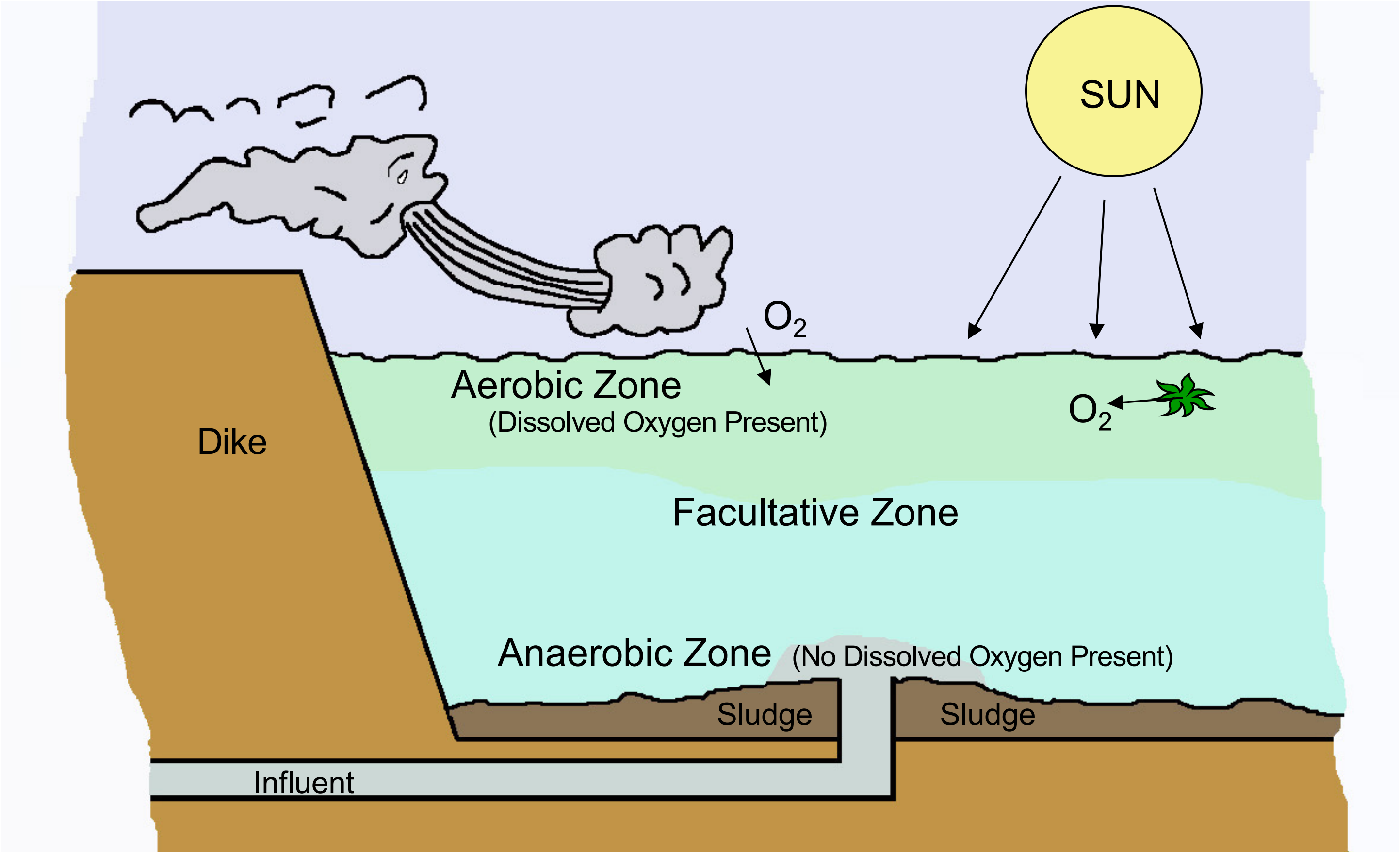
Zones in a Lagoon

AEROBIC

FACULTATIVE

ANAEROBIC

Zonal Relationships in a Lagoon



Zonal Differences

Environments

Bacteria

Activities

ANAERROBIC ZONE

Sedimentation

SOLIDS ↓

Stabilization

Organics → Bacteria → Organic Acids

Organic Acids → Bacteria →

Carbon Dioxide (CO_2)
Ammonia (NH_3)
Hydrogen Sulfide (H_2S)
Methane (CH_4)

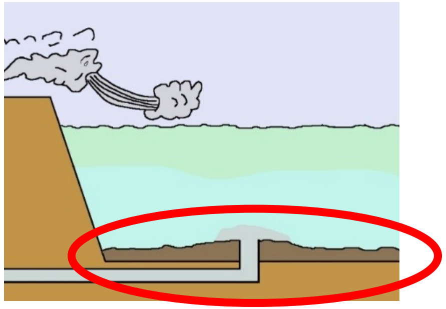
ANAEROBIC ZONE

SOLIDS

Sedimentation

Stabilization

Not All Of the Settled Solids Will Be Broken Down.



The Sludge Layer Will Increas
e Slowly Over the Life of the L
agoon

AEROBIC ZONE

Bacteria Use Soluble Organics

Influent

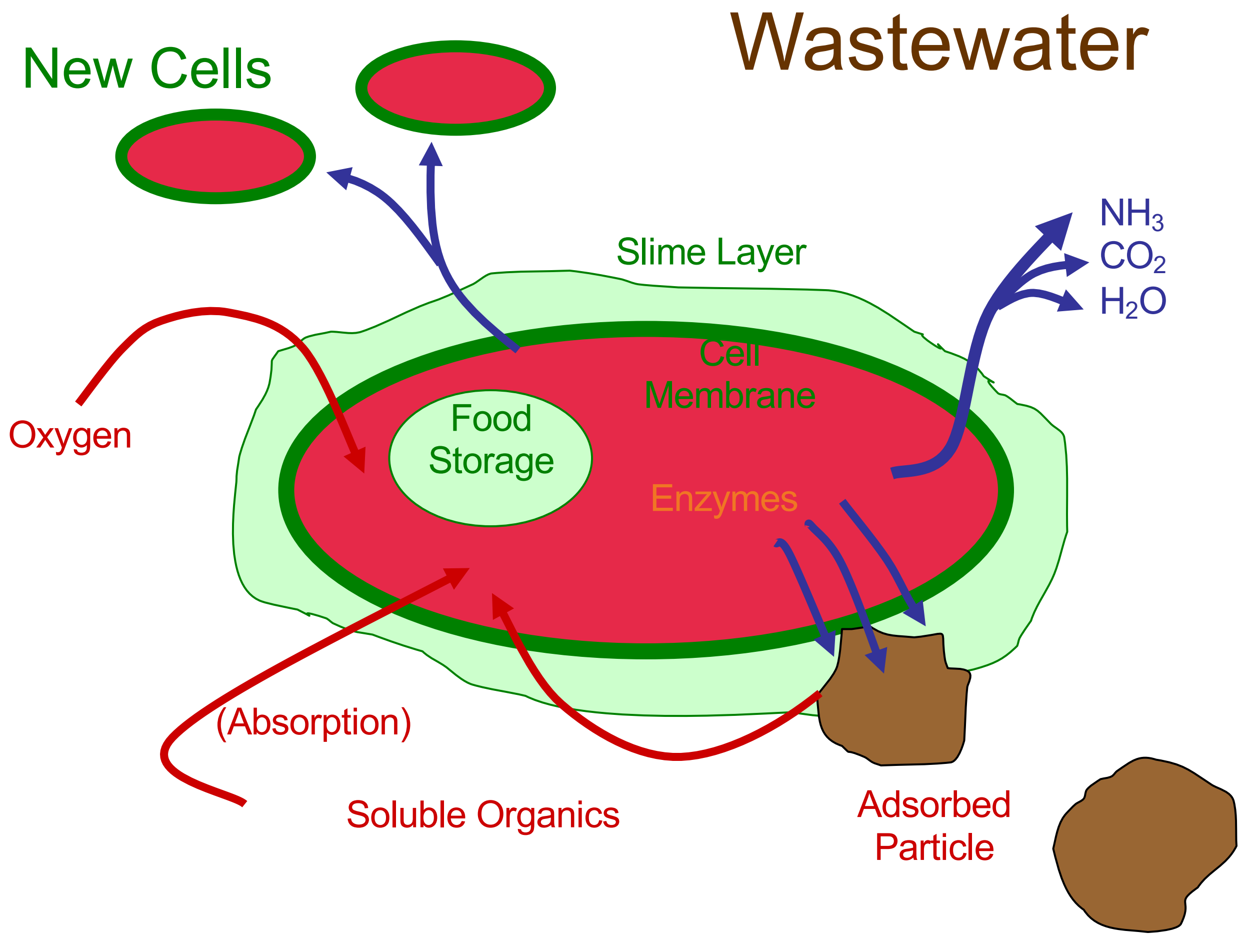
Anaerobic Zone

Respiration

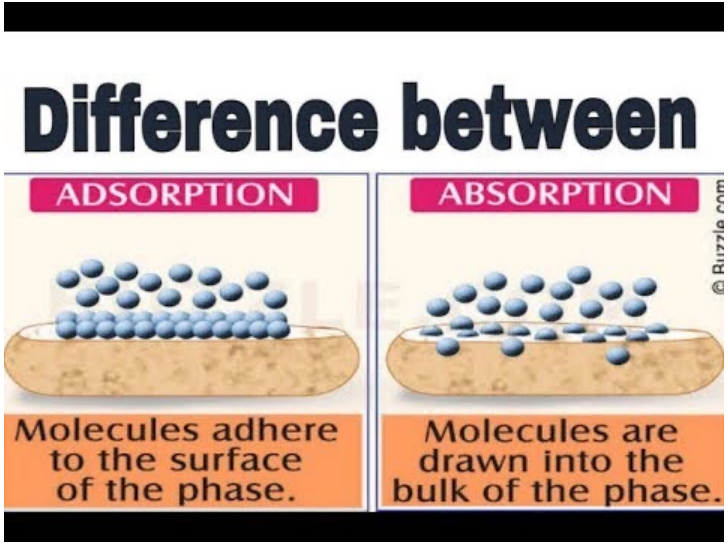
RESIPRATION

Organic Compounds + Oxygen → Carbon Dioxide + Water

$$CH_2O + O_2 \rightarrow CO_2 + H_2O$$



Wastewater
New Cells
Slime Layer
NH_3
CO_2
H_2O
Cell Membrane
Food Storage
Oxygen
Enzymes
(Absorption)
Soluble Organics
Adsorbed Particle


Difference between
ADSORPTION
ABSORPTION
Molecules adhere to the surface of the phase.
Molecules are drawn into the bulk of the phase.

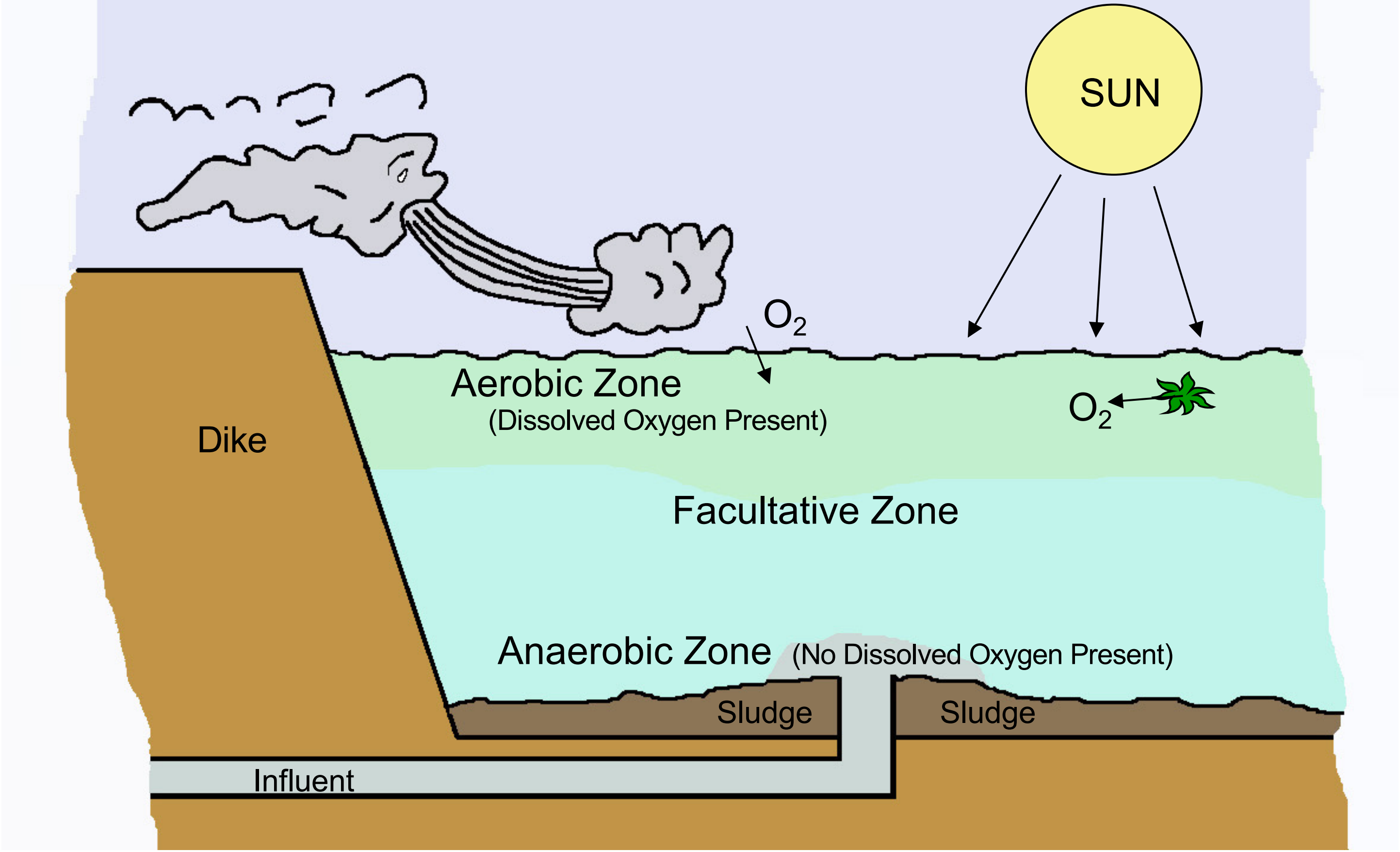
FACULTATIVE ZONE

Organisms Utilize Dissolved Oxygen
or Combined Oxygen

Adapt to Changing Conditions

Continue Decomposition
During
Changing Conditions

Zonal Relationships in a Lagoon



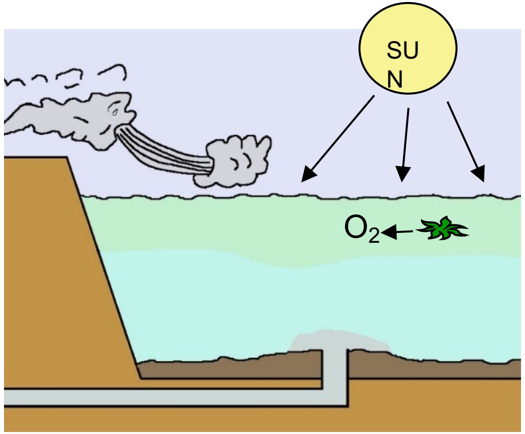
Importance of Sufficient Oxygen

Efficient Treatment

Preventing Odors

Sources of Oxygen

ABSORPTION from ATMOSHERE



<u>PHOTOSYNTHESIS</u>

PHOTOSYNTHESIS

A Process
in which
PLANTS
Utilize Sunlight and Chlorophyll
to Convert
Carbon Dioxide and Inorganic
Substances
to
OXYGEN
and
Additional Plant Material

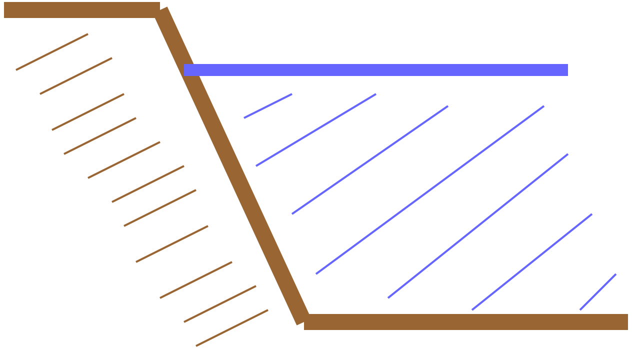
OXYGEN SOURCES

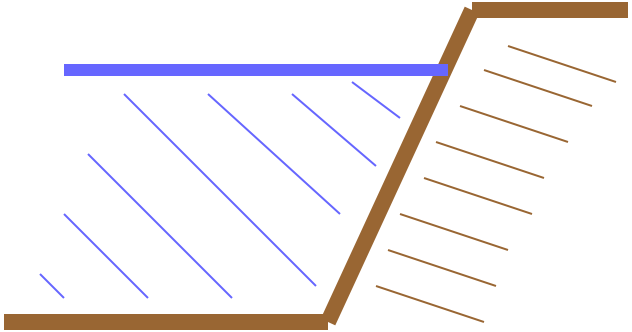
Surface Aeration
Provides

6 Pounds
per Acre
per Day

Algae
(Photosynthesis)
Provides

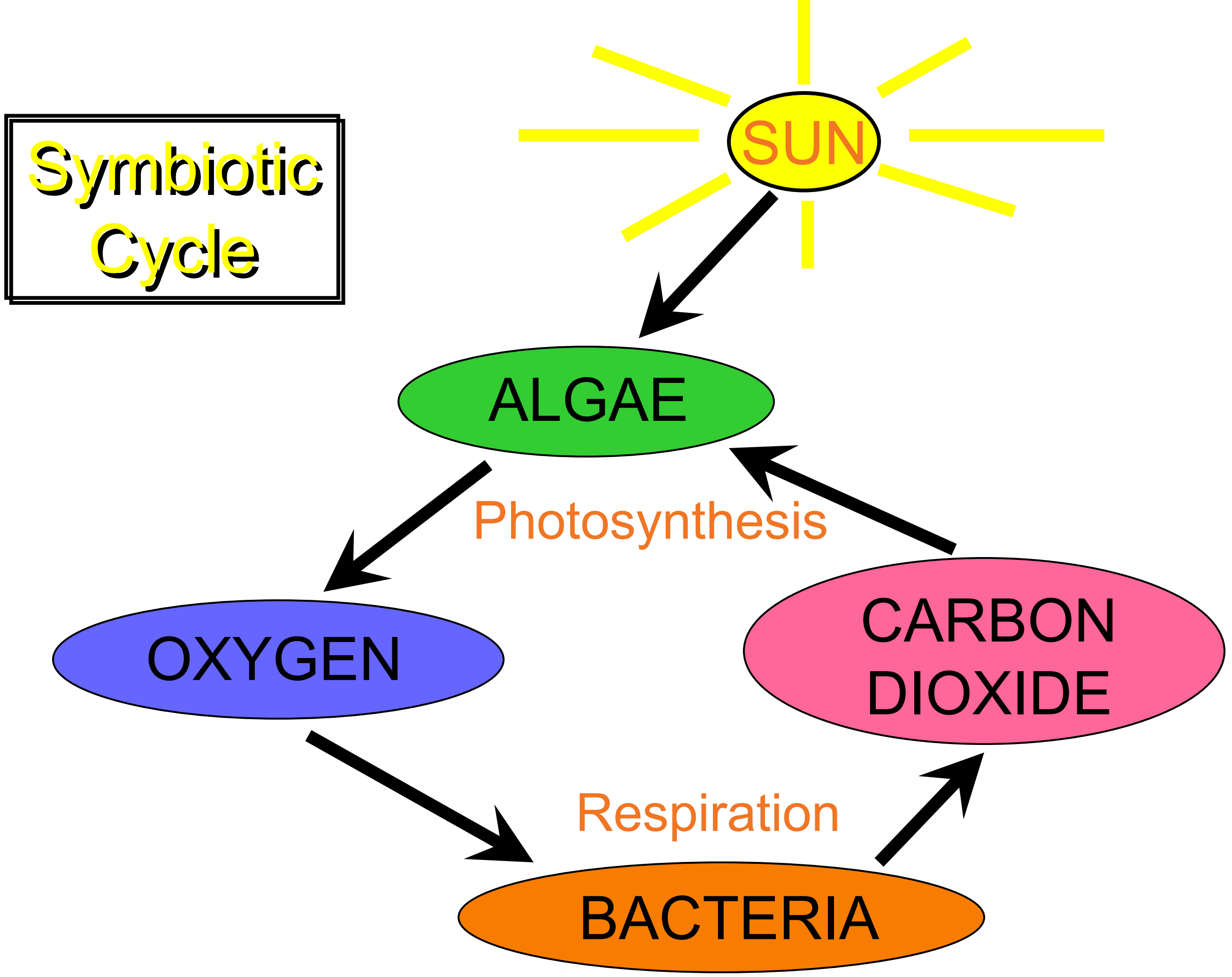
100 Pounds
per Acre
per Day





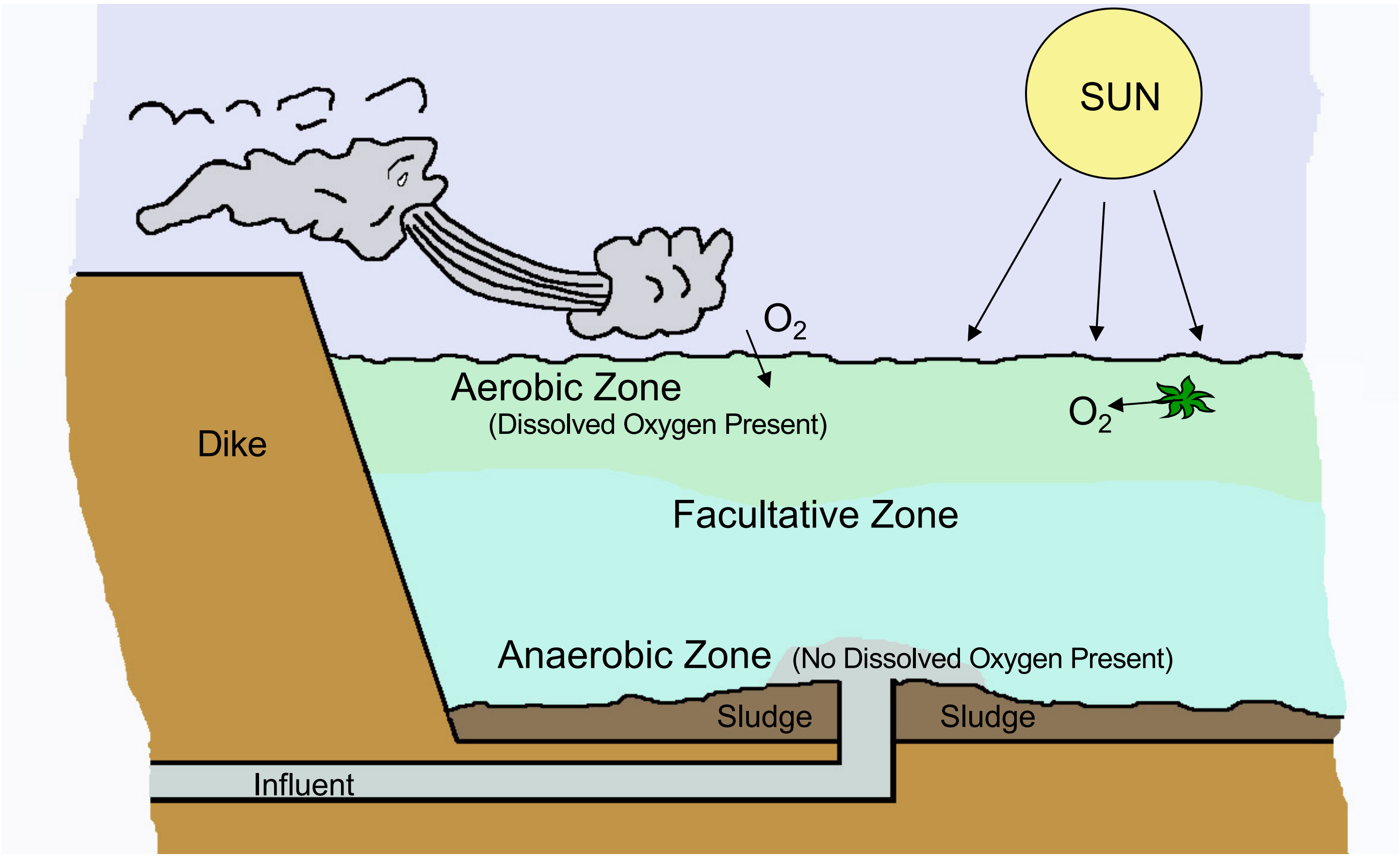
At Lagoon D.O. of 2.0 mg/L
Temperature Permitting 8.0 mg/L

Each 60 Pounds of Algae
Produce 100 pounds Oxygen

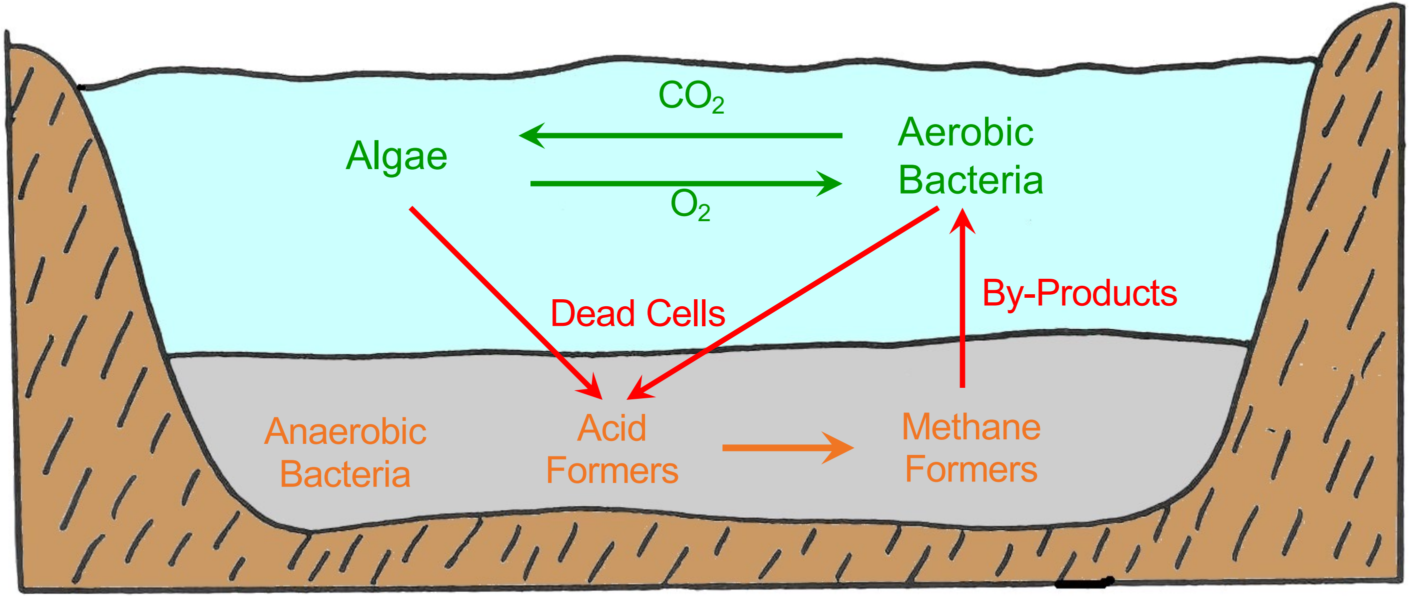


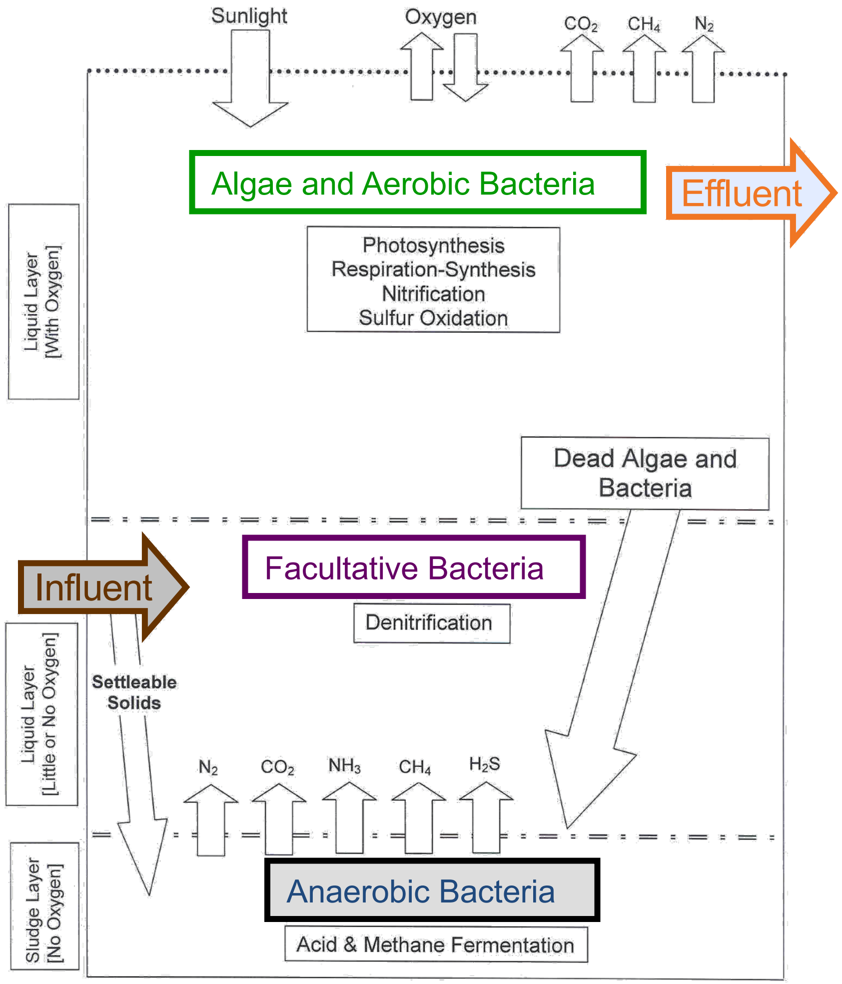
Symbiotic Cycle
SUN
ALGAE
Photosynthesis
OXYGEN
CARBON DIOXIDE
Respiration
BACTERIA

Zonal Relationships in a Lagoon



ACTIVITY IN FACULTATIVE PONDS





ACTIVITY IN FACULTATIVE LAGOONS

FACTORS THAT AFFECT THE TRE ATMENT PROCESS

Influence of Wind

Adds Oxygen

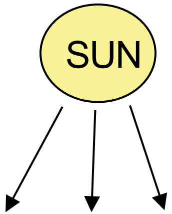
Increases Mixing

Must Be Controlled

By Minimizing Accumulations
of Material On, In, or Around the Lagoon

FACTORS THAT AFFECT THE TRE ATMENT PROCESS

Influence of Light



Photosynthesis

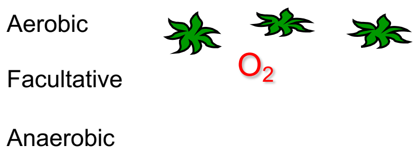
Disinfection

Must Be Controlled

By Minimizing Accumulations
of Material On, In, or Around the Lagoon

FACTORS THAT AFFECT THE TRE ATMENT PROCESS

Influence of Temperature



Rate of Bacterial Activity

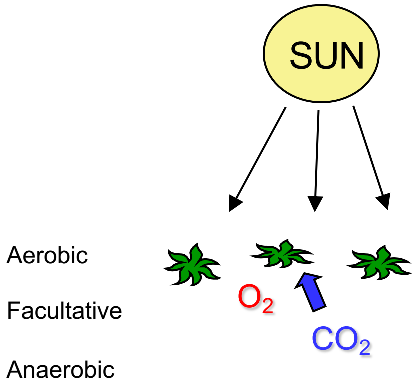
Growth of Algae

D.O. Saturation

Must Be Considered

FACTORS THAT AFFECT THE TRE ATMENT PROCESS

Daily Fluctuations



Temperature

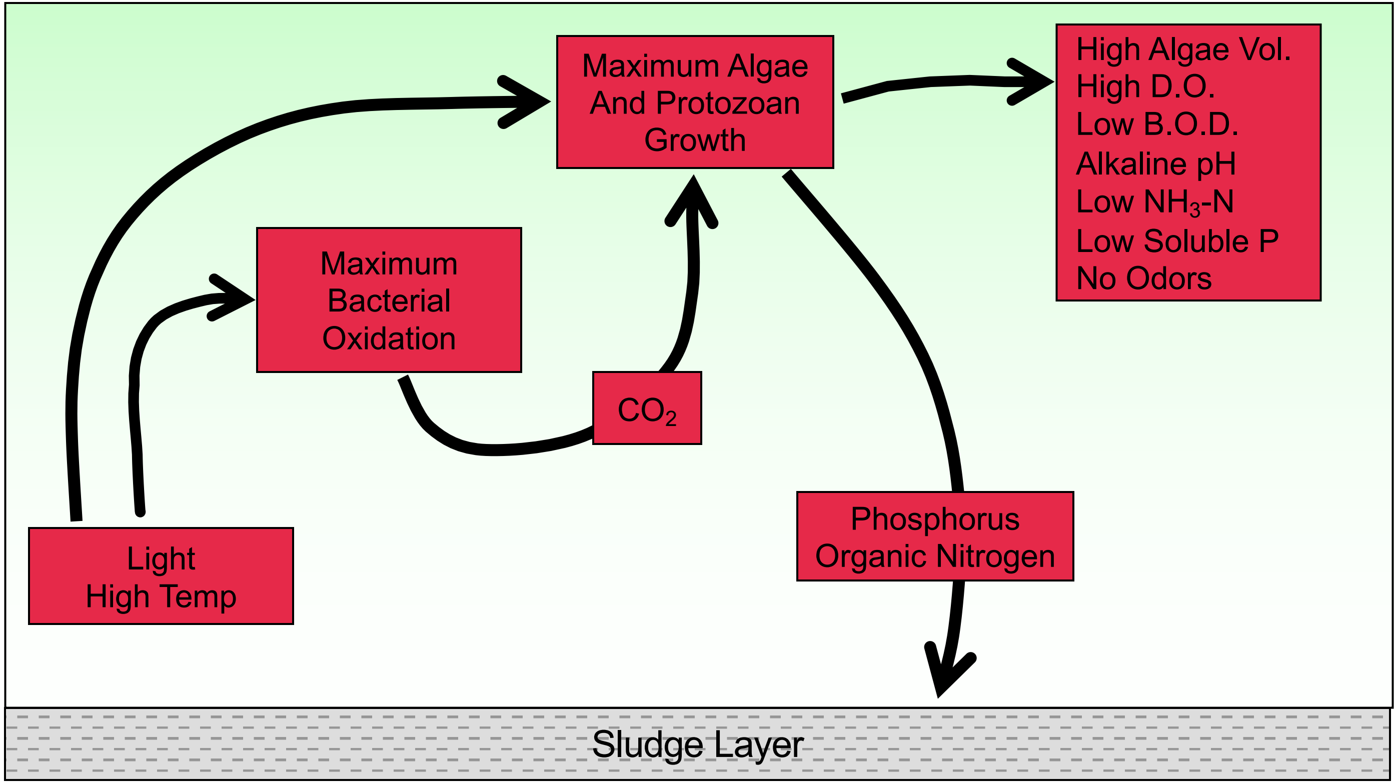
Dissolved Oxygen

pH

<u>Must Be Considered</u>

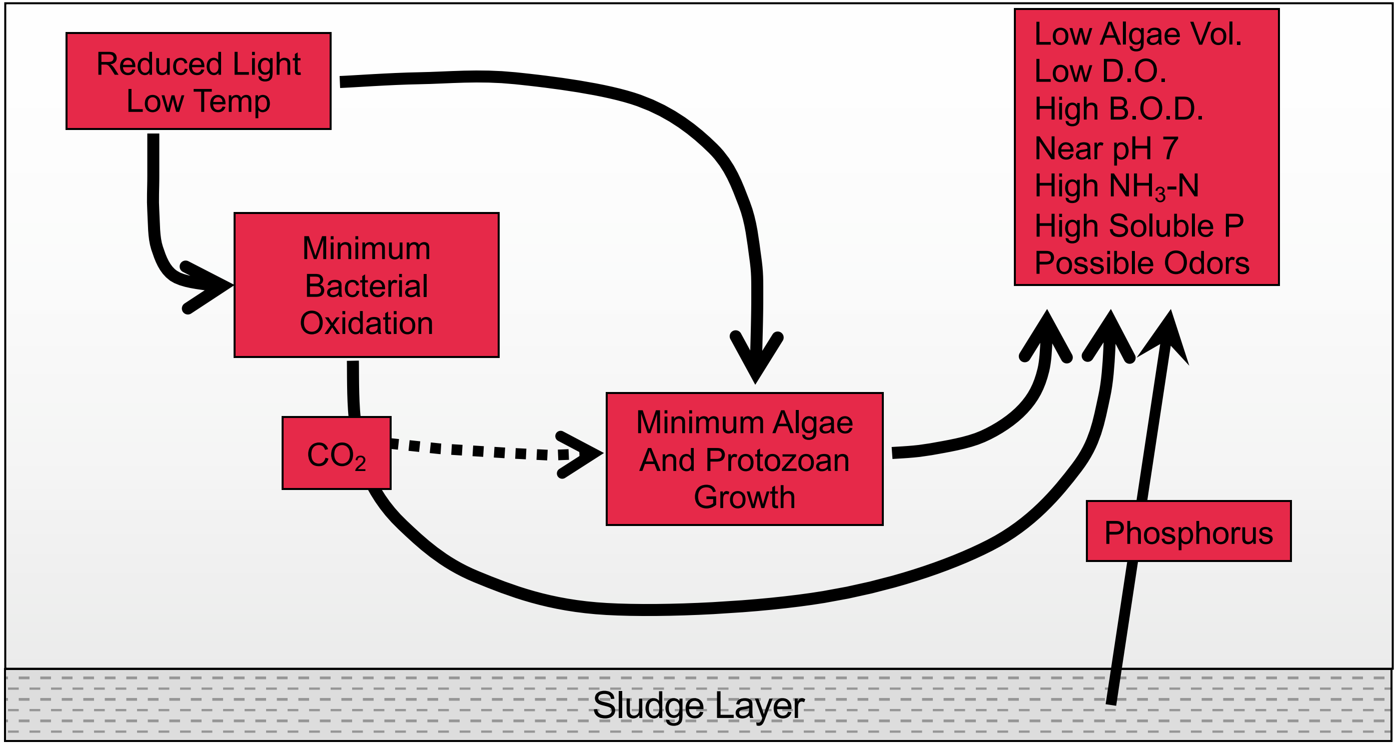
SEASONAL VARIATIONS

Summer To Fall



SEASONAL VARIATIONS

Winter To Early Spring



SEASONAL VARIATIONS

Spring and Fall

Transition Periods

Optimum for Discharging

Within Permit Limits
High Stream Flows - Dilution
High D.O. - Lagoon and Receiving Stream
Minimal Human Contact

ADVANTAGES of LAGOON SYSTEMS

1. Economical to Construct & Operate.
2. Low Monitoring & Control Requirements.
3. Rapid Recovery from “Shock” Loads.
4. Low Energy & Chemical Usage.
5. Low Mechanical Failure.
6. Minimal Sludge Disposal.
7. Long Life.

DISADVANTAGES of LAGOON SYSTEMS

1. Large Land Usage.
2. Low Control Options.
3. Operations Dependant on Climate.
4. Often High Suspended Solids.
5. Seasonal Odors.
6. Possible Ground Water Contamination.
7. Not Good In High Loading Situations.

RESULTS of PROCESS

Public Health Protected

- Pathogens Removed

Environment Protected

- Characteristics of Wastewater Changed
- End Products Stable

Process Itself Is Not Offensive

GOOD RESULTS
IF

Process Is In Balance

Properly Designed Facility

Process Is Controlled

System Is Maintained

Waste Stabilization Lagoons

A carefully designed structure constructed to contain and to facilitate the operation and control of a complex process of treating or stabilizing wastewater.

One Very Important Tool of

Design and Operation

Is The Ability and Use of

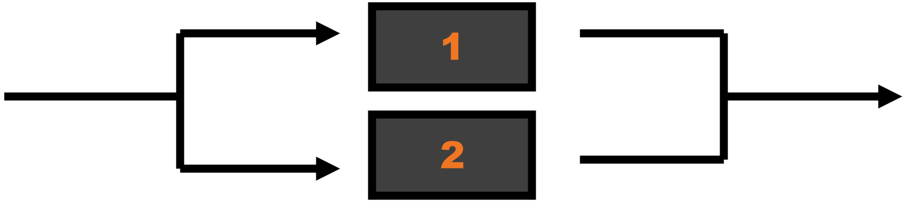
Series or Parallel

Flow Through the System

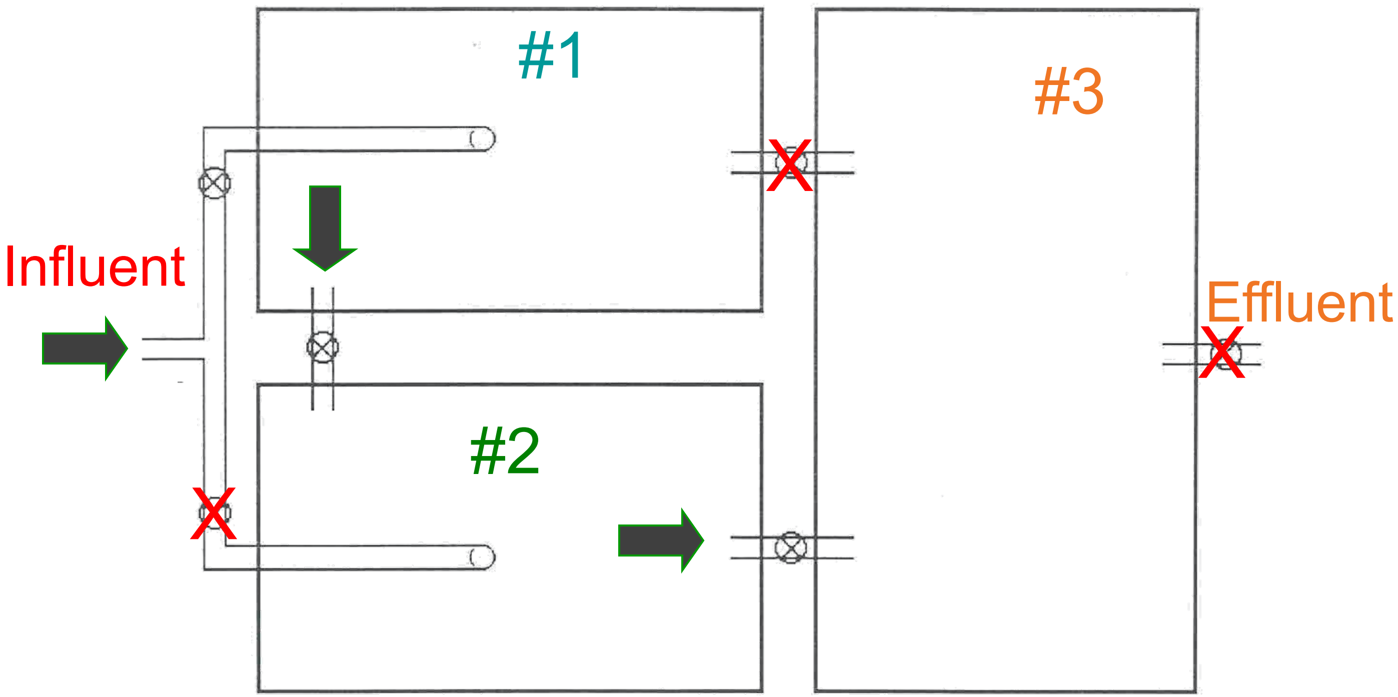
Series

OR

Parallel

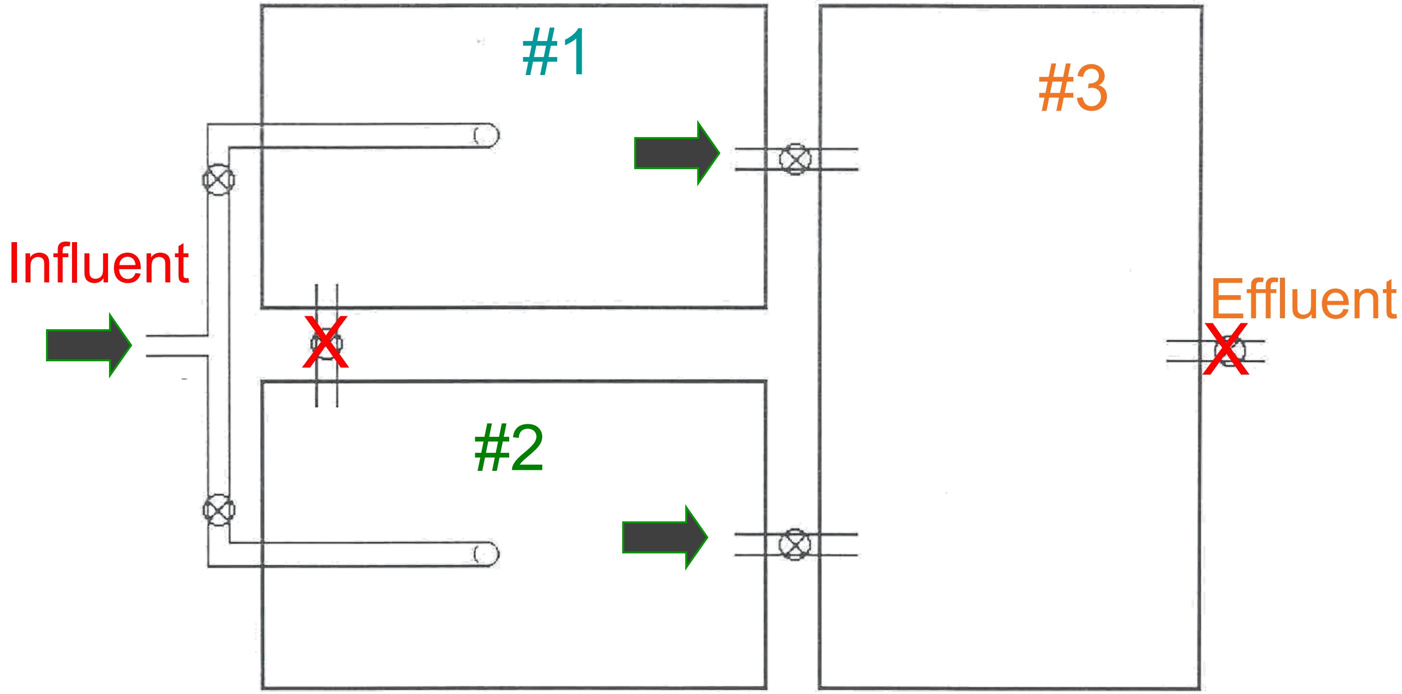


Typical Lagoon System



SERIES OPERATION

Typical Lagoon System



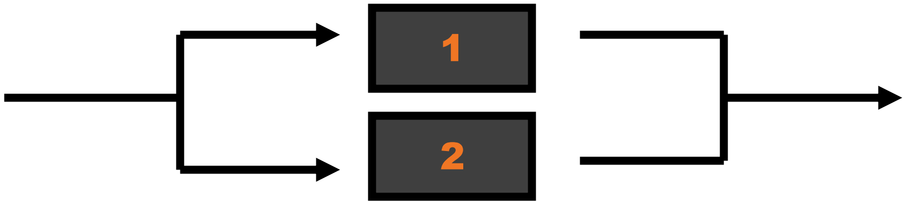
PARALLEL OPERATION

Series

Placing Majority of Load on First Cell

Summer Operation

Parallel



Dividing Organic Load Between At Least T wo Cells

Winter Operation

Loading

<u>Amount Applied</u>
<u>to the</u>
<u>Treatment Process</u>

Related to the SIZE of the Syste
m

For Lagoons

<u>Surface Area</u> of the System

Loading

Amount Applied
to the
Treatment Process

Population Loading

Hydraulic Loading

Organic Loading

POPULATION LOADING

Number of Persons per Acre

$$= \frac{\text{Population Served (persons)}}{\text{Area of Lagoon (Acres)}}$$

General

50 to 500 Persons per Acre

Michigan

100 Persons per Acre

Hydraulic Loading

VOLUME of Wastewater to be Treated

Flow Rate

Gallons per Day (gpd)

OR

Million Gallons per Day (MGD)

Inches per Day

$$= \frac{\text{Influent Rate (gallons per day)}}{\text{Pond Volume (gallons per inch)}}$$

1. A lagoon have 350 m long, 230 m width, and operating depth 5 m.

- Find surface area of median depth

350 m x 230 m = 80,500 m^2

- Calculate operating volume in m3

80,500 m^2 x 5 m = 402,500 m^3

convert into litre (1m3 = 1000 L) so become 402,500,000 L

- Calculate litre per metre of depth

402,500,000 L / 5 m = 80,500,000 L/m

- How many metres would the water drop if 2.35x10^3 m3 were discharged?

2350 m3 -> 2,350,000 L

2,350,000 L / (80,500,000 L/m) =0.291 m

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