EIMAS00889

A MODUL ON

INDUSTRIAL WASTEWATER TREATMENT SYSTEM

for

Training Course

On

2nd-3rd November 2011

Prepared by:

PMT

Pakar Management Technology (M) Sdn. Bhd.

1.0 Wastewater Treatment Standard

ACCESSION NO. : EIMAS 00889.
DATE : 18/2/2012.

UNIVERSITI PUTRA MALAYSIA

PMT

PAKAR MANAGEMENT TECHNOLOGY (M) SDN BHD

Training Course on Industrial Wastewater Treatment System
Hotel Residence, 21-22 Dec 2009

WASTEWATER TREATMENT STANDARD

Course instructor: Prof Dr Azni Idris

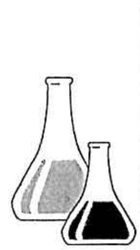
Wastewater Discharge

Introduction

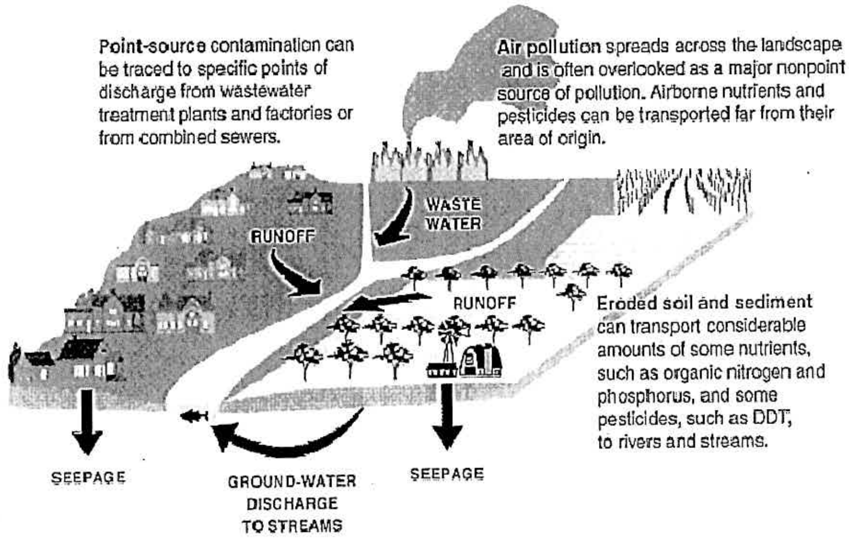
- Domestic wastewater from cities
- Industrial effluent
- Non-point sources

  eg Stormwater run-offs

  Sullage from restaurants



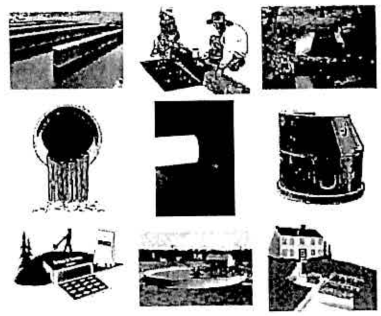
Water Quality Issues



Conflicting uses of river or water body

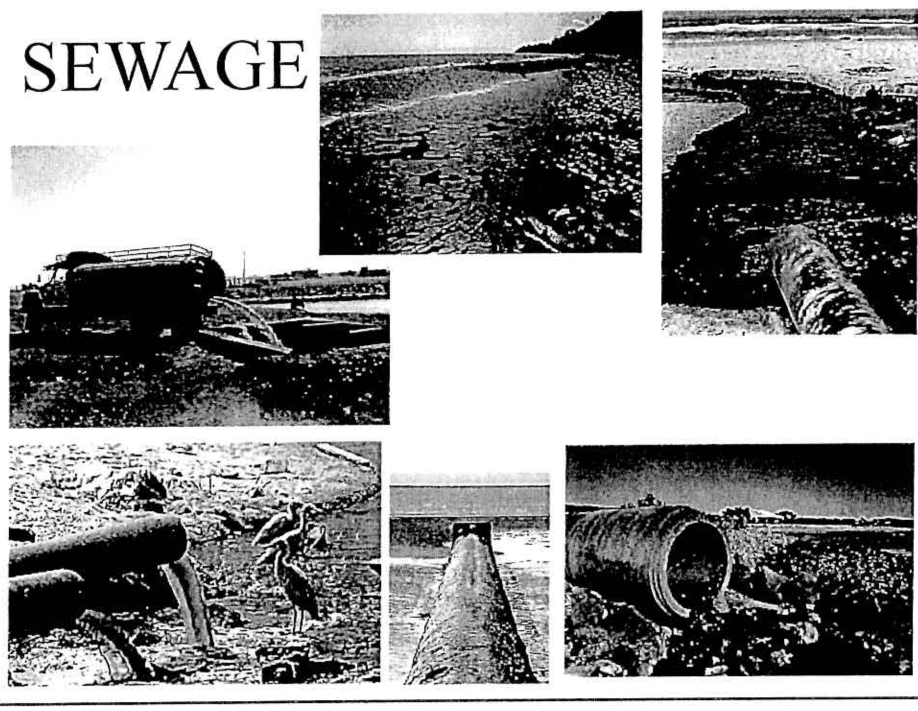
- ⇨ Potable water supply
- ⇨ Fisheries
- ⇨ Irrigation (agriculture)
- ⇨ Transportation
- ⇨ Power generation
- ⇨ Recreation

Stress in River Basin

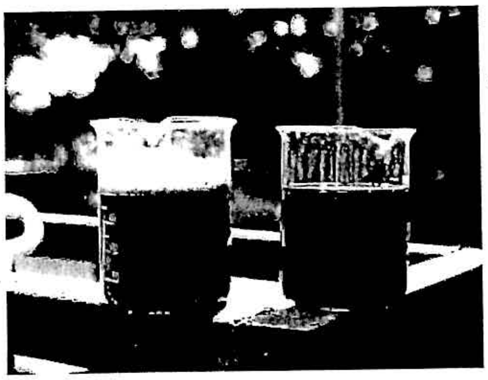


- ***Rapid urban development***
- ***Increase Pollution loads -sewage***
- ***Poor water quality***

SEWAGE



INDUSTRIAL WASTEWATER



Palm oil waste –high in organic

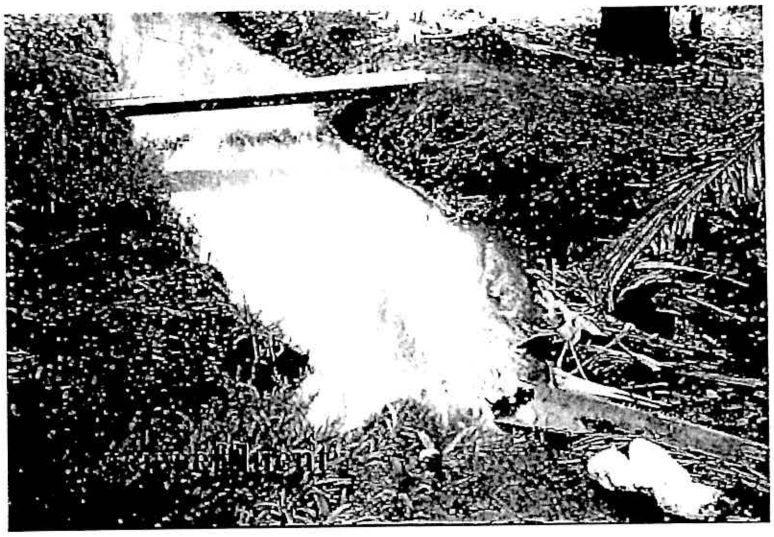
Paper mill waste – high in suspended solids, metals

TOXIC AND HAZARDOUS

- **more stringent laws to protect the environment.**
- **The traditional disposal options to surface waters, below ground or ocean have all been restricted.**

"IT'S PERFECTLY SAFE TO DUMP NUCLEAR WASTE IN THE SOUTH PACIFIC - BUT NOT IN JAPAN OR USA"

SENSITIVITY ISSUES



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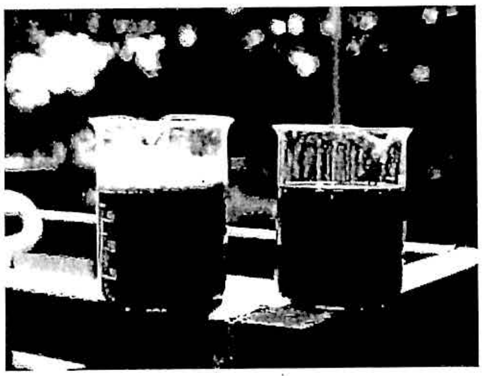
Protection of aquatic life

- Anthropogenic stresses, introduction of chemicals into water, affect many species of aquatic flora and fauna.
- Concern on ;
  - dissolved oxygen (kill fish at low concentrations)
  - phosphates, ammonium and nitrate (cause significant changes in community structure).
  - heavy metals and many synthetic chemical (ingested and absorbed by organisms and, if not metabolised or excreted, bioaccumulate in the tissues).
  - pollutant (carcinogenic, reproductive and developmental effects.

10

INDUSTRIAL WASTEWATER



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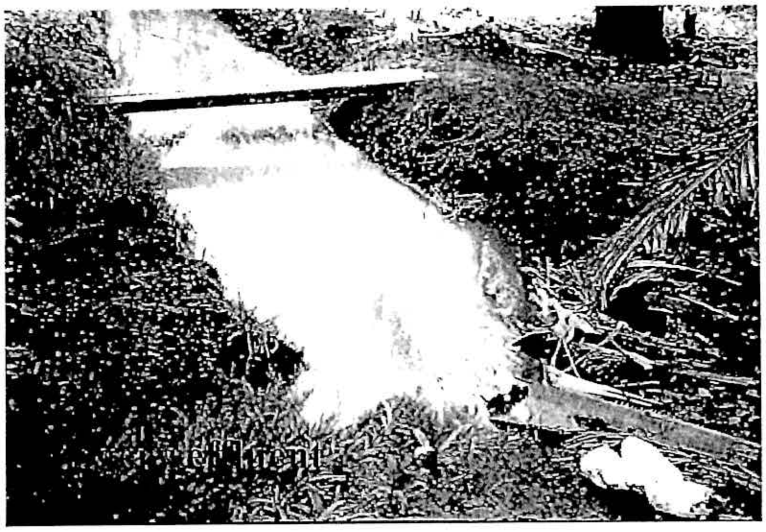

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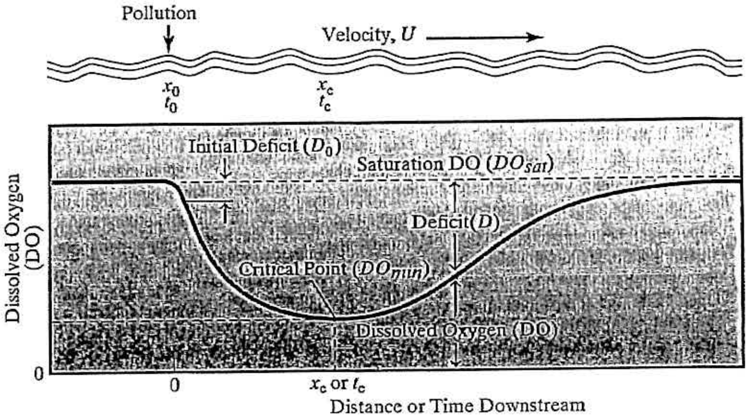
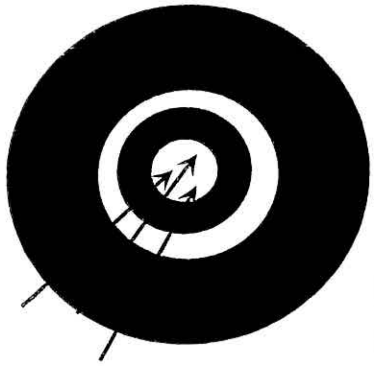


What happen when pollutant gets into river - Dissolved Oxygen Sag Curve

Targets of Environmental Laws:

Who or what gets regulated?

- Products
- Pollutants
- Industrial Facilities
- Government Agencies
- Individuals
- Land uses



Sources of Environmental Law

- Legislation (federal, state, local)
- Regulations (federal, state, local)
- Court decisions (interpreting statutes and regulations)
- Common law
- Constitutions (United States, state)
- International treaties
- Foreign regulations

POLLUTION CONTROL

Principles:

1. Pollution should be control at source
2. Polluters must pay
3. Discharge or emission standards should be uniform for a particular source, type of industry or activity.

Regulations and Environmental Standard

- Planning stage of project:
  - Environmental Impact Assesment (EIA) – regulation during planning stage.
- Operation stage of project:
  - Regulations for Pollution Control:
    > Direct regulation (by DOE)
    > Prohibition and zero discharge – Guideline
    > Effluent standard – EQA (Sewage and industrial effluent) Regulation 1979
    > Water Quality Index – to regulate river quality

NATIONAL POLICY ON THE ENVIRONMENT

Objectives:

- A clean, safe, healty and productive environment for present and future generations.
- Conservation of the country's unique and diverse cultural and natural heritage with effective participation by all sectors of society.
- Sustainable lifestyles and patterns of consumption and production.

MALAYSIA'S GREEN STRATEGIES

The National Policy on the Environment:

Scope:

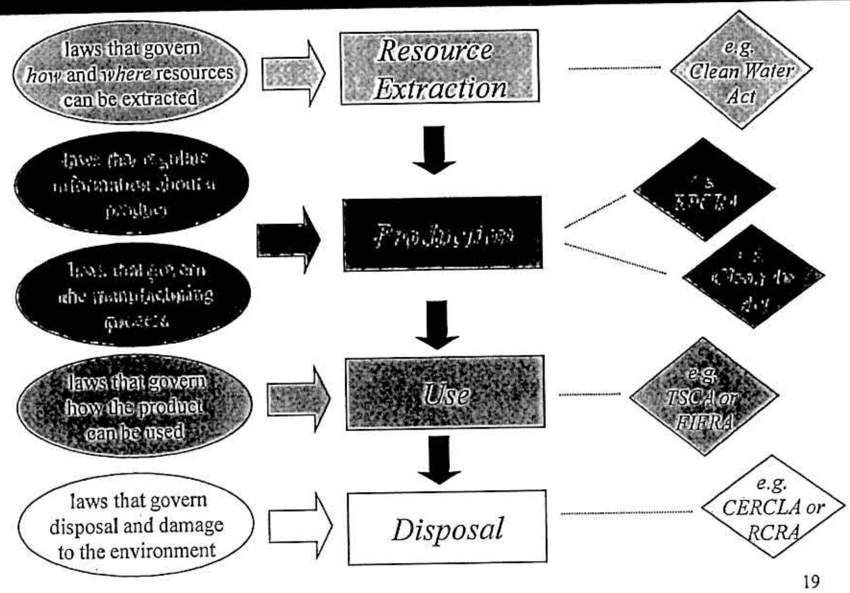
- To integrate environmental consideration into development activities and in all related decision-making processes
- To foster long-term economic growth and human development
- To protect and enhance the environment
- Formation of Dept of Green Technology 2009 (RM1.5billion)

Need for Environmental Regulations

- Polluters pay principle:

- The polluter has to pay for the prevention, abatement and remediation.
- Water was priced to cover the cost of abstraction, production and distribution; while the cost of sewer system, wastewater treatment and disposal was covered by property tax.

Organizing Environmental Laws with a Life Cycle Framework



Environmental Regulations

Water:

- To control discharge of wastewater entering water bodies from point sources.
- To have sustainable development, a balance between urbanisation, industrialization and conservation.
- To provide guideline for environmental monitoring and enforcement.

Classification of Rivers

Class 1

- No treatment needed for water supply, except chlorination. Very sensitive aquatic species.

Class 2

- Standard treatment needed for water supply and suitable for aquaculture and recreation (body contact).

Classification of Rivers

Class 3

- Intensive treatment needed for water supply. Non-sensitive aquatic species.

Class 4

- Suitable for agriculture only.

Class 5

- Not suitable for all uses.

Beneficial Use of Water

Introduction:

- Rivers are rated based on their Water Quality Index (WQI), defined as:

$$WQI = 0.22\ SIDO + 0.19\ SIBOD + 0.16\ SICOD + 0.16\ SISS + 0.15\ SIAN + 0.12\ SIpH$$

SI – subindex

- WQI combines 6 measurable parameters into one value representing the state of the water quality.

Class of River based on Individual Parameter

(Class I – III are acceptable)

Parameters	Classes				
	I	II	III	IV	V
Am-Nitrogen	0.1	0.3	0.9	2.7	>2.7
BOD	1	3	6	12	>12
COD	10	25	50	100	>100
DO	7	5 - 7	3 - 5	<3	<1
pH	6.5 - 8.5	6 - 9	5 – 9	5 – 9	-
Color (TCU)	15	150	-	-	-
TDS	500	1000	-	4000	-
TSS	25	50	150	300	>300
FC(per 100ml)	10	100	5000	5000	-
TC(per 100ml)	100	5000	20,000	50,000	>50,000

Beneficial Use of Water

Water Quality Index (WQI):

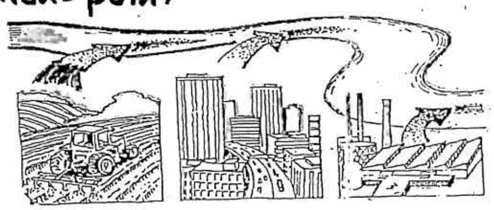
- Clean river WQI = above 80
- Slightly polluted WQI = 60 to 79
- Polluted river WQI = below 59

By calculation of WQI, the status of a river can be determined.

Standard A:
For discharge into river located within catchment areas (upstream of surface or above sub-surface water supply intakes, for the purpose of human consumption including drinking).

Standard B:
For discharge into municipal drain or river – specified other than A above. Less stringent and apply for most industrial estates.

non-point



- In some industrialised countries: industrial effluent discharge depends upon ability of the environment to accept a given wastewater - as such specific requirements for sewer discharge.
- Eg. allowable discharge of 50 kg COD/day, 10 kg SS/day (need to know the carrying capacity of a receiving river or water bodies)

Standard for Effluent Discharge into water catchment areas (eg Standard A)

Parameter	Unit	Standard A
Temperature	C	40
pH	-	6.0-9.0
BOD5 at 20°C	Mg/l	20
COD	Mg/l	50
Suspended Solid	Mg/l	50
Mercury	Mg/l	0.005
Cadmium	Mg/l	0.01
Chromium, Hexavalent	Mg/l	0.05
Arsenic	Mg/l	0.05
Cyanide	Mg/l	0.05
Lead	Mg/l	0.10

Standard for Effluent Discharge into water catchment areas (eg Standard A)

Parameter	Unit	Standard A
Chromium, Trivalent	Mg/l	0.20
Copper	Mg/l	0.20
Manganese	Mg/l	0.20
Nickel	Mg/l	0.20
Tin	Mg/l	0.20
Zinc	Mg/l	1.0
Boron	Mg/l	1.0
Iron (Fe)	Mg/l	1.0
Phenol	Mg/l	0.001
Free Chloride	Mg/l	1.0
Sulphide	Mg/l	0.5
Oil and Grease	Mg/l	Not detectable

Malaysian Effluent Standard

Environmental Quality (Sewage And Industrial Effluents) Regulations 1979 - P.U. (A) 12/79

Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 - P.U.(A) 338/78

Environmental Quality (Prescribed Premises) (Crude Palm-Oil) Regulations 1977 - P.U.(A) 342/77

Environmental Quality (Scheduled Wastes) Regulations 2005 - P.U.(A) 294/2005

Regulation do not apply: Flow < 60 m3/d
Load less than 6 kg BOD/d

The effluent standard are required to:

- Protect the river self purification (biological processes)
- Ensure that the effluent is suitable for discharge.
- Protect the health and safety of personnel working in the sewers or at wastewater treatment plants.
- Protect the structure of the sewers and wastewater treatment plants

End of slides

- Q&A

2.0 Wastewater Treatment Process

- Chemical Treatment

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Chemical Treatment of Wastewater

Course instructor: Prof Dr Azni Idris

WHAT TO REMOVE?

High BOD (Biochemical Oxygen Demand)

Excessive BOD deoxygenates the rivers making them septic, sulphate reducing bacteria are responsible for corrosion of concrete.

Grease

- term for fats and oily and greasy materials of animal, mineral and vegetable origin. Oily waste problems usually emulsified.

WHAT TO REMOVE?

- **Suspended solids**

SS are a measure of the insoluble material suspended in a waste. Suspended solids tend to settle in the sewers or rivers creating sludges which promote anaerobic conditions.

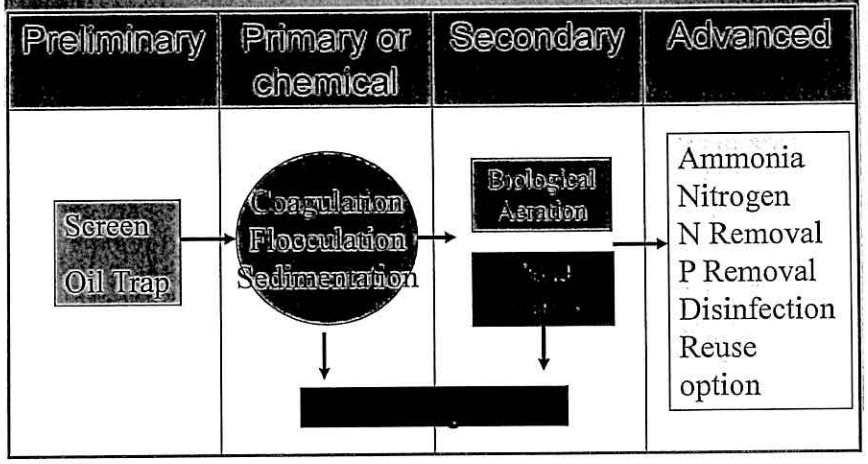
- **Sulphides**

S when present in certain conditions, are easily converted to hydrogen sulphide - poisonous gas.

Wastewater characteristic for selected food industries

Type	Food	Meat	Palm Oil	Textile
Volume (lit/tonne)	10,000	12,000	600	100,000
BOD	1,200	640	25,000	1,200
COD	2,000	1,500	50,000	2,500
SS	700	300	8,000	400
PH	6.8	7	4	11
Heavy metals	V. low	V. low	V.low	moderate

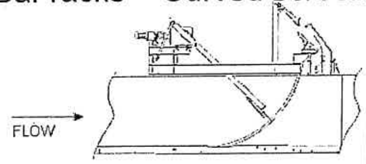
STEPS IN WASTEWATER TREATMENT PROCESS



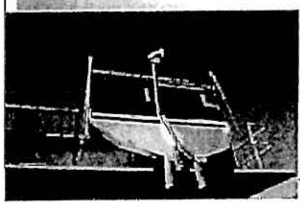
Screening

- To remove coarse solids/floating materials from entering treatment system

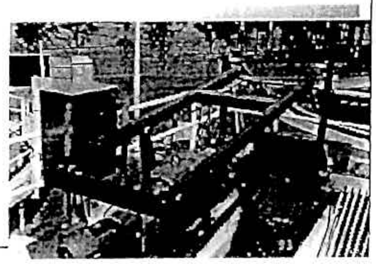
Bar racks - Curved screen

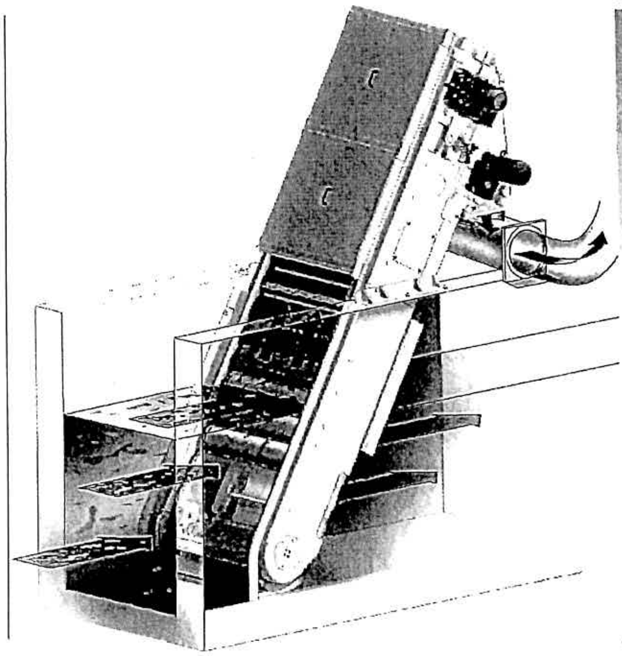


- Screening :
  - bar racks
  - mechanical screen



Fine static screen





Huber Screen

mechanical screen

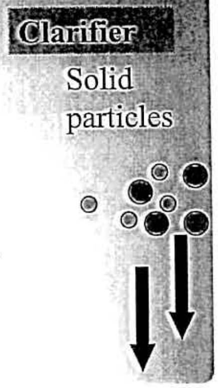
Primary Sedimentation

- Primary Sedimentation
  to provide physical removal of suspended particles
- Chemicals are often added to the waste stream to form a precipitate or a floc (this will assist suspended solid removal).

Why remove solids ?

Remove settleable solids means removing :

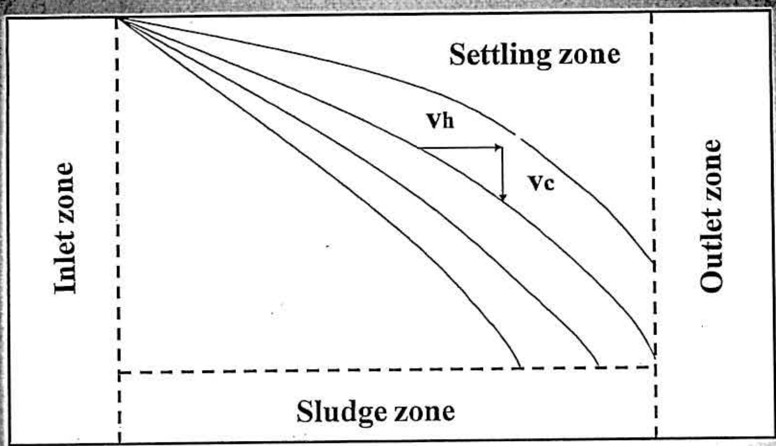
- 30 % BOD removal
- 60% TSS removal
- turbidity
- improves dissolve oxygen level in effluent



Design Consideration

- Hydraulic retention time (1.5 – 3 hrs at Qavg)
- Surface loading (40 m3/m2/d)
- Weir loading (185 m3/m/d)
- Depth of settling (3m) @ 10 feet

Primary Treatment



Settling path of particles in an idealised settling tank, in Type II settling

Types of Sedimentation Tank

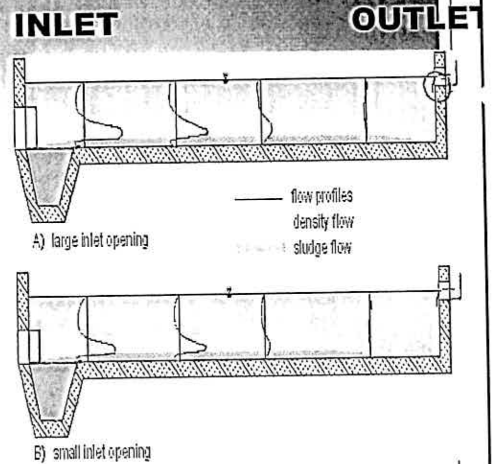
- Horizontal flow
- Inclined surface

Typical efficiencies...

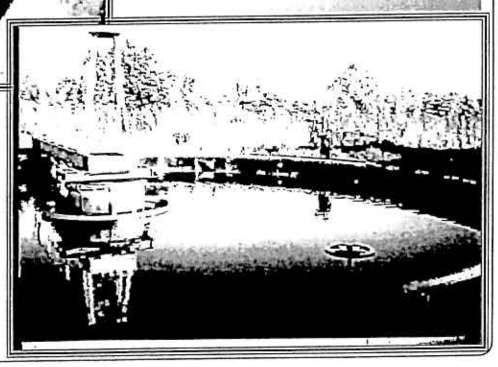
[illegible]	[illegible]
Biochemical Oxygen Demand	25% - 35%
Settleable Solids	90% - 95%
Suspended Solids	40% - 60%
Total Solids	10% - 15%

Horizontal Flow - Rectangular clarifiers

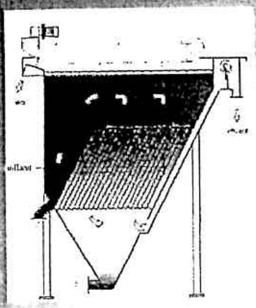
- Use common walls
- Provide longer travel time
- Less short circuiting
- Require multiple rows of weirs
- Sensitive to flow surges

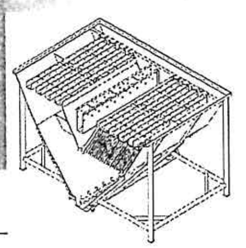


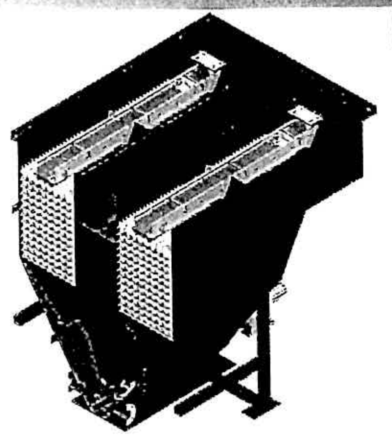
Horizontal Flow Clarifier - circular



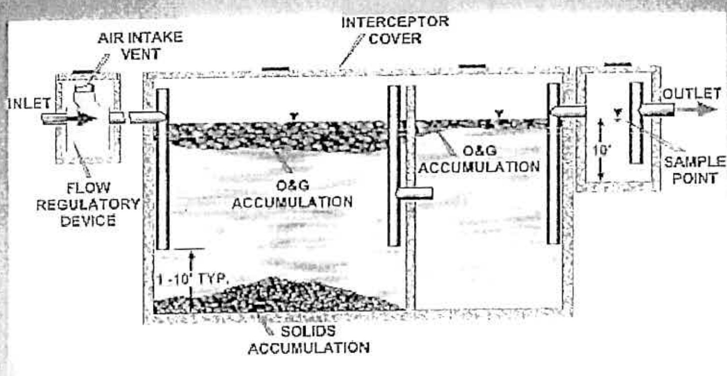
Inclined Plates Clarifiers







Oil & Grease Trap

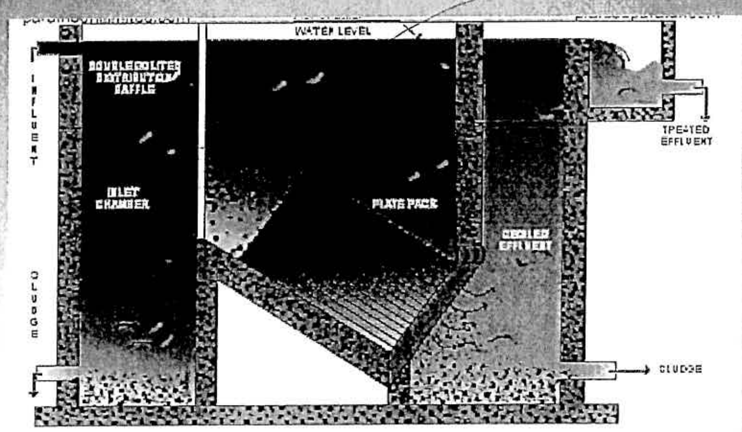


- O&G Trap using 2 tanks in series
- At least 60 minutes retention time - effective for oily wastewater
- Manual skimming of floating O&G

Design consideration

- One stage or 2-stage
- Hydraulic retention time (30 -60 minutes)
- Scum skimmer

Grease Chamber with Inclined Plates



Chemical Treatment of Wastewater

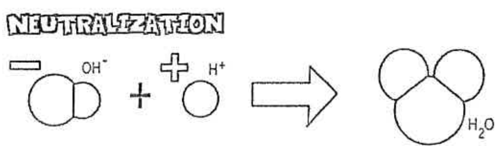
What are the methods used?

- pH adjustment
- Coagulation
- Flocculation
- Dissolved Air Flotation

pH ADJUSMENT

Why pH need adjustment – neutralisation?

- Acid and alkaline – greatest volume generated from industries
- Strong acid or alkaline effluent represent a hazard to sewer or pipe structures, personnel and wastewater treatment processes.



- Electroplating industries
- Metal finishing mills
- Electronic manufacturing industries
- Aircraft maintenance
- Mining industries
- Acid battery industries

Acid Wastes - Sources

Objective :

- to destroy corrosiveness of acid/alkaline to change to neutral state
- to eliminate hazards for safe handling and treatment of the effluent
- To provide optimum growth condition for biological treatment process

Neutralization

- Neutralization of a waste - involves the addition of chemical substance to change the pH to a more neutral level – in the range 6 to 8.
- Acidic waste neutralized with – lime, caustic soda, soda ash.
- Alkaline waste neutralized with – strong mineral acid: sulfuric acid, hydrochloric acid, and carbon dioxide.
- Neutralization of alkaline wastewater with CO_2 usually consists of bubbling CO_2 in the bottom of the neutralization tank.

	$[H^+]$	pH	Example
	1×10^{0}		HCl
	1×10^{-1}		Stomach acid
	1×10^{-2}		Lemon juice
Acid	1×10^{-3}		Vinegar
	1×10^{-4}	4	Soda
	1×10^{-5}	5	Rainwater
	1×10^{-6}	6	Milk
Neutral	1×10^{-7}	7	Pure water
	1×10^{-8}	8	Egg whites
	1×10^{-9}	9	Baking soda
	1×10^{-10}	10	Tums® antacid
Base	1×10^{-11}		Ammonia
	1×10^{-12}		Mineral lime - $Ca(OH)_2$
	1×10^{-13}		Drano®
	1×10^{-14}		NaOH

Source: http://www.visionlearning.com

pH Adjustment and problems

Reagent demand for Neutralisation of Acids/Bases

pH

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
						← 1	→←	1 →						
					←	10	→←	10 →						
				←		100	→←	100	→					
			←			1,000	→←	1,000		→				
		←				10,000	→←	10,000			→			
	←					100,000	→←	100,000				→		
←						1,000,000	→←	1,000,000					→	
←						10,000,000	→←	10,000,000						→

Units: in 10^{-6} mol/lit.

pH Adjustment and problems

Reagent demand for Neutralisation of Acids/Bases

p

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
						← 1	→←	1 →						
					←	10	→←	10 →						
				←		100	→←	100	→					
			←			1,000	→←	1,000		→				
		←				10,000	→←	10,000			→			
	←					100,000	→←	100,000				→		
←						1,000,000	→←	1,000,000					→	
←						10,000,000	→←	10,000,000						→

Case of pH 2
Neutralise to pH 7
Need 10,000

Units: in 10^{-6} mol/lit.

Reagents for Neutralisation

- Lime – quicklime CaO or hydrated lime $Ca(OH)_2$

Source: www.lowimpact.org

- Sodium carbonate
  – Na2CO3 used in water softening


Source: http://www.pool-chem.co.uk

- Caustic soda - NaOH

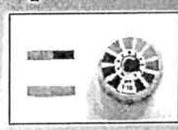
Caustic Soda

- Sulphuric acid – H2SO4

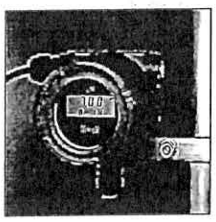
www.germes-online.com

pH Measuring Equipment

- portable pH meter
- On-line pH meter
- Litmus indicator


Litmus paper
Source: www.funsci.com


On-line pH meter
Source: www.funsci.com

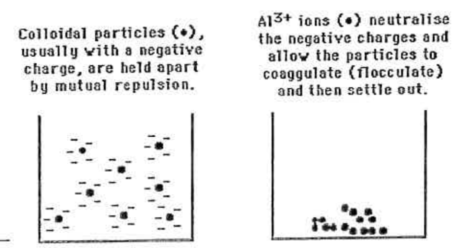

On-line pH meter
Source: www.dkktoa.net

COAGULATION AND FLOCCULATION

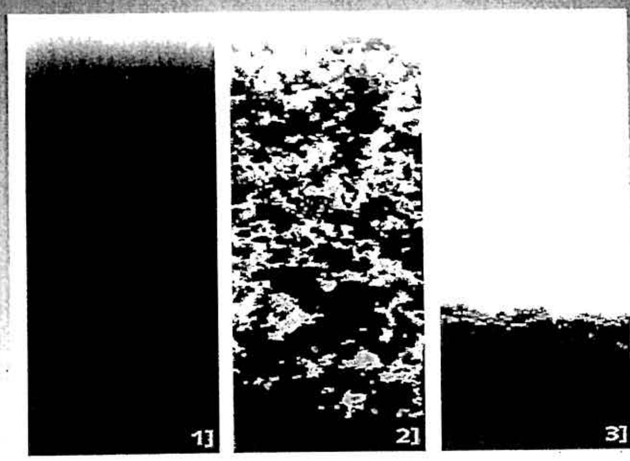
When do you use Coagulation-flocculation?

COAGULATION

- The purpose is to form flocs from suspended matter.
- Suspended matter which will not settle is colloidal.
- Colloids - range in size : below 0.001 to 1 micron.
- To cause the particles to settle, the negative charge on colloid must be neutralised.
- Coagulation is destabilization of charge on colloid and creates micro-floc.



Mechanism of Coagulation



raw waste *floc formation* *settled floc*

Design consideration

- Coagulants
- Retention time (10 - 20 minutes)
- Mixing
- dose

Chemical used as Coagulants

- Aluminum sulphate
- Ferric chloride
- Ferric sulphate
- Lime (not true coagulant)
- Polymer as coagulant aid eg cationic, anionic, non-ionic.
- PAC – new types

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Selection of coagulant

- Effectiveness in coagulation - give good flocs
- Handling aspects eg hazards and storage
- Relative cost of chemicals

36

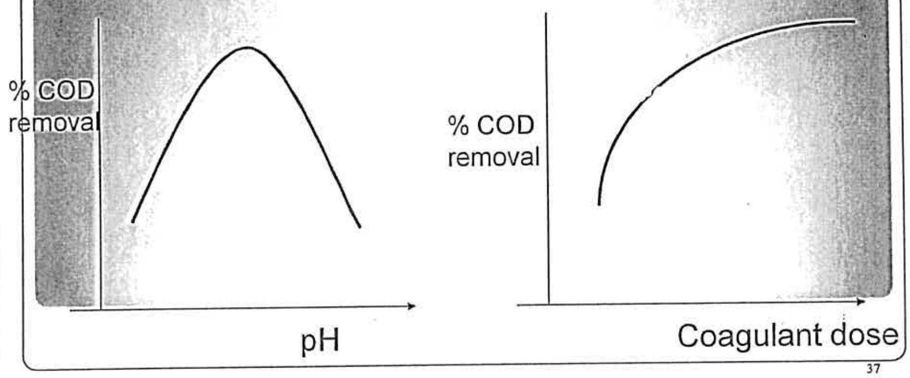
Coagulation Equipment

- Rapid mix tank
- Flocculation tank
- Settling tank

Dosage of coagulant

Small amount is needed (in ppm)

Follows typical curve below:



FLOCCULATION

- Process of forming aggregate of flocs
- Agglomerate into larger settleable particle
- Polymer is added to enhance floc build up

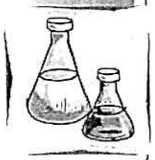
The following **chemicals** are used as flocculants:

- **alum**
- **aluminum sulfate**
- **iron(III) chloride**
- **iron(II) sulfate**

The following natural products are used as flocculants:

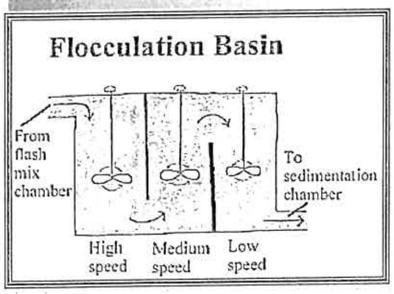
- **Chitosan**
- **Moringa oleifera** seeds

Flocculating chemicals



Method used in flocculation:

- Mixing tank with short retention time
- static mixer
- Air agitation (if no stirrer is provided)
- Baffle or partitions
- Paddle wheel

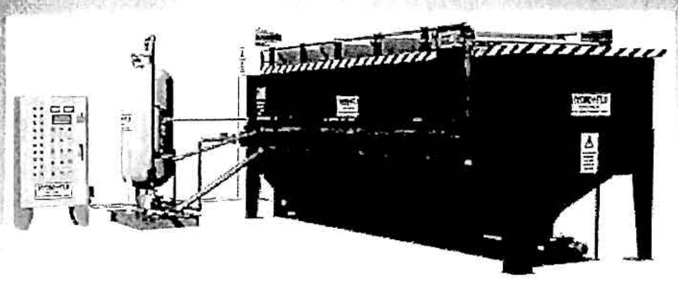


Dissolved Air Flotation (DAF)

Separation of solid from liquid using fine bubbles.

- ▶ Process air is injected under pressure into the liquid.
- ▶ Under this pressure, a large amount of air can be dissolved in the sludge.

- ▶ The bubbles attach themselves to solids particles and float them to the surface.

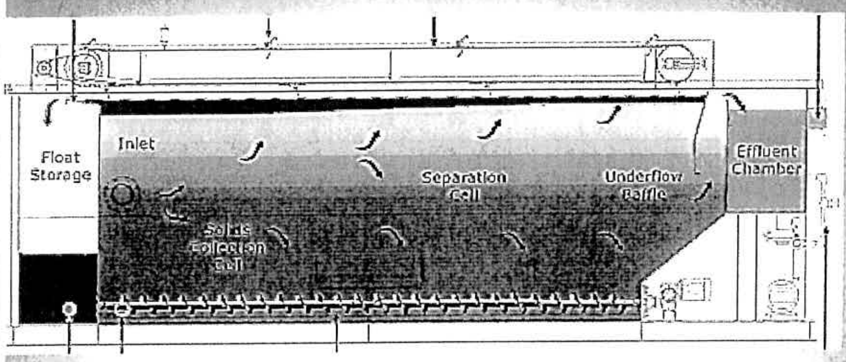


Design consideration

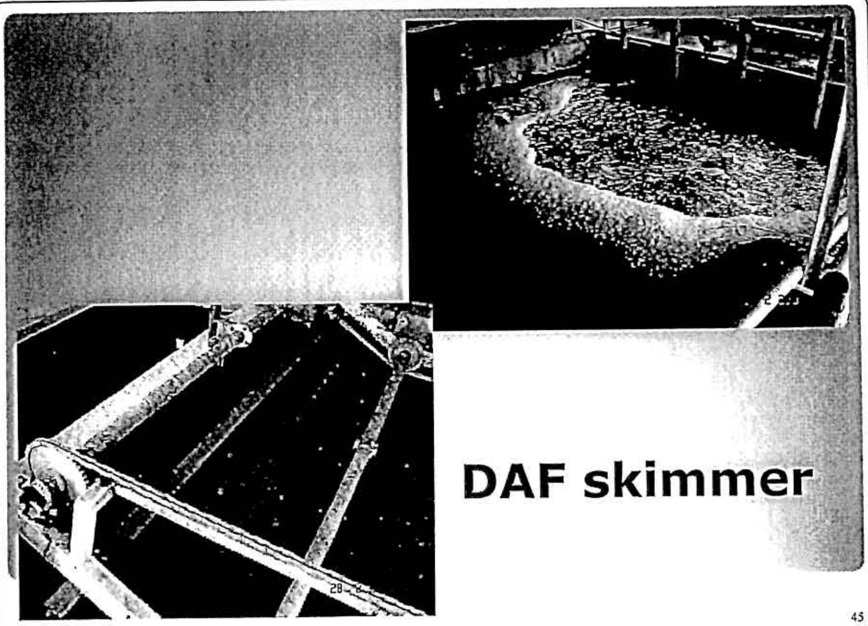
Air injection under pressure followed by release of pressure

- Pressure : 50 to 70 psi.
- Bubble size : 30 to 120 microns
- Detention time: 20 – 30 minutes
- The process typically increases the solids content for easy removal :

TS 0.5-1 % → 3 - 6 %.

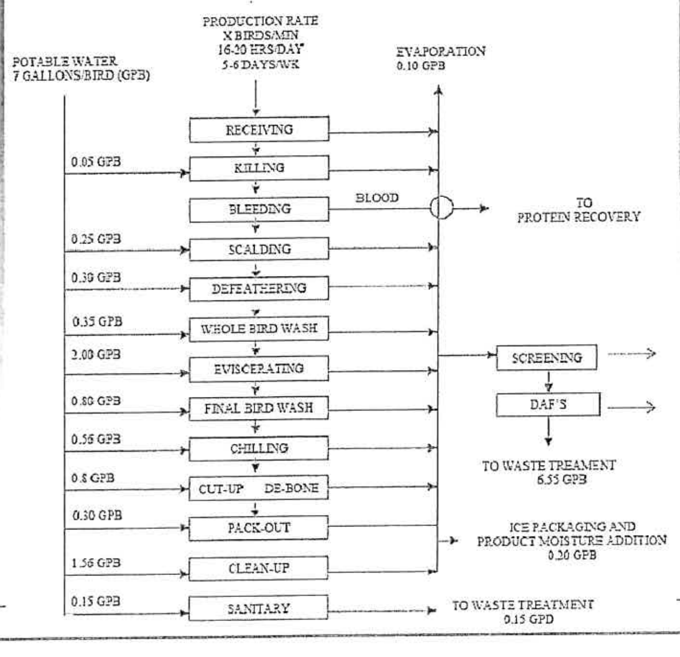


DAF in operation



DAF skimmer

TYPICAL WATER USE SCHEMATIC FOR BROILERS



TYPICAL POULTRY PLANT
Unit Operation Performance

Parameter	Screened Wastewater (mg/l)	DAF Effluent (mg/l)	DAF with Chemicals (mg/l)	Anaerobic Effluent (mg/l)	Activated Sludge Effluent (mg/l)	Filter Effluent (mg/l)
BOD	3000	1800	350	200	20	10
TSS	2000	900	250	200	30	10
TKN	150	130	100	100	10	5
NH3	50	40	30	90	0	1.0
FOG	500	200	30	20	7	3

End of slides

- Q&A

3.0 Biological System
- Aerobic

UNIVERSITI PUTRA MALAYSIA

PMT

PAKAR MANAGEMENT TECHNOLOGY (M) SDN BHD

Training Course on Industrial Wastewater Treatment System
Hotel Residence, 21-22 Dec 2009

Biological Treatment of Wastewater - Aerobic

Course instructor: Prof Dr Azni Idris

STEPS IN WASTEWATER TREATMENT PROCESS

Preliminary	Primary or chemical	Secondary	Advanced
Screen Oil Trap	[illegible]	Biological Aeration Pond system	Ammonia Nitrogen N Removal P Removal Disinfection Reuse option

Biological Treatment System of Wastewater

Why must we use biological treatment?

- Very effective for removal of organics
- Stabilisation of biodegradable material
- Removal of heavy metals (less effective)?
- Removal of colour (less effective)?

TYPES OF AEROBIC SYSTEM

Suspended growth:

- Stabilisation Pond (or oxidation pond)
- Aerated Lagoon
- Activated Sludge Process
- Sequencing Batch Reactor

Attached growth or biofilm:

- Trickling filter
- Biological Aerated Filter

What happen during biological treatment

Aerobic reaction:

Organic $O_2 \longrightarrow CO_2 + H_2O$ + new cells

Auto-oxidation – endogenous:

Cells + $O_2 \longrightarrow CO_2 + H_2O + NH_3$

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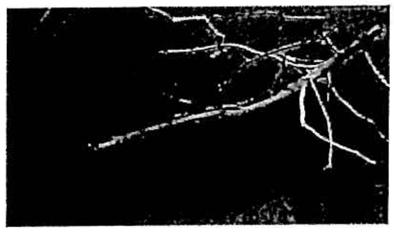
STABILISATION PONDS

- Ponds are used as low cost solution for stabilising wastewater
- Problems: Nutrient release – accumulate in pond



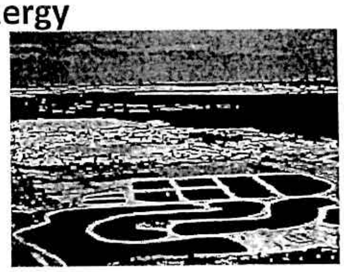
Oxidation Ponds

- most conventional system
  (normally called waste stabilization ponds)
- normally constructed in series
- most common in developing countries
- low maintenance , no energy

WASTE STABILIZATION PONDS

Shallow, generally rectangular lakes, usually arranged in a series of:

Anaerobic,
Facultative, and
Maturation ponds



Design of Ponds

- Retention time : 5 – 50 days (per pond)
- Compared with WWTP: 1 day
- Cheapest option for organic removal
- High removal of pathogens

Oxidation Pond Design

SURFACE BOD LOADING

λ_s, kg BOD/ha day

$$\lambda_s = 10L_iQ/A$$

Important equation!

L_i = influent BOD, mg/l*

Q = flow, m^3/day

A = pond area, m^2

NOTE UNITS!! * = g/m^3

- ❑ Design loading is a fn of temperature:

MARA'S GLOBAL DESIGN EQUATION

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

Another important equation

Note: 25°C

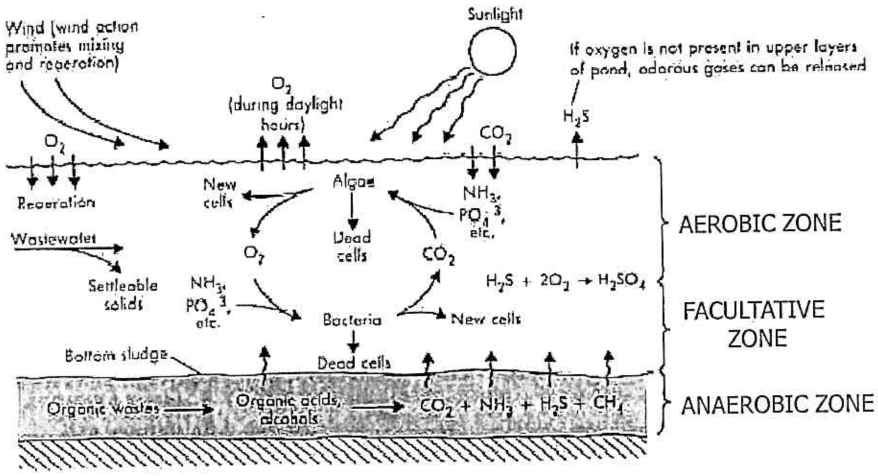
❖ Based on:

(a) T = 8 °C, λ_s = 80 kg/ha day [experience in Europe & NZ]

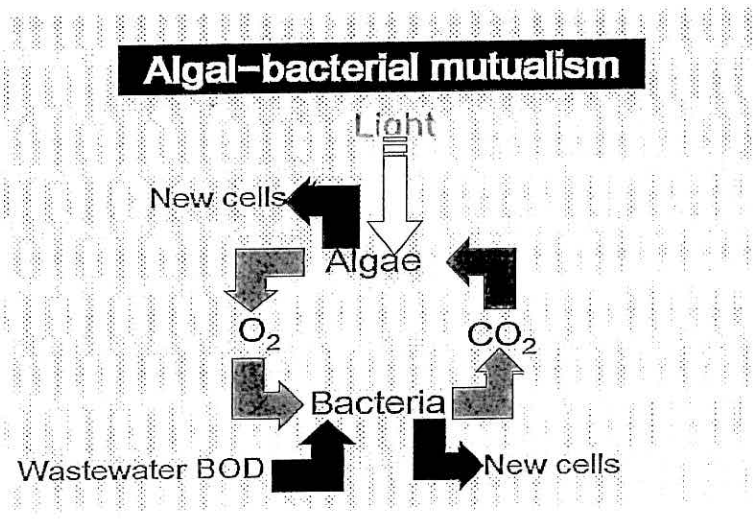
(b) T = 25 °C, λ_s = 350 kg/ha day [experience in NE Brazil]

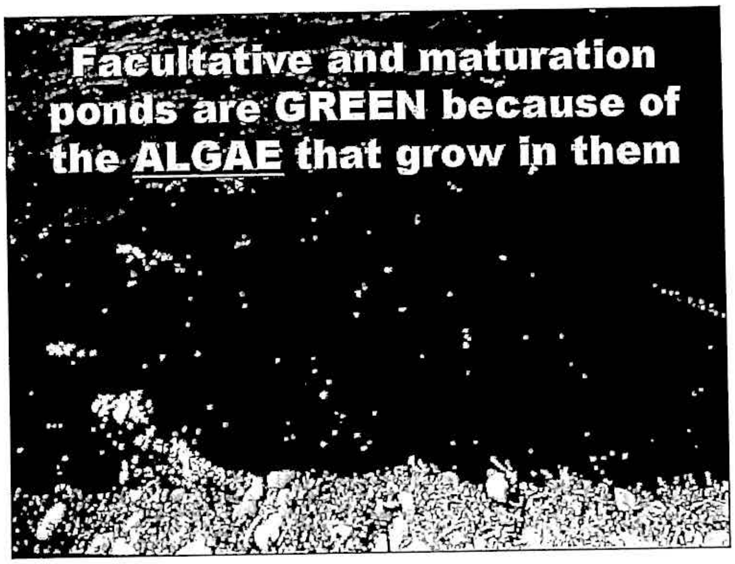
(c) T = 35 °C, λ_s = 500 kg/ha day [arbitrary upper limit]

Facultative ponds



ALGAE – BACTERIA INTERACTION

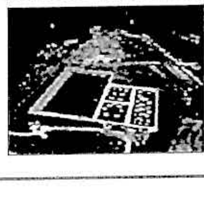


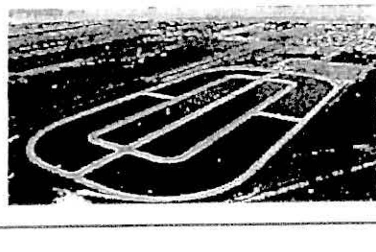


(Source: Mara, Univ. of Leeds UK.)

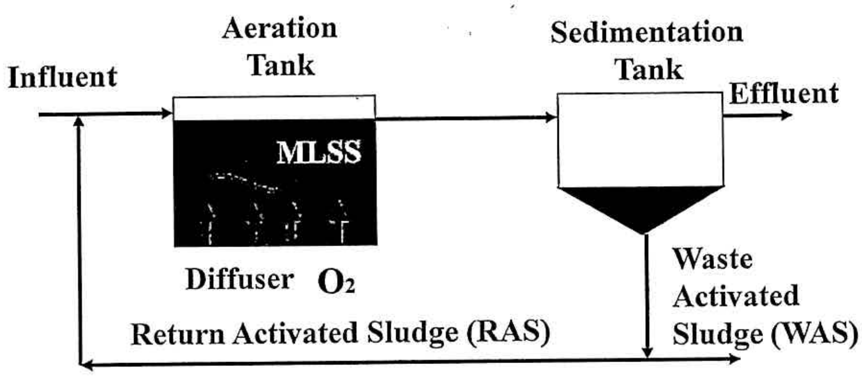
Aerated lagoons

- better version of oxidation pond with aeration devices

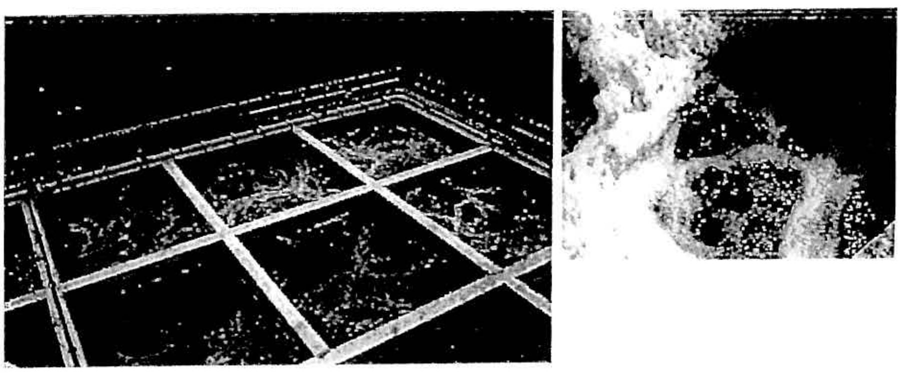




Activated Sludge Process



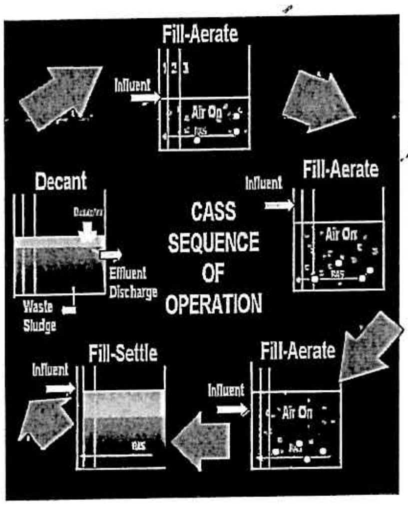
Activated sludge - Fine bubble aeration



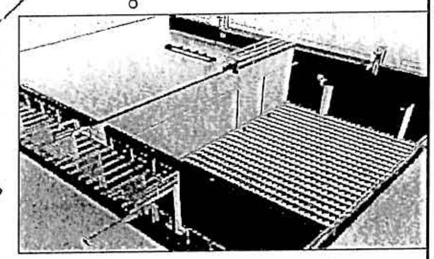
Process Design

Parameters	Conventional process	Notes
Y = mg VSS / mg BOD5	0.5 – 0.67	Biomass yield
Volumetric loading, kg BOD5 / m^3	0.3 – 0.6	Ability of bacteria to consume
MLSS, mg/l	1500 - 3000	Biomass conc.
HRT, hr Longer HRT for BOD > 1000 mg/l	8 – 16 (1 – 5 days)	Food - Bacteria contact in tank
Recirculation ratio	0.25 – 0.5	To maintain biomass in aeration

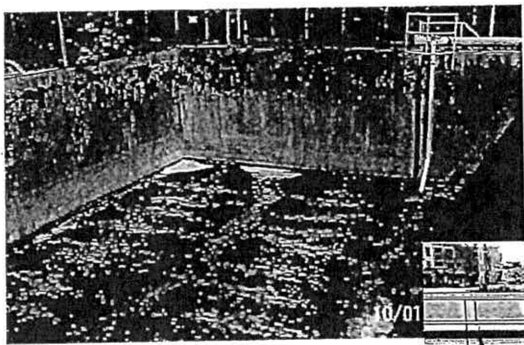
Sequencing Batch Reactor SBR



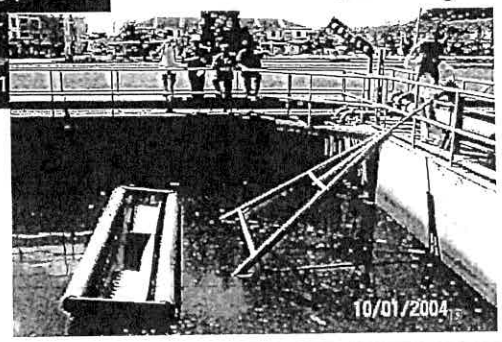
- Decanter system



SBR for Wastewater Treatment

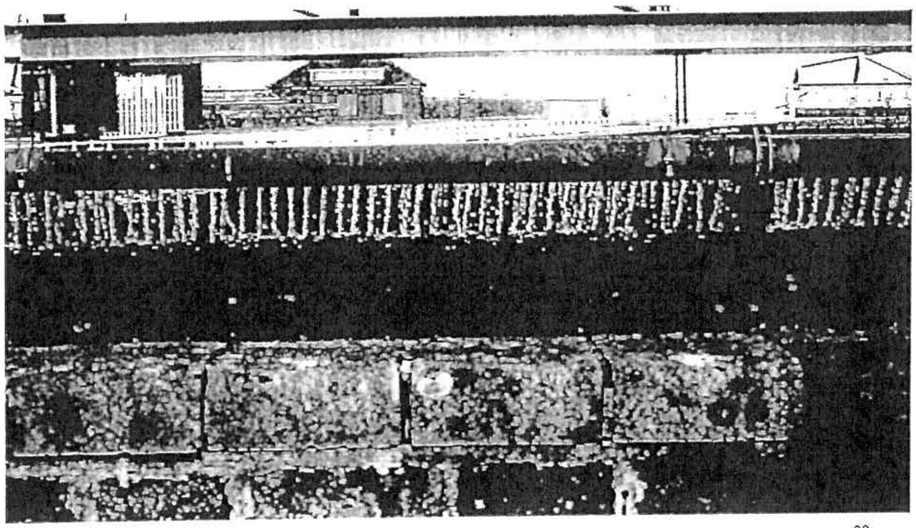


Settling and decanting

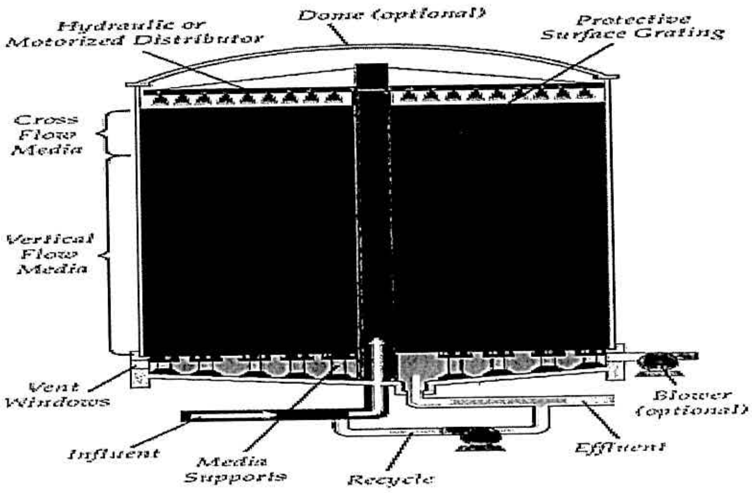


Aeration in progress

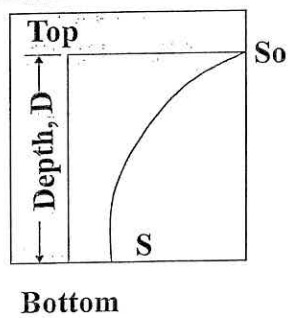
Trickling filters

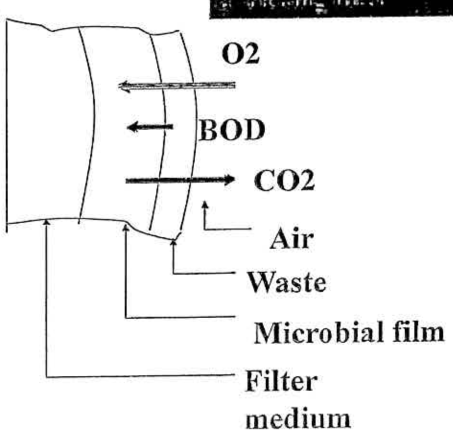


TRICKLING FILTERS IN TANK



Trickling Filter





Settled sewage + oxygen $\xrightarrow{\text{bacteria}}$ oxidised effluent + new bacteria cell

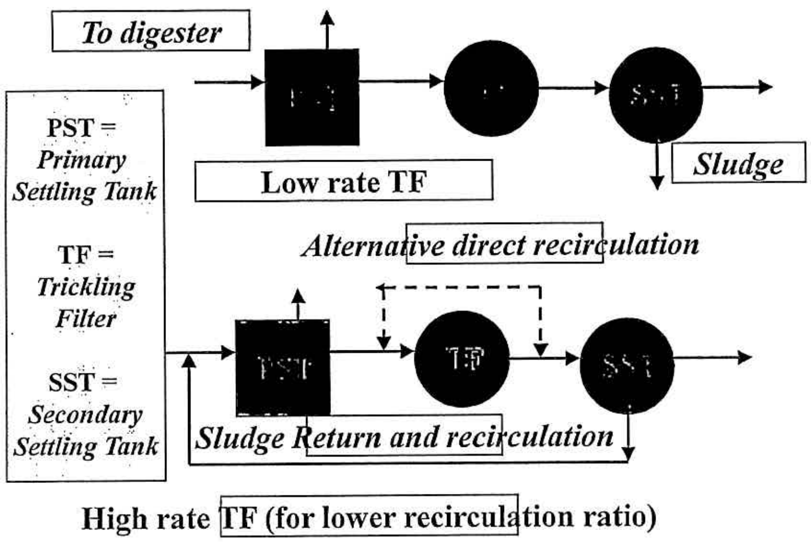
Trickling Filter

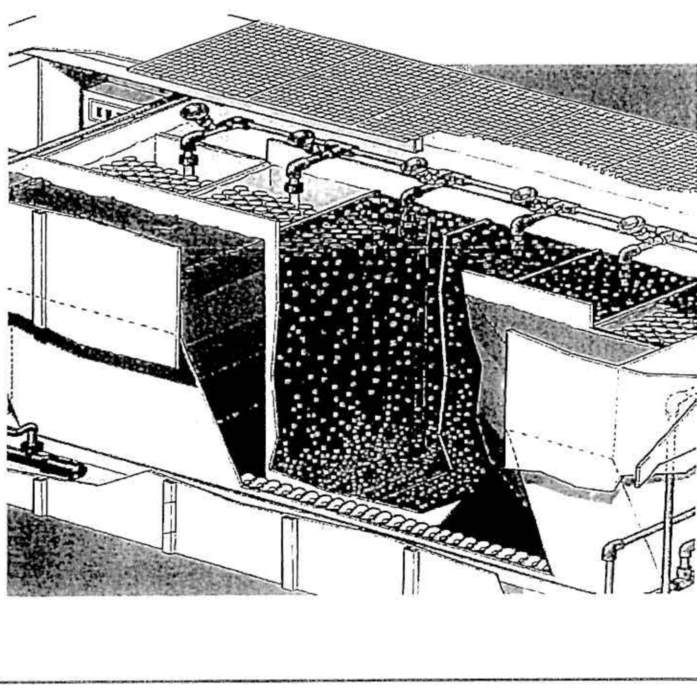
- Trickling filters may be classified into two categories; Low rate trickling filters and high rate trickling filters
- Recirculation is employed in high rate filters to improve efficiency
- Recirculation dilutes a strong waste and may provide a satisfactory operating rate for the rotary distributors during low flows

Process Design

Parameter	Low rate filter	High rate filter
Organic loading kg BOD_5/d	0.11 – 0.37	0.37-1.85
Depth	1.8 – 3.0	0.9 – 2.4
Recirculation	None	1:1 to 4:1
Bed volume	5 x	1 x
Sloughing	Intermittent	Continuous
Effluent characteristics	Nitrified fully	Nitrification only at low loading
Nuisance potential	Many flies and chances of odour	Less odour and flies

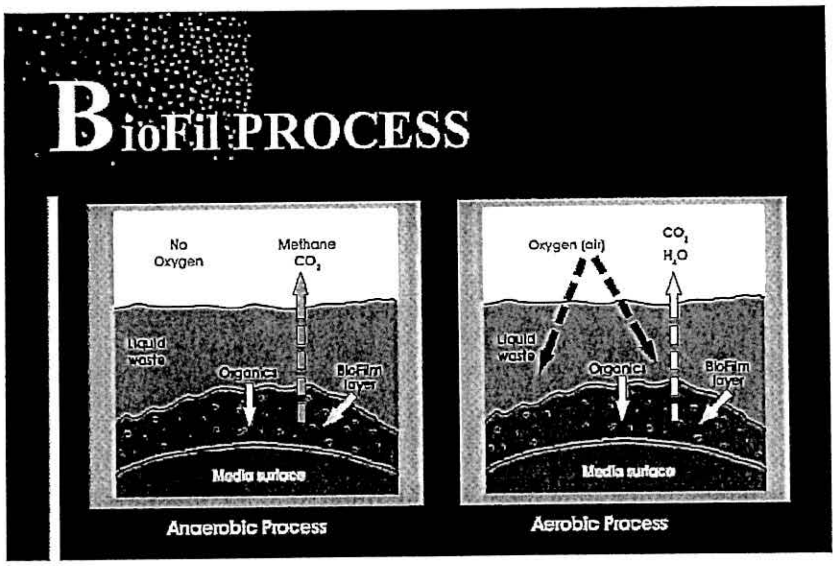
Trickling Filter





Biological
Aerated
Filter
(BAF)

Attached Biofilm - BioFil Technology



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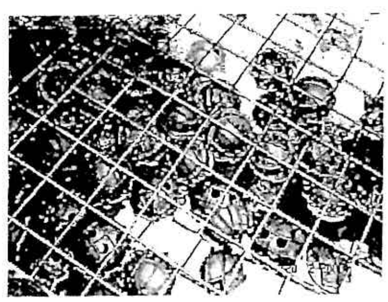
Plastic media – Cosmo balls

System Principles

- Utilize the naturally occurring micro-organisms to convert complex organics into methane, carbon dioxide
- Up flow filtration



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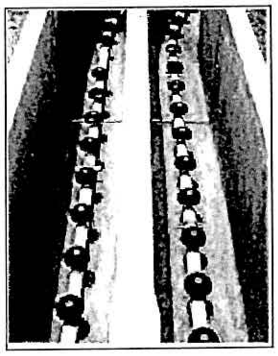
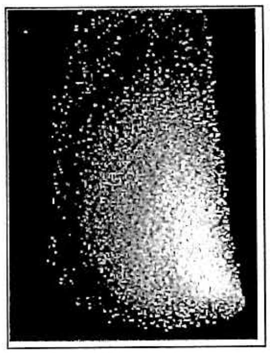
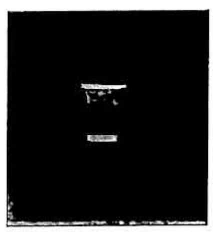
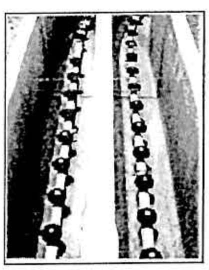
Components of Aeration

Aeration equipment
– air diffusers



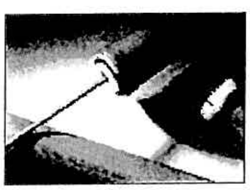


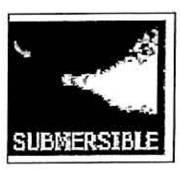




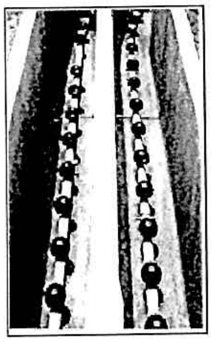
Air diffusers
Purpose:

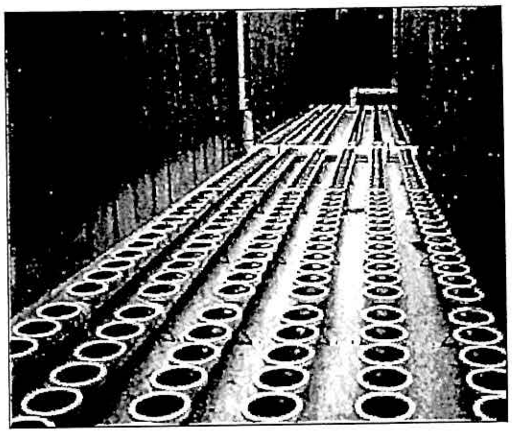
– to increase oxygen transfer
- to mix the bacteria-wastewater-oxygen





Air headers – provide oxygen to the bottom of tank





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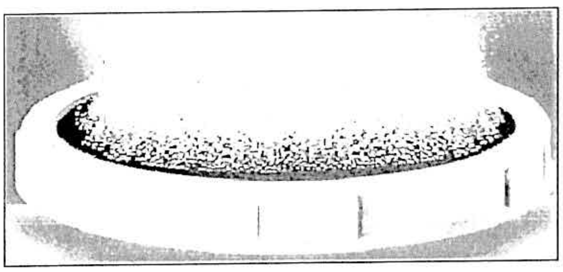
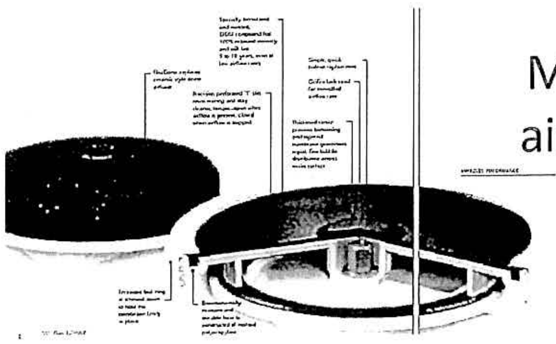


Membrane air diffusers



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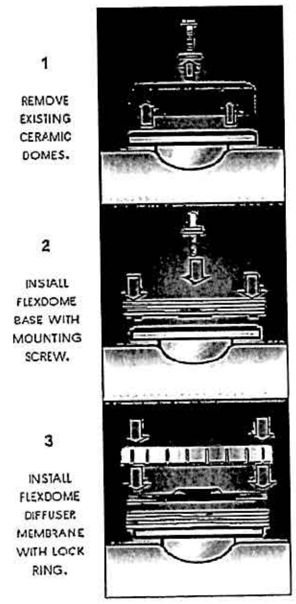
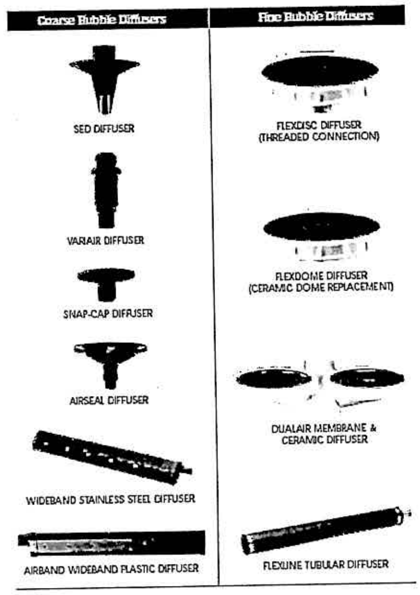
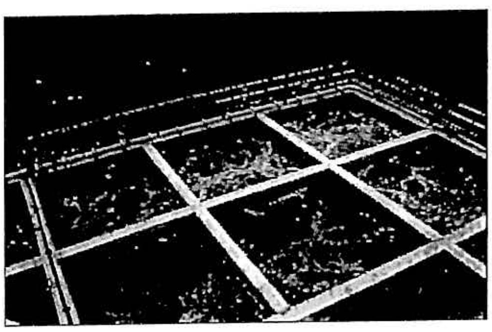


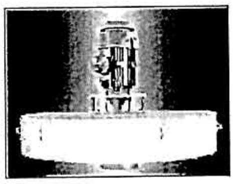
Entire removal and installation

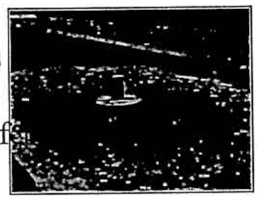


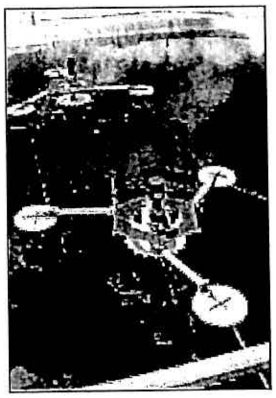
Fine bubble aeration



Mechanical surface aerators
– floating types

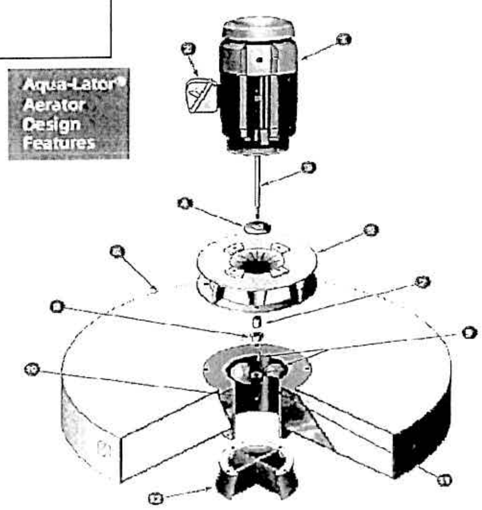




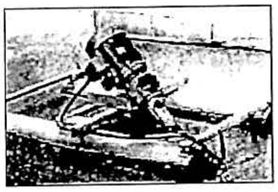


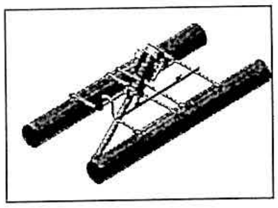
Features and Benefits

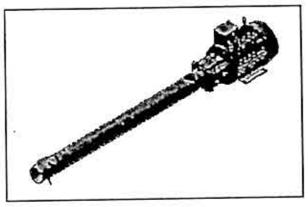
Excellent oxygen transf
Low operating costs
Trouble-free performance
Unequaled resistance to the environmental extremes
to which aerators are exposed.



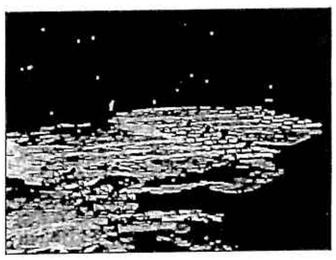
Mechanical surface aerators – jet or tornado types

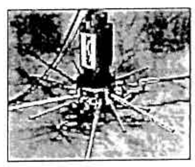


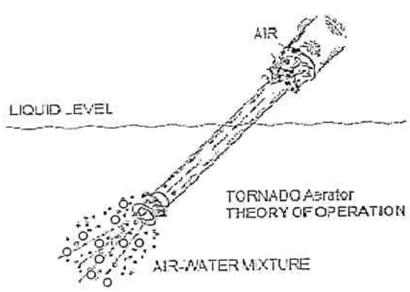




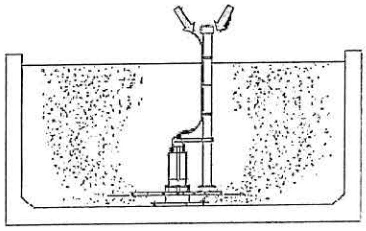
Tornado aerator



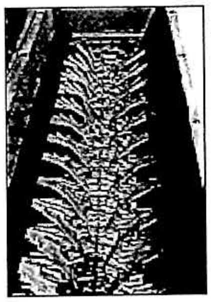


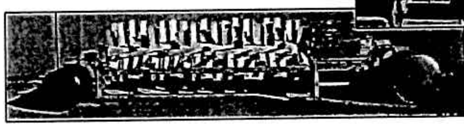


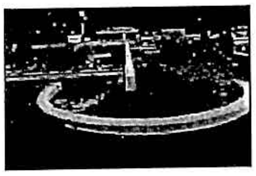
Hurricane aerator

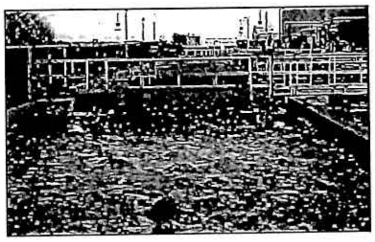


Brush aerators



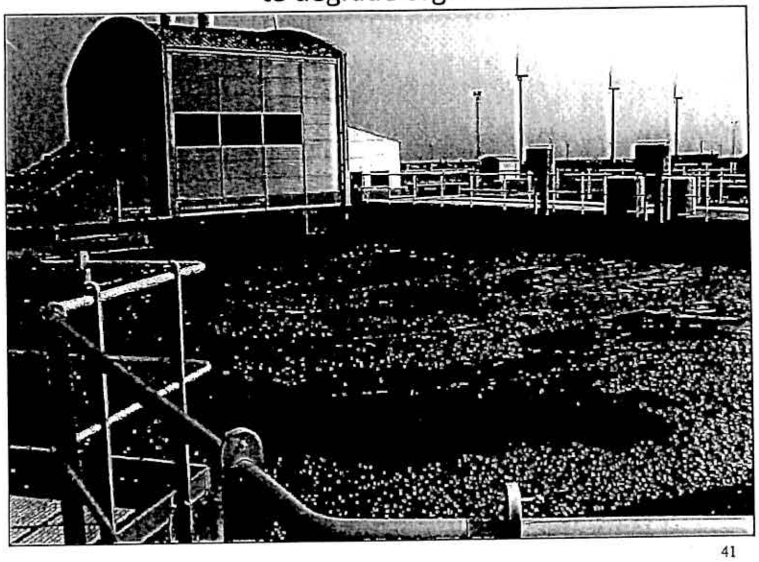






MICROORGANISMS IN WASTEWATER TREATMENT

WWTP depends on healthy microbes to degrade organic matter



Microorganisms in Biological Treatment

The main types of micro-organisms:

- bacteria
- protozoa
- algae

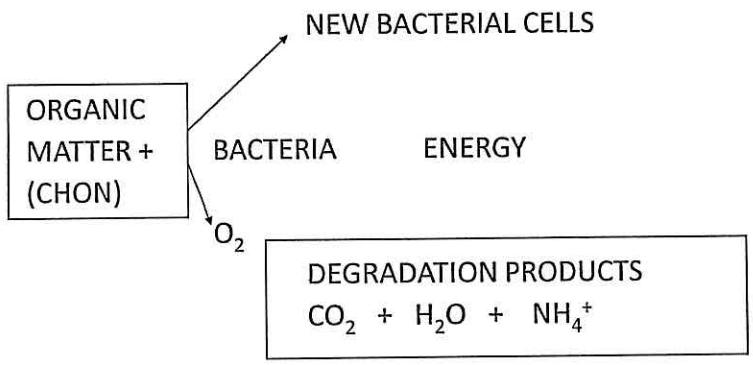
- An important basis for classifying micro-organisms, relevant to the study of wastewater treatment:
- ***food***
- ***energy***
- ***oxygen***

Aerobic organisms - need oxygen

Anaerobic organisms - require the absence of oxygen.

Facultative organism - some organisms adapted to either aerobic or anaerobic conditions.

- *Such organisms are able to obtain a higher yield when operating aerobically and thus prefer aerobic respiration.*



Growth requirements of Aerobic Heterotrophic Bacteria

Environmental factors

Affecting bacterial growth:

- ❑ temperature,
- ❑ pH
- ❑ mixing intensity
- ❑ presence of *toxic* agents.

pH for healthy growth

The pH for optimum biological growth: pH 6.5 to 7.5

Growth will occur: pH 4.0 to 9.5

Types of microorganisms:

BACTERIA

Bacteria are single-celled microorganisms; an essential part of nature's food chain since they degrade organic (and some inorganic wastes) which would potentially be toxic to the environment and human health.

Bacteria are everywhere. Every human being has about 100 billion on the surface of his/her body! The principal microbial shapes are:

• Spherical (cocci) • Rods (bacilli) • Spirals (spirilli)

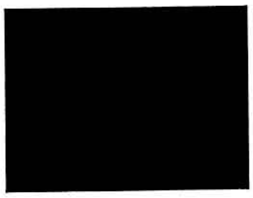
Some bacteria also form filaments or hairlike appendages. Others have flagella (whiplike appendages) or cilia (hairlike appendages around the cell) for motility and food gathering.

Bacteria
Make up about 95% of the activated sludge biomass.
These single celled organisms grow in the wastewater by consuming (eating) bio-degradable materials such as proteins, carbohydrates, fats and many other compounds

Bacteria

- *Pseudomonas sp*

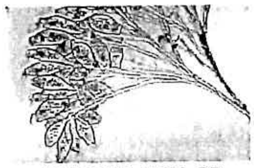
- *E. Coli sp*



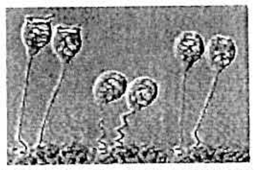
- *Nitrobacter sp*

Ciliated protozoa

CARCHESIUM SP



OPERCULARIA SP



VORTICELLA CONVALLARIA

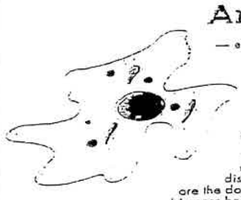
Protozoa

Protozoa are typically unicellular microorganisms which are active predators within an aquatic environment. They can be seen swimming about, capturing and consuming prey such as bacteria, small algae, fungi, or other protozoa. They exist in many varieties commonly classified in five groups:

1. Amoebae 2. Flagellates 3. Free-swimming ciliates 4. Crawling ciliates 5. Stalked ciliates

Amoebae

— example *Amoeba sp.*
(length 30-600 µm)



Members of the genus *Amoeba* have no distinct shape because the flow of cytoplasm continually changes their shape. Motility occurs by formation of pseudopodia which are cytoplasmic extensions often referred to as false feet. They feed on bacteria and protozoa.

Amoebae are present in significant numbers during start-up of a treatment plant, and after a toxic overload, when dissolved oxygen is marginal or depleted. When *Amoebae* are the dominant protozoa present, they indicate poor overall biomass health.

The presence of protozoans is related to effluent quality and plant performance. Protozoan play secondary but important role in purification of aerobic wastewater.

When amoeba are in large numbers in the aeration basin - indicates some sort of shock loading occur to the plant (there is lots of food available). Their presence indicate there is a low D.O. in the aeration basin, because they can tolerate very low amounts of D.O.

Crawling Ciliates

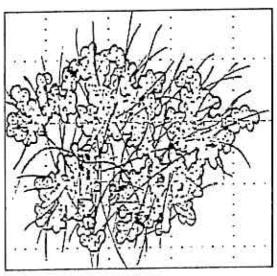
– example *Aspidisca* (length 30-50 μm)

Crawling ciliates differ from free-swimmers by the location of their cilia. They typically have cilia on only one side of the organism. These protozoa utilize cilia to seemingly crawl over bacterial floc for selective feeding.

– Crawling ciliates generally proliferate in environments rich in oxygen, where organic levels are moderate, and bacteria are plentiful. These indicators reflect a stable wastewater environment and healthy activated sludge.

Ciliates feed on bacteria not on dissolved organics. While bacteria and flagellates compete for dissolved nutrients, ciliates compete with other ciliates and rotifers for bacteria. The presence of ciliates indicate a good sludge, because they dominate after the floc has been formed and after most of the organic nutrients have been removed

Filamentous organisms – unwanted species

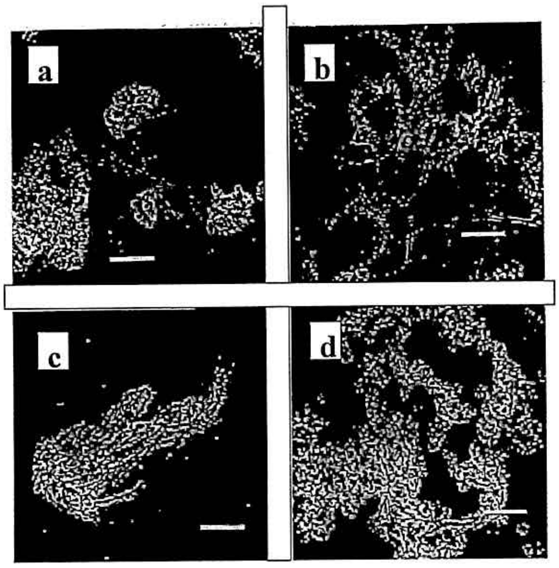


Found in many wastewater treatment systems. While existing in low concentrations, the filamentous organism is benefecial in aiding to the development of biological floc; however, while existing in higher concentrations, extreme settling and bulking conditions may exist.

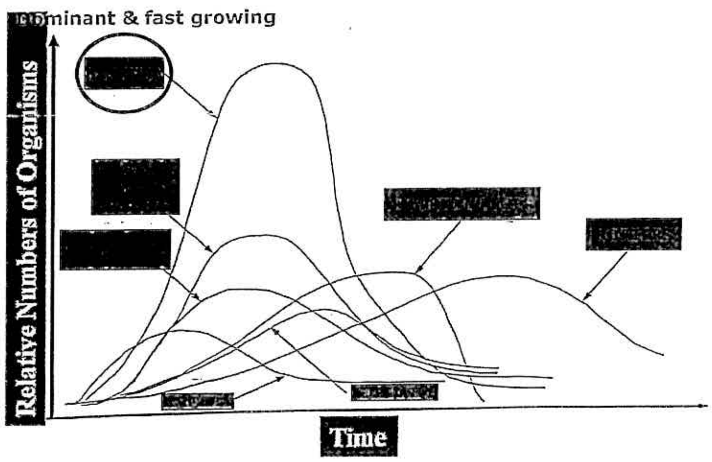
Their appearance in wastewater can be caused by many factors:-

- Low DO residuals
- Low NH3-N and PO4 residuals
- Low food to microorganisms ratios
- Easily degradable compounds, etc.

Filamentous organisms



Indicator Organism Predominance



F/M ratio

F to M : measure of the substrate loading (BOD) on the biomass, and is known as the "food -to-microorganism ratio".

F/M ratio : convenient measure of organic loading rate for most practical treatment systems.

$$F/M = \frac{\text{Mass of BOD added to the system each day}}{\text{Total Mass of MLVSS in the system}}$$

Solids retention time (SRT) (also call Sludge age)

- Time of biomass or bacteria cell stay in aeration basin
- Longer SRT: more effective bacteria contact with organic matter in aeration tank
- $SRT = \frac{\text{mass of solid in reactor}}{\text{mass of solid removed/day from system}}$

End of slides

- Q&A

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Training Course on Industrial Wastewater Treatment System
Hotel Residence, 21-22 Dec 2009

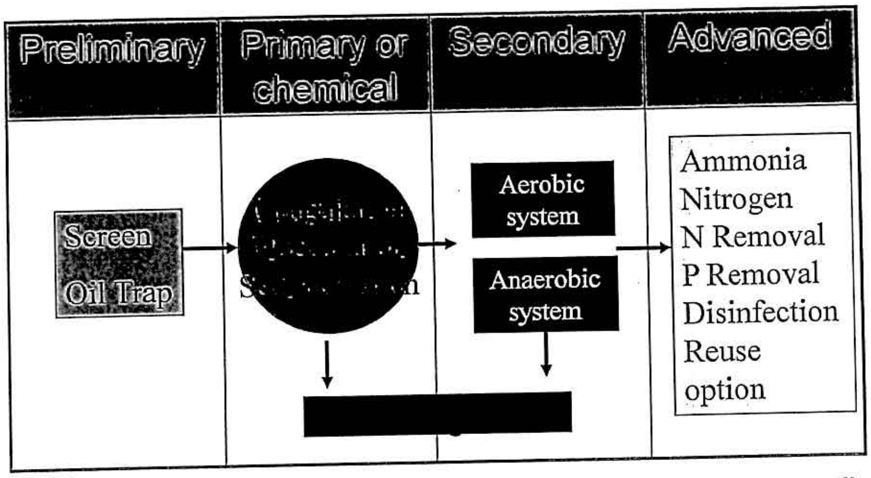
Biological Treatment of Wastewater - Anaerobic

Course instructor: Prof Dr Azni Idris

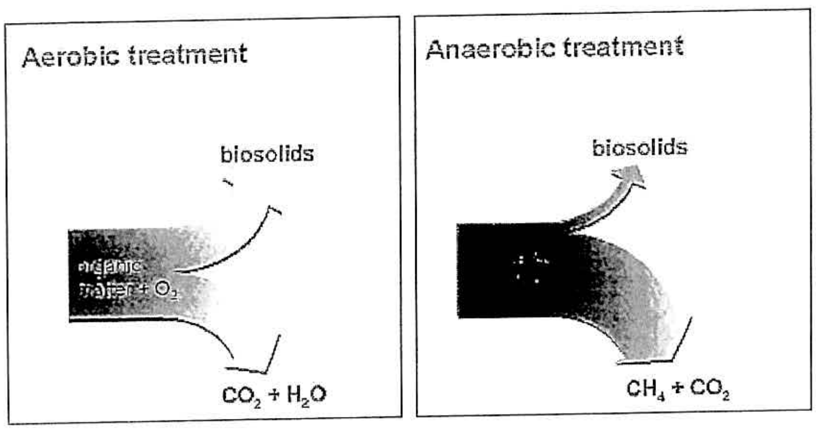
3.0 Biological System

- Anaerobic

STEPS IN WASTEWATER TREATMENT PROCESS



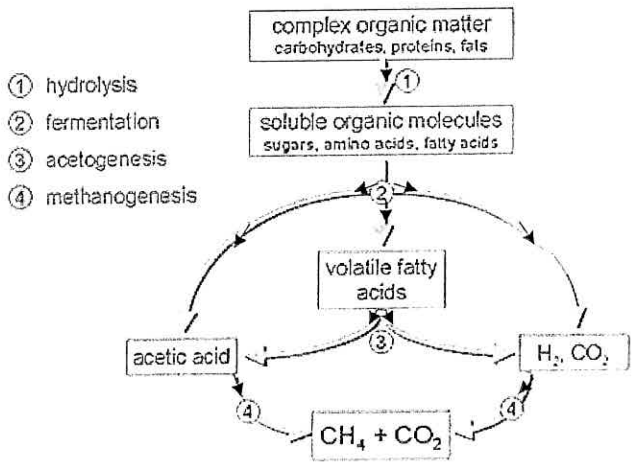
Waste Treatment Option
Which route?
Anaerobic versus aerobic

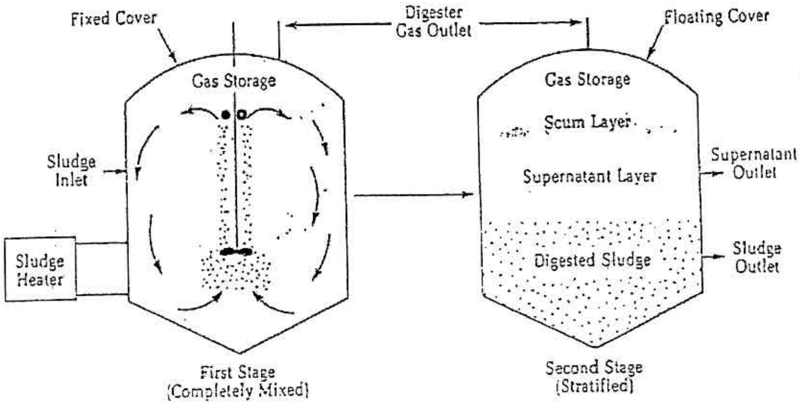


Anaerobic Process: 2 stages.

- The first stage is **acid fermentation**. In this stage organic material is simply converted to organic acids, alcohol and new bacterial cells, so that little stabilization of BOD and COD is realized.
- In the second stage, the end products are converted to gases (methane and carbon dioxide). This stage is generally referred to as **methane fermentation**.

How methane gas is produced?



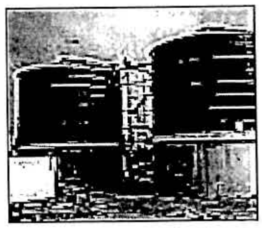


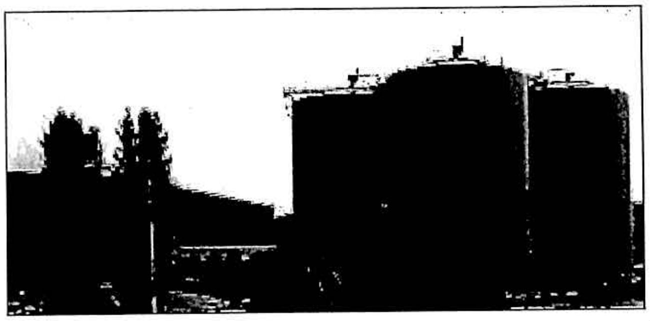
Anaerobic Digester

Estimation of gas from anaerobic digestion

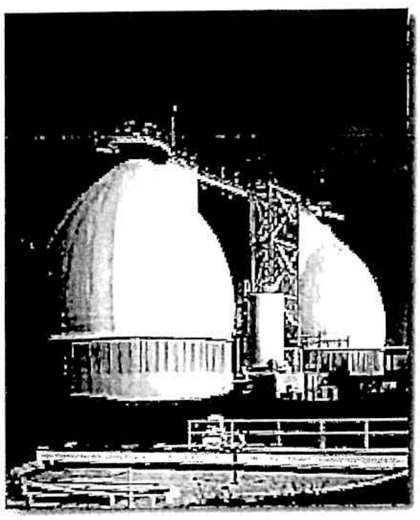
Feedstock	Number of animals to produce 1 tonne/day	Dry Matter Content	Biogas Yield(M3/t)	Energy Value(MJ/ m3) Biogas
Cattle Slurry	20-40	12	25	23-25
Pig Slurry	250-300	9	26	21-25
Laying Hen Litter	8,000-9,000	30	90-150	23-27
Broiler Manure	10,000-15,000	60	50-100	21-23
Food Waste	~	15	46	21-25

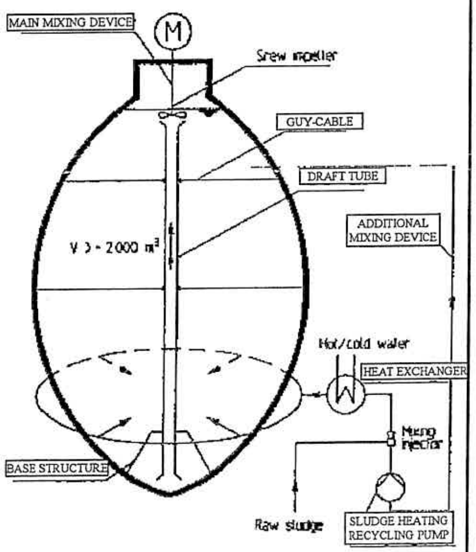
Common Sludge Digester





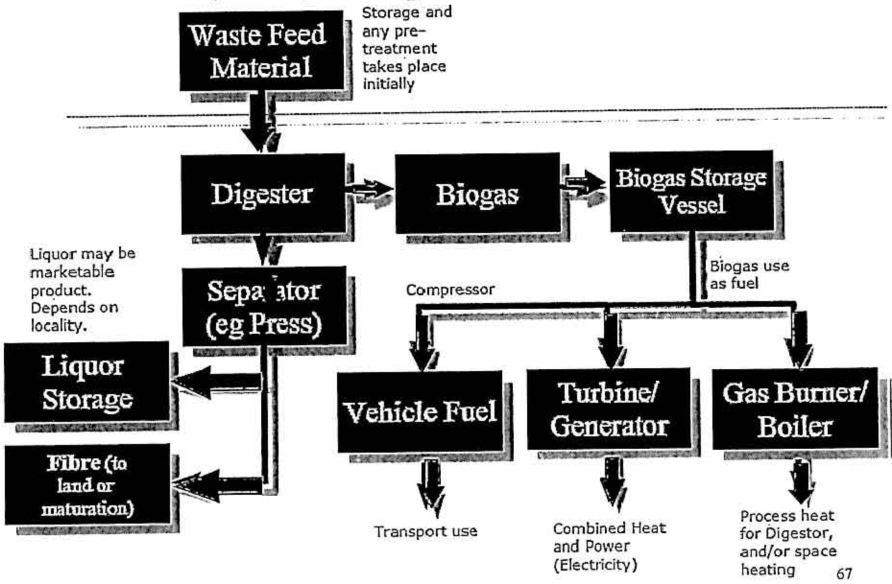
Egg shaped anaerobic digester





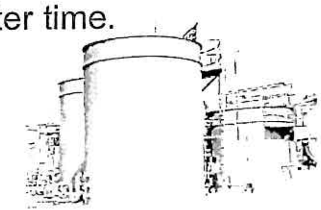
Biogas to energy

Anaerobic Digestion Flow Chart



Anaerobic Bioreactor System

- Anaerobic bioreactor consist of several tanks in series
- The anaerobic digestion is carried out in the digester, then the facultative anaerobic and aerobic ponds.
- In has been shown that a better reduction of BOD can be achieved in a shorter time.



Bioreactor System

- This is a simple and innovative bioreactor process that is capable of treating POME efficiently.
- The system is superior to the conventional system as it operates with very short hydraulic retention times, takes high organic loading, requires less space and is more environmentally friendly.

Design – Construction

- Digesters in Palm oil mills are constructed of mild steel at various volumetric capacity ranging from 600m^3 to 3600m^3.
- The treatment using tank digester normally range between 20 to 25 days, but modern high rate process = 15 days HRT.

Hydraulic retention time (HRT)	20 – 25 days
Loading , BOD kg/m^3.day	0.8 – 1.0

Anaerobic Pond Design - Construction

	Anaerobic pond	Facultative pond	Aerobic pond
Depth (m)	5 - 7	1 - 1.5	0.5 - 1
Hydraulic retention time (days)	45	20	14
Loading, BOD kg/m^3.day	0.2 – 0.35	-	-

- Between the different stages of the ponding system, no pumping is required as the treated POME will flow using gravity.
- The number of ponds is will depend on the production capacity of each palm oil mill.

End of slides

- Q&A

4.0 Problem Related to Treatment System

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Hotel Residence, 21-22 Dec 2009

PROBLEMS OF WASTEWATER TREATMENT SYSTEM

Course instructor: Prof Dr Azni [illegible]

What are Common Problems ?

- Problems related to Waste Stream
- Problems related to Design
- Problems related to Operation

Who is responsible for IETS failure?

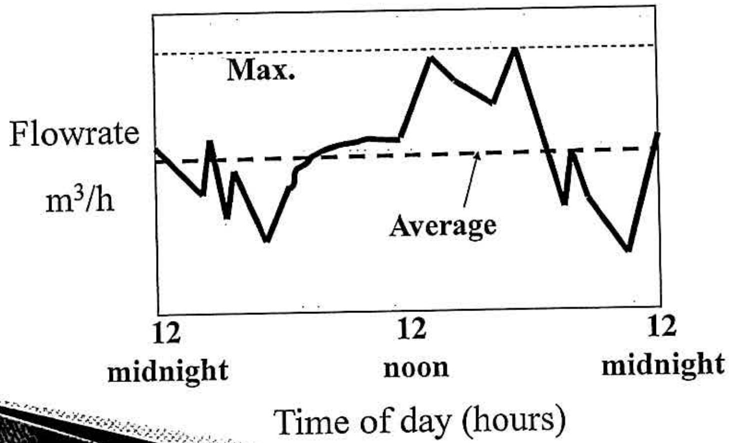
Problems related to Waste Stream

- Problems related to changing waste characteristic, eg. Concentration
- Problems related to peak flows
- Problems related to large variation in organic loading (kg/d)

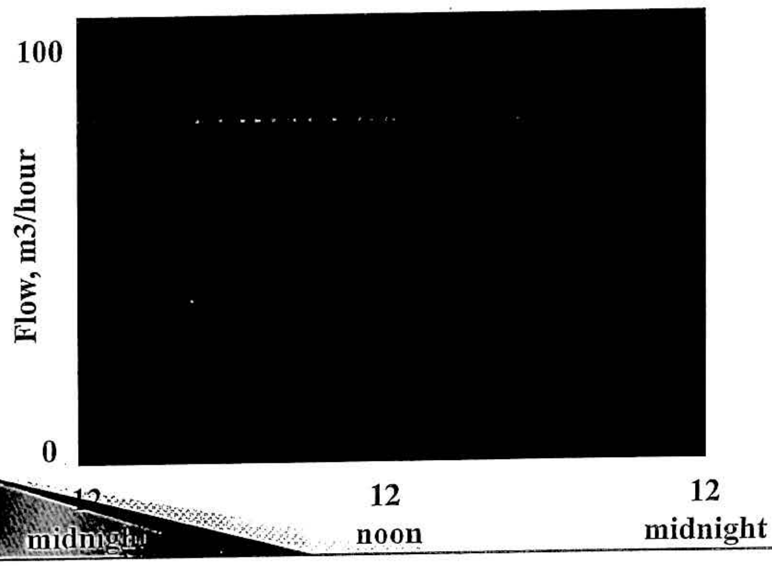
Variation in flow:

- Very wide fluctuation even from similar industries.
- Fluctuation in waste strength is common.
- Variation in waste stream depends on diversity of products produced.

Variation of hourly flow in IETS



Variation in Municipal Water Demand and Wastewater Flow



Problems Related to Wastewater Characteristic for Industries

Type	Food	Textile	Meat	Palm Oil	Sewage
Volume (Lit/Tonne)	10,000	12,000	600	100,000	225 L/PE/d
BOD	1,200	1,200	640	25,000	250
COD	2,000	2,500	1,500	50,000	450
SS	700	300	8,000	400	300
pH	6.8	11	7	4	6.5
Heavy Metals	Very low	Very low	Very low	Moderate	Very Low

Degree of Biodegradability of Selected Industrial Effluent

Raw Effluent	BOD	COD	BOD/COD
Pharmaceutical	3290	5780	0.6
Cellulose	1250	3455	0.47
Tannery	1160	4360	0.28
ABS detergent	1070	4650	0.25
Tobacco	2420	4270	0.59
Paper mill	380	686	0.58
Vegetable oil	3474	6302	0.55
Organic chemicals	3171	8597	0.56
Textile dyes	393	951	0.53
Hardboard	3725	5827	0.67
Domestic sewage	250	450	0.6

Problems related to Design

ACTIVATED SLUDGE SYSTEM

Common approach in design

- Rule of thumb
- Hydraulic parameters
- Kinetic method

Process Design

Parameters	Conventional
Y, mg VSS / mg BOD_5	0.5 – 0.67
k_d, d^{-1}	0.056 – 0.01
θ_c, d	5 - 15
FM ratio (kg BOD_5 / kg MLVSS)/d	0.2 – 0.4
Volumetric loading, kg BOD_5/1000 m^3	320 – 640
MLSS, mg/l	1500 - 3000
HRT, hr	4 – 8
RAS, recirculation ratio	0.25 – 0.5

Know the design – Establish Mass balance

- Describe mass flow in a system
- Important for design and process evaluation

- Flow in = Flow out – established for all units
- BOD in & BOD out at all points in WWTP
- BOD load (kg/day) = BOD (kg/m^3) x Flow (m^3/d)

Assessment of Treatment Plants

Why Treatment Plants fail?

Possible cause:

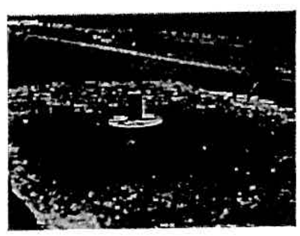
- Process design – not suitable or effective for treatment the type of effluent
- Under-designed cases – actual BOD load is excessive, eg Q is higher than expected
- Settling tank fails – TSS is unsettleable, tank is too small, or tank geometry is wrong.

Problems related to Operation

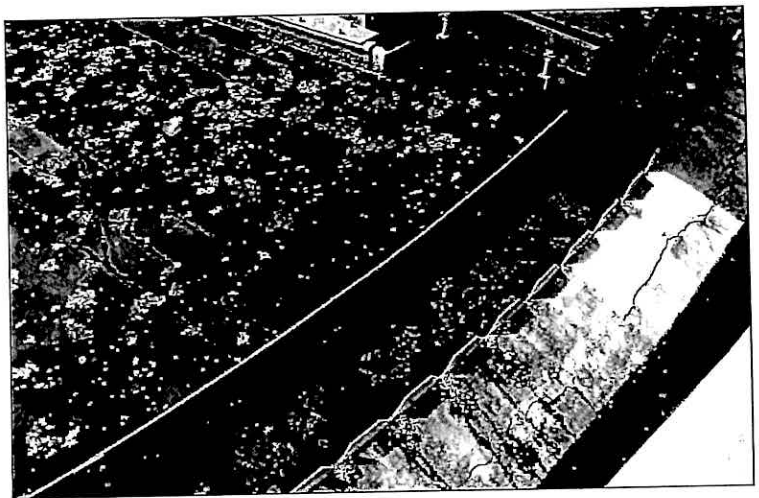
- Dosing of chemicals - not adjusted
- Dead microorganisms
- Environmental conditions - upset
- Toxicity issues for MO - presence of toxic chemicals
- Settleability of solids - unsettleable or bulking sludge
- Increase flow - due to production or wastage

Problems - Overloaded system

- Wastewater flow
  - reduce hydraulic retention time
- Organic loading
  - too much food for MO (FM ratio?)
- Shock loading - rapid dose of high BOD with equalization



Problems – Sludge bulking



End of slides

- Q&A

5.0 Selection of Suitable Treatment System

- Design Consideration

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Hotel Residence, 21-22 Dec 2009

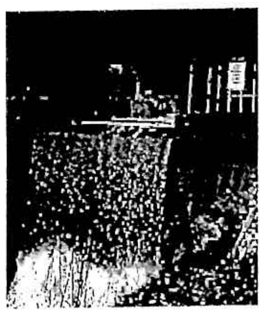
SELECTION OF SUITABLE TREATMENT SYSTEM

Course instructor: Prof Dr Azni Idris

Design Consideration

What is required ...

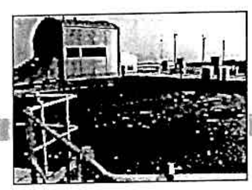
- □ Waste volume
- □ Waste load
- □ Peak flow
- □ Average flow
- □ Regulatory requirement
- □ Cost limitation
- □ Operational issues – skill or non-skill



Developing options

- □ Organic removal
- □ Nutrient removal
- □ Specific pollutants
- □ Resource recovery – recycle/reuse
- □ Zero discharge
- □ Carbon credits

Process Options



Select from available processes:

- □ Physical
- □ Chemical
- □ Biological
- □ Combined (hybrid)
- □ Advanced or polishing

Biological Process Options – which one ?

5

AEROBIC	ANAEROBIC
COD < 3000 mg/l	COD > 3000 mg/l
BOD < 1000 mg/l	BOD > 1000 mg/l
LOW STRENGTH	HIGH STRENGTH
Rapidly biodegradable	Slowly biodegradable
Mineralization of organic	Transformation of organic

Case examples

6

- □ Food processing
- □ Edible oil (palm oil)
- □ Tannery
- □ Sewage
- □ Automotive painting
- □ Electronic plating

End of slides

7

□Q&A

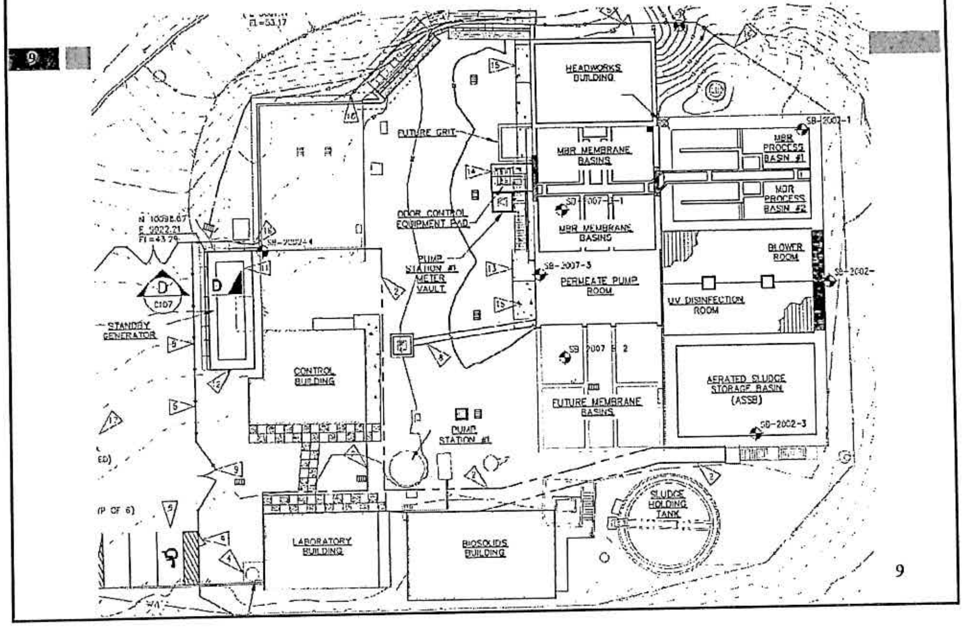
Plant Layout

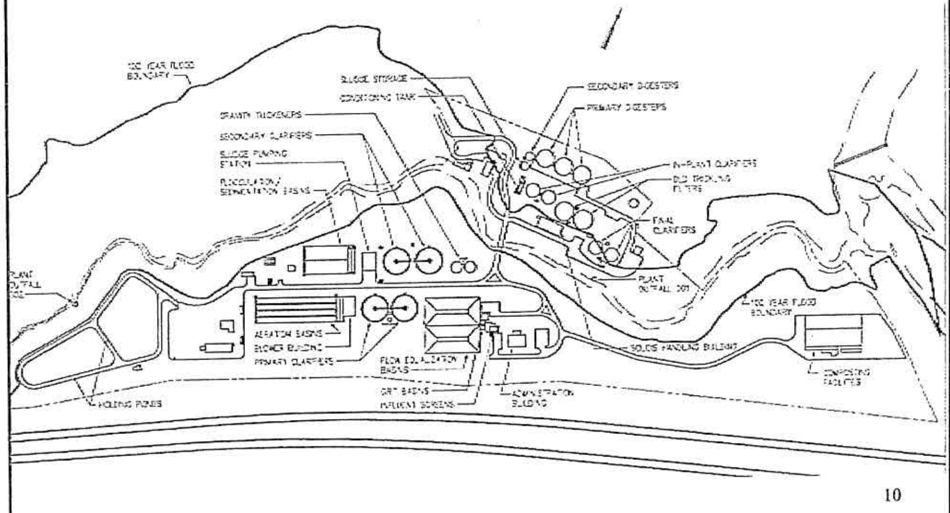
8

Factors affecting layout

- □ Site topography
- □ Foundation – soil stability & geology
- □ Access roads – need for servicing and loading/unloading
- □ Noise – isolated with sound barriers
- □ Odour sources – sited downwind
- □ Lighting
- □ Utilities

Plant Layout





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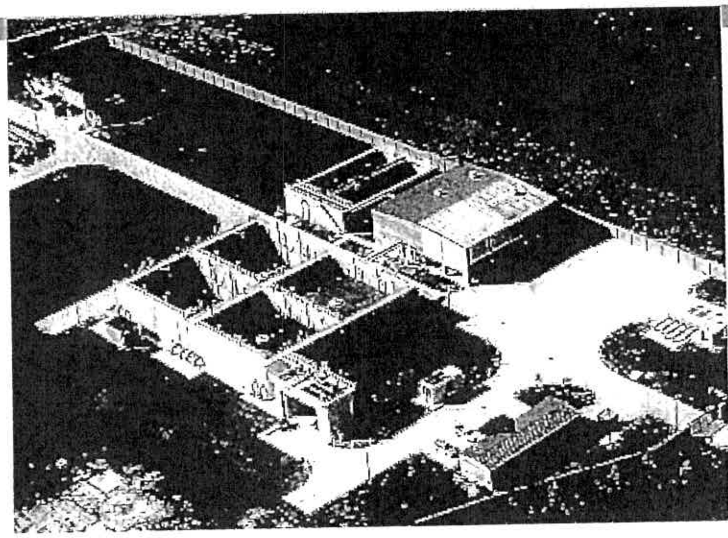

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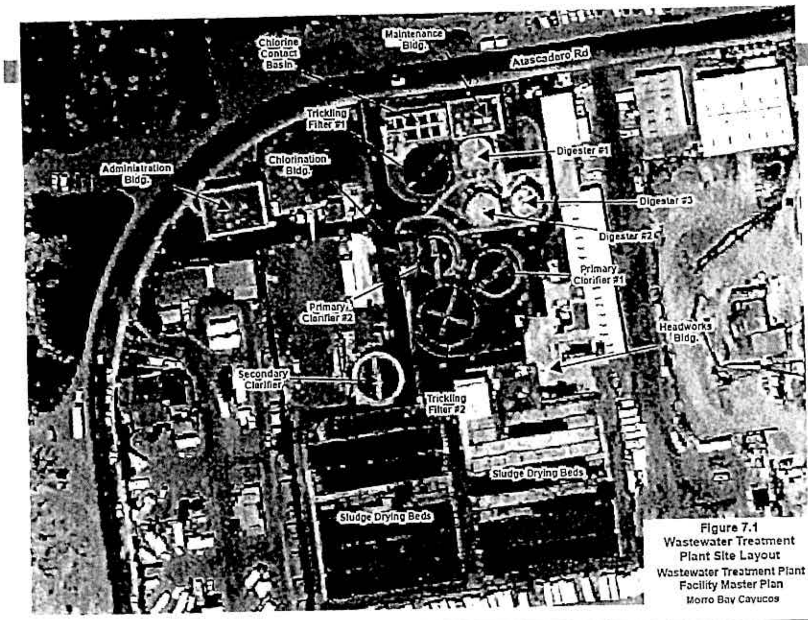


Figure 7.1
Wastewater Treatment Plant Site Layout
Wastewater Treatment Plant Facility Master Plan
Morro Bay Cayucos

Key issues

- □ Serviceability of equipments
- □ Access to machine parts/ IETS component
- □ Hazop (safety issues)
- □ Storage of chemical
- □ Storage of sludge (scheduled toxic wastes)
- □ Drains (surface vs effluent drainage)

End of slides

15

- Q&A

15

Cost Estimation

16

Capex

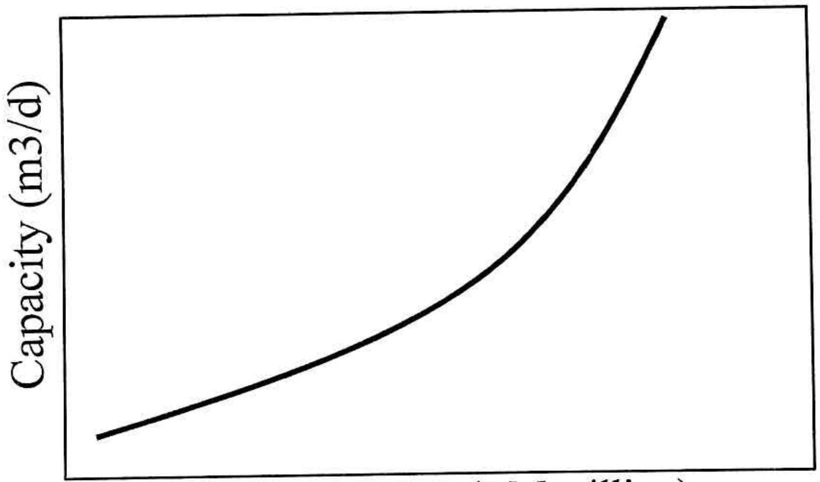
Opex

Based on Arnd Wendland, Germany
http://www.tu-harburg.de/aww/lehre/wbt/emwater/documents/slides_c2.pdf

16

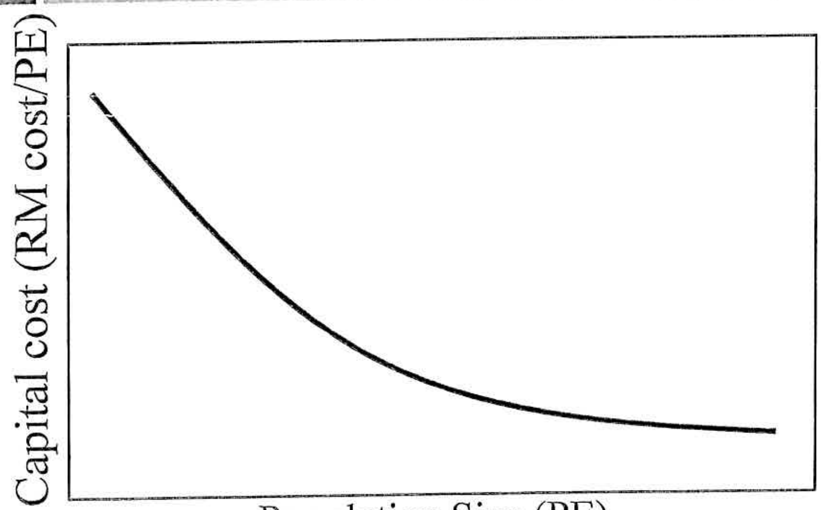
WWTP Cost vs Capacity

17



WWTP Cost vs PE (Domestic)

18

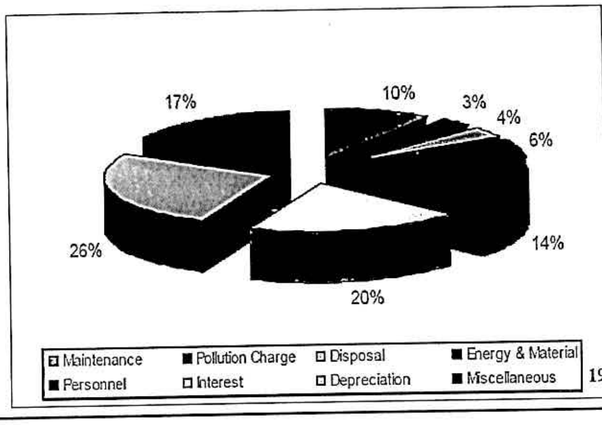


Operation Cost in relation to Total Annual Cost

19

- Operation costs are the expenses related to the operation, maintenance and monitoring of the plant
- Operation costs can amount up to 50 % of the total annual costs.
- The evaluation of operation costs during the evaluation of of process alternatives is of crucial importance.

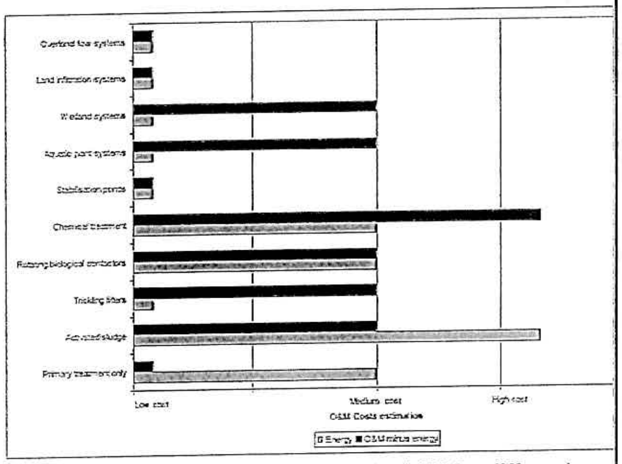
Composition of total annual costs for wastewater systems in Germany [ATV, 2003]



Factors affecting Operation Cost

20

- Size and load of the plant
- Topography and geographical situation of the site (affecting pumping energy costs)
- Characteristics of wastewater and the discharge norm
- Technologies and the selected treatment process
- Type of sludge treatment and way of disposal
- Energy supply and energy recycling
- Degree of automation, measurement and process control
- Organization of the plant and its management



Comparison of operation costs O&M for different types of secondary treatment options [Kampet, 2000]

Personnel

21

The major parameters that influence the number of operational staff employed are:

- the size of installation,
- the treatment processes and systems,
- the degree of automation,
- productivity efficiency of personnel,
- managerial efficiency and
- others.

Personnel costs subject to the treatment capacity of wastewater treatment plants [Reicherter, 2003].

< 10.000 p.e.	35 – 40 % of total operation costs
10.000 – 100.000 p.e.	25 % of total operation costs
> 100.000 p.e.	15 % of total operation costs

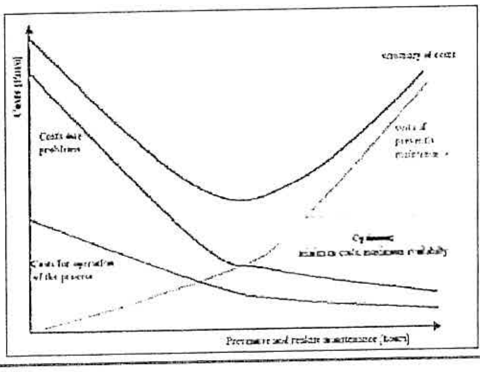
21

Maintenance

22

The costs for maintenance of wastewater treatment plants usually amount up to 15 – 25 % of the total operation costs.

Civil Constructions	0.5 – 2.0 % of investment costs per year
Renovations of Civil Constructions	2.0 – 4.0 % of investment costs per year
Mechanical Equipment	2.0 – 6.0 % of investment costs per year
Electrical and Electronical Equipment	2.0 – 6.0 % of investment costs per year



Costs and maintenance seen as a whole; the optimum is achieved from the best relationship between costs and availability [Müller, 2003]

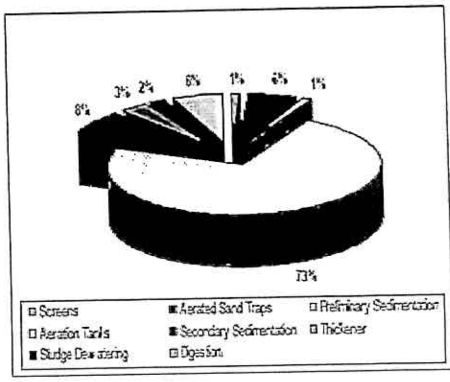
22

Energy

23

The costs for energy usually amount up to **10 – 30 %** of the total operation costs.

- Pumping Stations 10 – 15 Wh /m³
- Screens 0.3 – 0.5 kWh / (p.e. &.a)
- Aerated Sand Traps 1.7 – 2.2 kWh / (p.e. &.a)
- Prel. Sedimentation Tanks 0.4 – 0.6 kWh / (p.e. &.a)
- Aeration Tanks 17.2 – 25.8 kWh / (p.e. &.a)
- Sec. Sedimentation Tanks 1.2 – 2.3 kWh / (p.e. &.a)
- Thickener 0.7 – 1.1 kWh / (p.e. &.a)
- Sludge Dewatering Devices 3.0 – 4.0 kWh / (p.e. &.a)
- Digestion 2.4 – 2.9 kWh / (p.e. &.a)



Composition of energy demand for different process components of wastewater treatment plants [Bohn, 1993]

Disposal of sludge

24

The costs for disposal consist of the disposal of sewage sludge, screenings, sand and municipal waste. The disposal costs can differ between 15 and 50 % of the total operation costs.

Generally, disposal costs depend to a large degree on

- the size of the treatment plant,
- national regulations for the disposal of organic materials like sewage sludge,
- local conditions and market price conditions respectively.

Practical experience with sludge disposal in different European countries (S, DK, G, F, CH) can be summarized as follows:

- For the very large number of small treatment plants (e.g. <20.000 PE) landspreading / agricultural use of sewage sludge seems to be the most economical and sustainable solutions as long as source abatement of possibly hazardous substances is successful. Landspreading of semi-solid and landspreading of solid sludge entail on average the lowest total cost.
- Landspreading of composted sludge, use of sludge in land reclamation and use of sludge in silviculture record intermediate total costs.
- Landfilling, mono-incineration and co-incineration of sludge with other wastes entail the highest costs.

Chemicals and Material

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The costs of chemicals and materials usually range between **5 – 7 %** of the total operation costs.

The costs mainly depend on the characteristics of wastewater and the discharge norm, the selected chemicals, correct dosing, quantities kept in stock and purchasing deals.

The market situation and the price structure for chemicals differ strongly.

- Polymers, alum and lime for sludge conditioning
- $NaCl$, Cl_2, O_3 for disinfection
- $FeCl_2$, $FeCl_3$, AlCl for precipitation of phosphorous
- Methanol, ethanol for denitrification
- Reagents for laboratories
- Oil and gas for machinery and vehicles
- Others

End of slides

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□Q&A

6.0 Operation of Wastewater Treatment System

- Important Control Parameter for Operation

UNIVERSITI PUTRA MALAYSIA

PMT

PAKAR MANAGEMENT TECHNOLOGY (M) SDN BHD

Training Course on Industrial Wastewater Treatment System
Hotel Residence, 21-22 Dec 2009

OPERATION OF WASTEWATER TREATMENT SYSTEM

Course instructor: Prof Dr Azni Idris

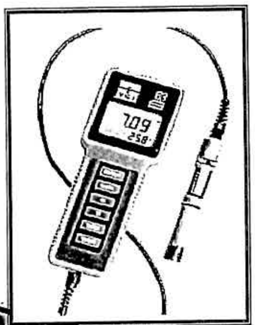
Successful Operation of IETS

Important control parameters:

- pH
- DO
- Coagulation dose
- Flocculation dose
- Healthy microbial population (biomass)
- Settleability in clarifiers

pH Calibration Check

- pH meter calibration to be done once per week



Commercial pH probe for analysis

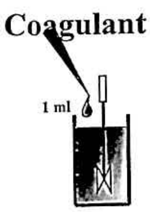
Effect of pH on Wastewater Coagulation

pH drops causing poor coagulation – turbid colour

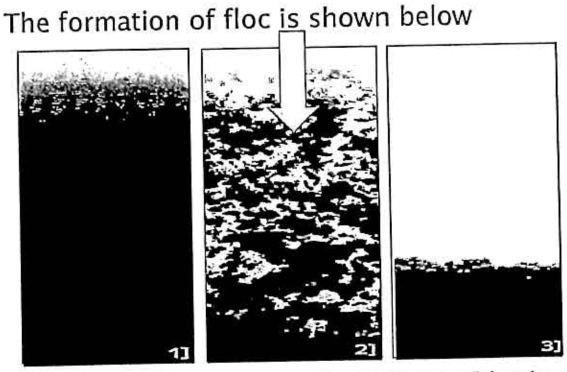
pH is corrected to produce good coagulation – clear color

Coagulation dose: Jar Test Procedure

- The formation of floc is shown below



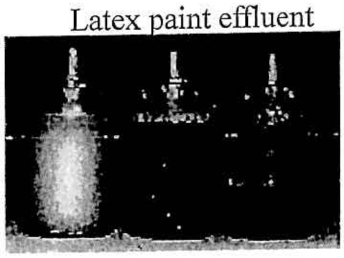
Jar test



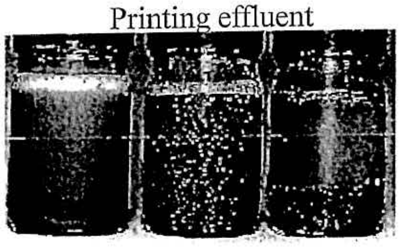
- After 15 minutes, measure turbidity in all beakers, plot % turbidity removal vs chemical dose. The chosen dose is optimum dosage to give highest % turbidity removal

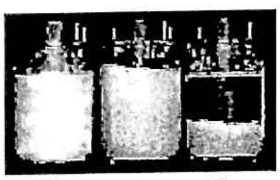
Examples of effective polymer floc formation

Latex paint effluent



Printing effluent

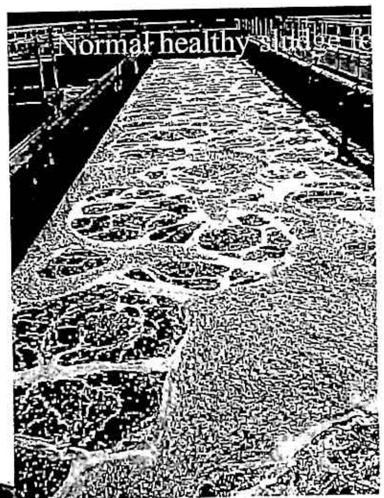


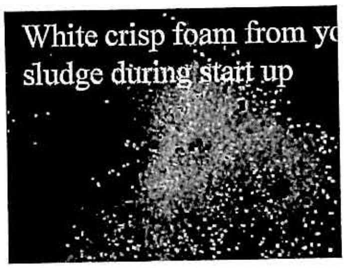


Jewellery effluent

Metal finishing effluent

Microbial Check for Normal healthy foam





SVI Procedure for Aeration system

- Check settleability of aeration biomass using sludge volume index (SV30)
- SVI procedure (next page)

SLUDGE VOLUME INDEX (SVI)

The sludge volume index (SVI) = the volume in mL occupied by 1 g of a BIOMASS after 30 min settling.

SVI is used to monitor settling characteristics of activated sludge.

Procedure

1. Determine the suspended solids concentration of a well-mixed sample of the suspension

2. Measure the 30 min settled sludge volume

3. Calculations :

$$\text{SVI (in mL/g)} = \frac{\text{settled sludge volume (mL/L) X 1000}}{\text{suspended solids (mg/L)}}$$

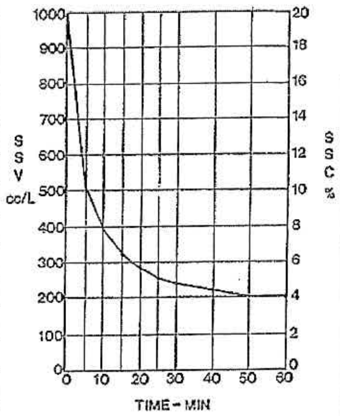
SVI ANALYSIS

Type of sludge	SVI (mL/g)
Well settling	< 100
Light	100 - 200
Bulking	> 200

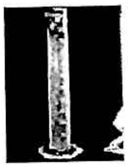
Time (min)	SSV (mL/ L)
0	1,000
5	500
10	400
15	325
20	290
25	260
30	**250**
40	220
50	200
60	200

Settled sludge volume

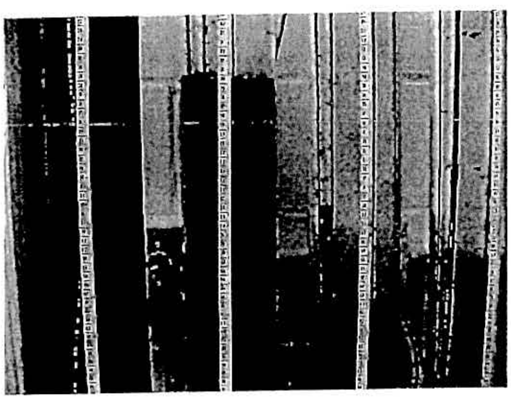
- SSV

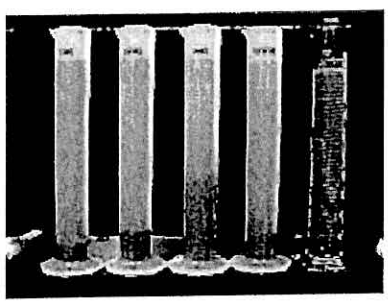


SVI test

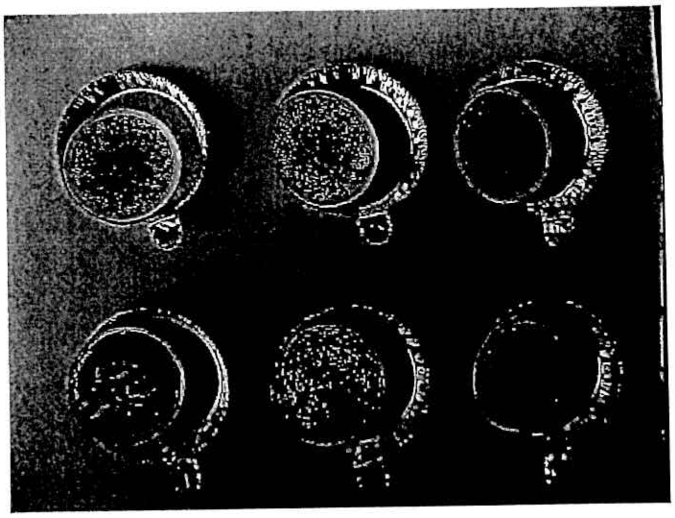
					
After 1 min	**After 2 min**	**After 3 min**	**After 5 min**	**After 10 min**	**After 15 min**

◈ SVI test





◈ MLSS test using filter paper



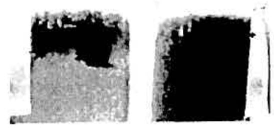
End of slides

- Q&A

PERFORMANCE MONITORING OF INDUSTRIAL EFFLUENT TREATMENT

15

What is Performance Monitoring?



- Preventive or routine maintenance to prevent failure of process during use.
- Pro-active monitoring of certain parameters to provide diagnostic indication of process operating condition.

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Why we need to monitor?

Objectives:

- Assessment of performance
- Protection of environment
- Regulatory requirement for Performance Monitoring (DOE - Regulation 5 (2) SIER)
- Standard operating procedures (ISO14000)

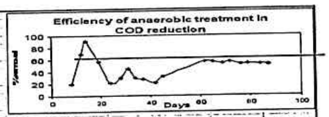
Issues in Monitoring of Waste Treatment Plants

- Compliance to Process Design
- Which unit is the critical path in IETS ?
- Regulatory requirement - discharge limit
- Budget and cost elements
- Minimization/recycling/reuse of effluent

Performance indicator:

What and how to monitor ?

Days	% removal
8	20
12	70
14	91
19	57
24	22
28	30
31	45
34	30
37	27
42	22
45	32
62	57
65	58
69	54
72	56
76	52
79	53
84	52
87	51
average:	42
min:	20
max:	91



Monitoring Parameters

- ✓ Flowrates
- ✓ BOD
- ✓ COD
- ✓ TSS
- ✓ pH
- ✓ MLSS
- ✓ **D.O. level in aeration**
- ✓ **SVI – sludge vol index**
- ✓ **Phosphate (PO_4)**
- ✓ **Nitrogen**
- ✓ **Sludge rate – volume**
- ✓ **Pressure level**
- ✓ **Conductivity**
- ✓ **TDS**

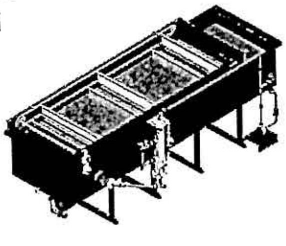
Sampling and analysis

Sampling points

- Influent monitoring
- Effluent monitoring
- Frequency of sampling
- Flow measurement
- Where to take samples ?

Analysis of samples

What parameters to test
In-situ analysis
Lab analysis



RECORD KEEPING

- To maintain the complete record of performance monitoring data
- To record corrective actions taken

Components of Record Keeping

- Inventory listing of process data
- Format used for recording data
- Raw data (daily record on process)
- Analysed data (daily and weekly records)
- Flowrate data
- Reporting – use of graph and table
- File – to have suitable filing system

Table of Record Performance Monitoring Data

Daily Record for Activated Sludge Process

Date	Flowrate m^3/h	pH	DO mg/l	SV_{30} mL	Remarks	Signature of operator

Table of Record Performance Monitoring Data

Weekly Or Monthly Record for Activated Sludge Process

Date	BOD mg/l		COD mg/l		MLSS mg/l	MLVSS mg/l	SS of clarifier	Nutrient mg/l	F/M ratio	SVI	Remarks	Signature
	inlet	outlet	inlet	outlet								

Computation of Oxygen Uptake Rates

Date: Time	DO mg/l	Oxygen uptake rate (OUR)	Remarks	Signature
		OUR = slope of dissolved oxygen vs time graph		

Table of Record Performance Monitoring Data

Daily Record for Chemical Precipitation

Date	Flowrate m^3/h	pH	ORP mv	Chemical dose	Heavy metals mg/l	COD mg/l	Signature

Table of Record Performance Monitoring Data

Daily Record for DAF system

Date	Recirculation m^3/h	Flowrate m^3/h	Pressure Psi or kPa	Airflow m^3/h	Signature

Table of Record Performance Monitoring Data

Daily Record for Ion Exchange & Regeneration

Date	Flowrate m^3/h	Heavy metals mg/l	Pressure Diff. kPa	Conductivity us/cm	Signature

Date	Regeneration site		If onsite name and address of company conducting regeneration		Signature
	Onsite	Offsite			

Table of Record Performance Monitoring Data

Daily Record for Carbon Adsorption & Regeneration

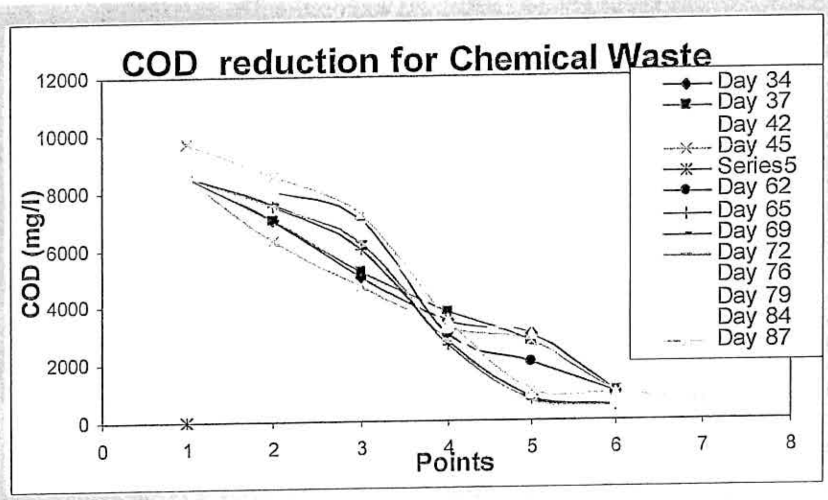
Date	Flowrate m^3/h	Contaminant to be removed mg/l	Press Diff. kPa	Signature

Date	Regeneration site		If onsite name and address of company conducting regeneration		Signature
	Onsite	Offsite			

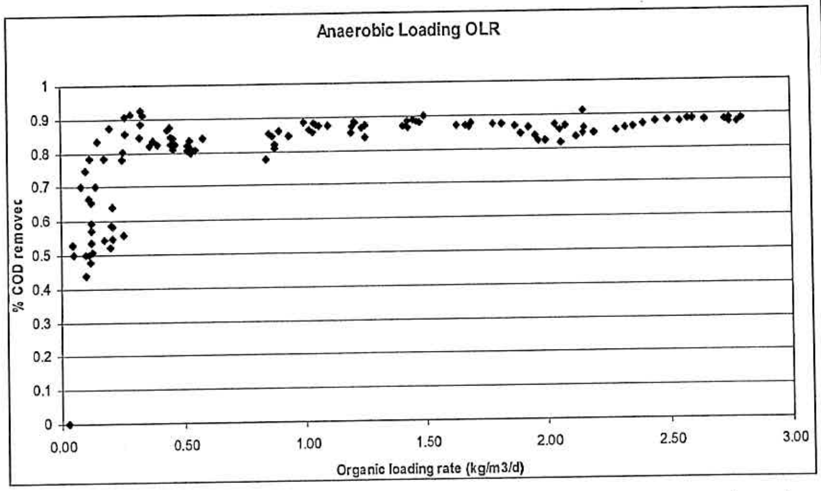
Record of process performance data helps to:

- Analyse trends in process upset
- Alarm level for bioreactors
- Diagnosis or trouble shoot problems

Profile of COD
- taken at all points in a treatment system



Loading Rate Data



...ction of performance can be observed on loading rate at high values

Trend curves

- BOD_5 loading rate
- COD loading rate
- % BOD_5 removal
- % COD removal
- Sludge generation (tonne/month)

Sampling Points & Monitoring Datasheet

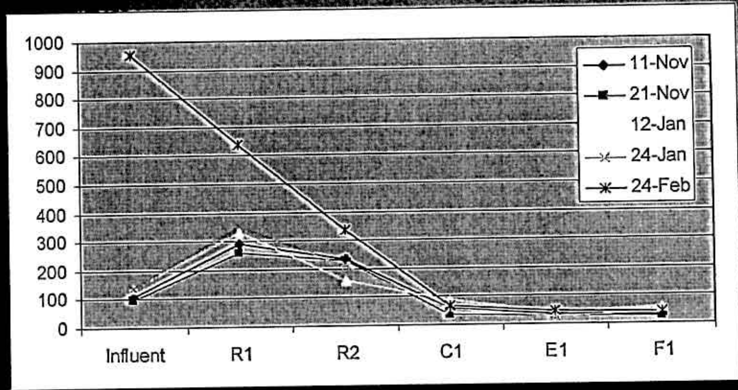
Sampling point	Parameter	Tag
RAW (T-171-001)		FE8001
	flow	(F-171-001)
	COD	(F-171-001)
	BOD5	(F-171-001)
	TSS	(F-171-001)
	VSS	(F-171-001)
	TDS	OE8021
	PH	(F-171-001)
		(F-171-001)
INLET AN-AEROBIC 1 (T-171-007) (CONDITIONING TANK) (T-171-006)		(T-171-006)
	COD	(T-171-006)
	BOD5	(T-171-006)
	TSS	(T-171-006)
	VSS	(T-171-006)
	ALK.	OE8010
	PH	(T-171-006)
	TKN	(T-171-006)
		(T-171-006)
OUT LET AN-AEROBIC 2 (T-171-008)		SC211
	COD	SC211
	BOD5	SC211
	TSS	SC211
	ALK.	SC211
	VA	SC211
		SC211
AERATION TANK (T-171-009)	BOD5	(T-171-009)
	MLVSS	(T-171-009)
	DO	DI8027
	PH	(T-171-009)
CLARIFIER (T-171-010)		(T-171-010)
	COD	(T-171-010)
	BOD5	(T-171-010)
	TSS	(T-171-010)
	VSS	(T-171-010)
	SVI	(T-171-010)
	ALK.	(T-171-010)
	VA	(T-171-010)
		(T-171-010)
TREATED WATER HOLDING TANK (T-171-011)		(T-171-011)
	COD	(T-171-011)
	BOD5	(T-171-011)
	TSS	(T-171-011)
	TDS	(T-171-011)
	PH	(T-171-011)
	TKN	(T-171-011)
	NH3-N	(T-171-011)
RO TREATED WATER TANK (T-171-022)	FLOW	FL
	COD	(T-171-022)
	BOD5	(T-171-022)
	TSS	(T-171-022)
	TDS	(T-171-022)
	PH	(T-171-022)

Examples of a Performance Monitoring Schedule in a Chemical IETS

PARA METER Mg/l	RAW T-171-001	INLET AN-AEROBIC 1 T-171-007	OUTLET AN-AEROBIC 2 T-171-008	AERATION TANK T-171-009	OUTLET AERATION T-171-009	TREATED WATER HOLDING TANK T-171-011	RO TREATED WATER TANK T-171-022
COD	M	W	W		W	T	M
BOD5	AR	M	M	M	W	W	M
TSS	M	M	W		W	W	M
VSS	M	M			AR		
TDS	M					W	W
MLVSS				W			
SVI					W		
ALK.	AR	AR	M		AR		
VA		AR	AR		AR		
PH	W	D			D	D	D
TKN	M	M	M			M	
NH3-N	M	M	M			M	
TOTAL P		M			M	M	

TW twice weekly
T three times weekly
W weekly
M monthly
AR as required (to evaluate performance/inhibition/toxicity)

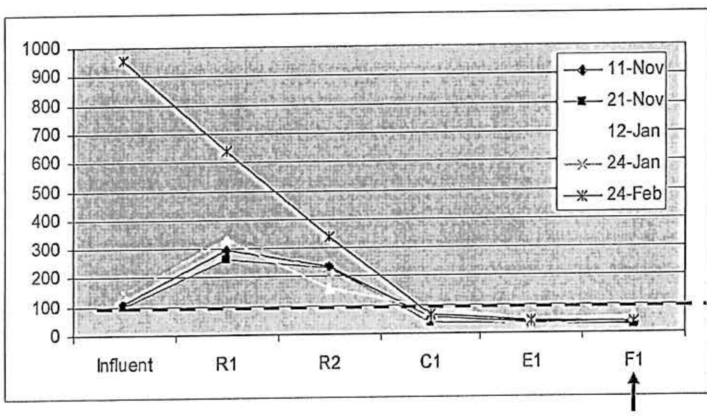
BOD Removal



% BOD removal

49.5 62.9 38.6 58.1 93.2

Final BOD concentration



Std A

Final discharge

End of slides

- Q&A