Wastewater Treatment

CE 326 Principles of Environmental Engineering

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Spring 2009

Announcements

- Wednesday lab: field trip to Ames Water Pollution Control Facility (alternative assignment) - see sign up sheet for carpool
- BOD and TSS Lab
  - Need to weigh solids
  - Check DO in BOD bottles
- Water Quality Management Problems Chapter 5: 2, 6, 36, 42 (starting on page 407) due 4/8/09

Wastewater generation

TABLE 1
Typical wastewater flowrates from various sources

Source	Unit	Flow, L/unit - d	
		Range	Typical
Airport	Passenger	8-15	11
Cabin, resort	Person	30-190	150
Cafeteria	Customer	4-11	8
	Employee	30-45	38
Campground (developed)	Person	75-150	115
Cocktail lounge	Seat	45-95	75
Coffee shop	Customer	15-30	23
Dormitory, bunkhouse	Person	75-190	150

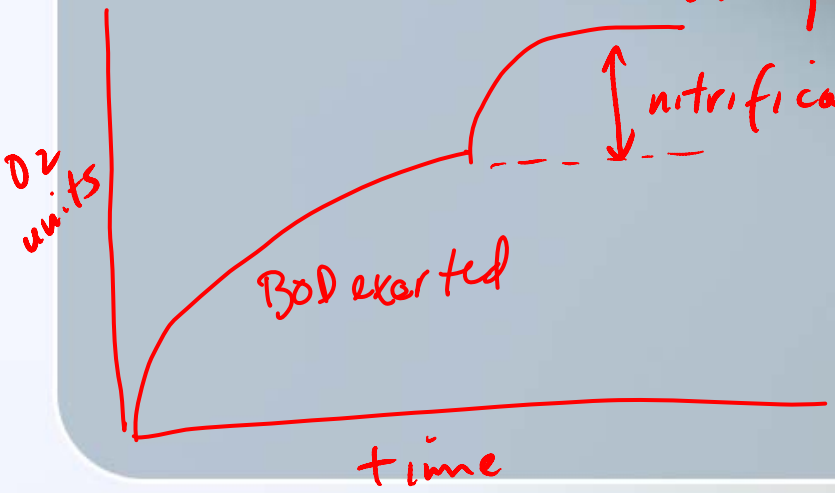
BOD and DO

biochemical oxygen demand

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{biomass}} 6CO_2 + 6H_2O$$

Theoretical BOD

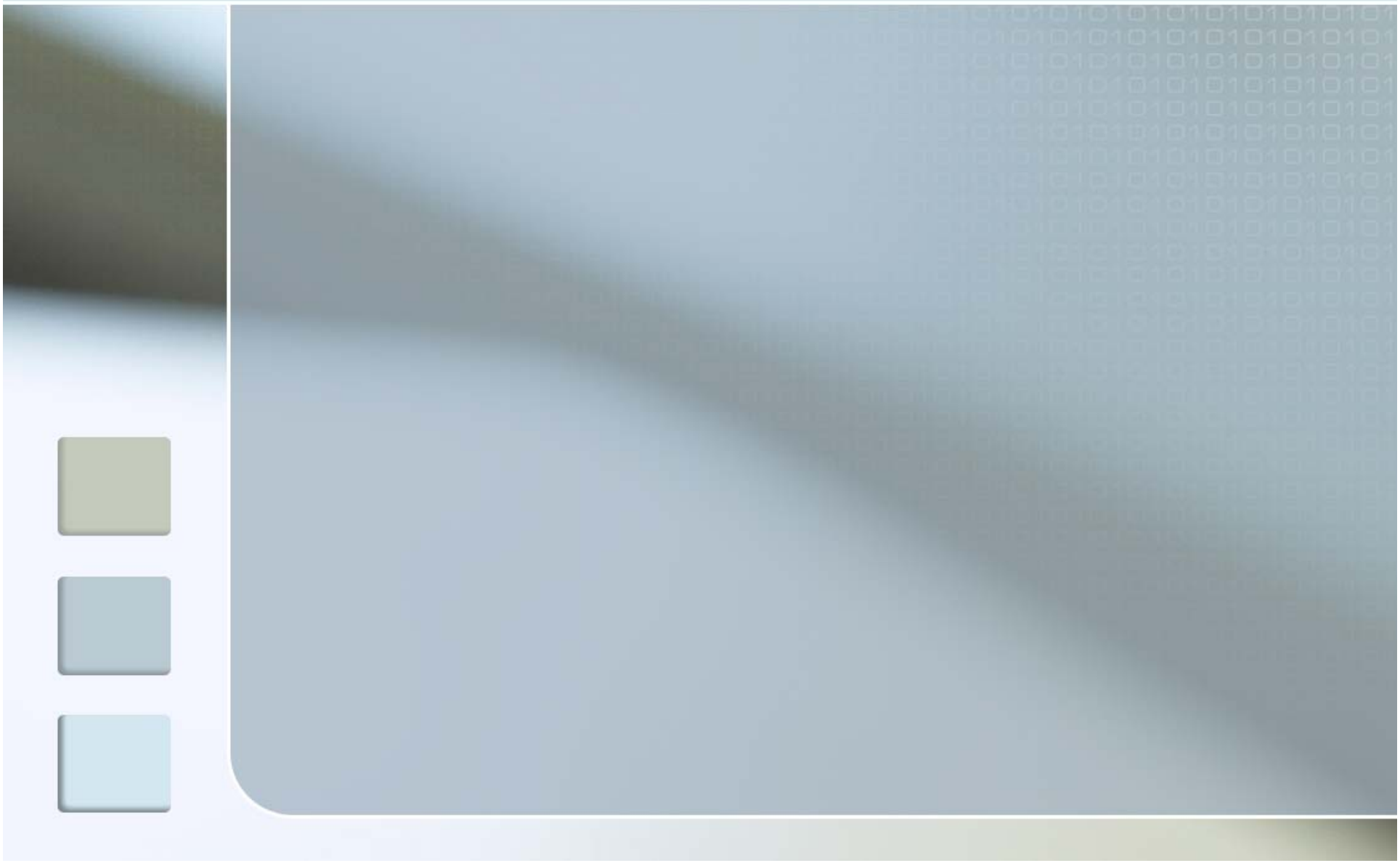
$$\frac{6 \text{ mole oxygen}}{\text{mole glucose}} \times \frac{(16.2)\ g/\text{mole}}{6 \cdot 12 + 12 \cdot 1 + 6 \cdot 16} = \frac{1.07\ g\ BOD}{g\ \text{glucose}}$$



$$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$$

$$\frac{4.57\ mg\ O_2}{mg\ NH_4^+ - N}$$

BOD and DO



Collection Systems

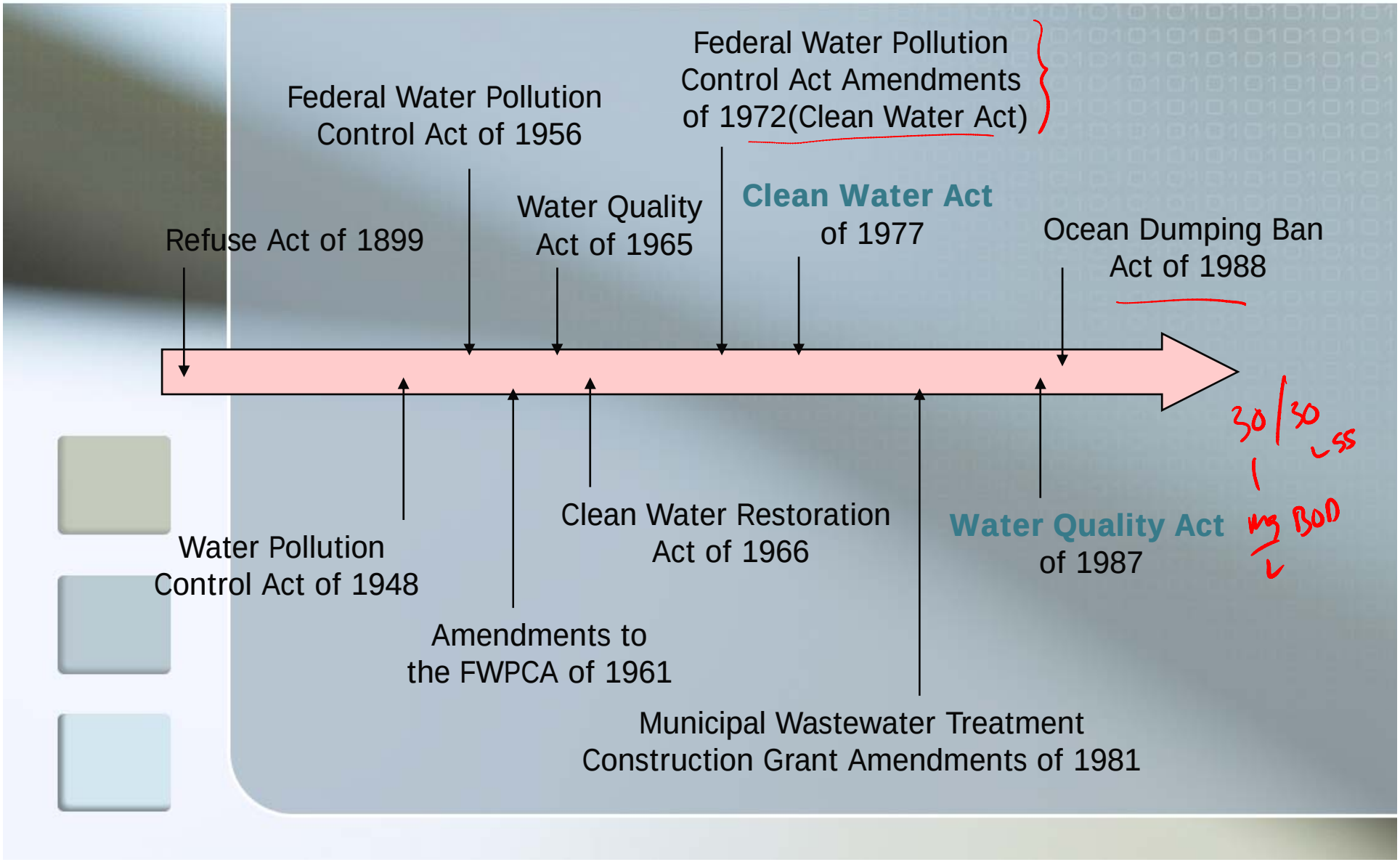
- Separate sewers
- Combined sewers

Combined sewer overflows

Photo courtesy of Water Environment Federation Collection Systems Committee –cMOM Subcommittee

Regulations

Federal Water Pollution Control Legislation, US

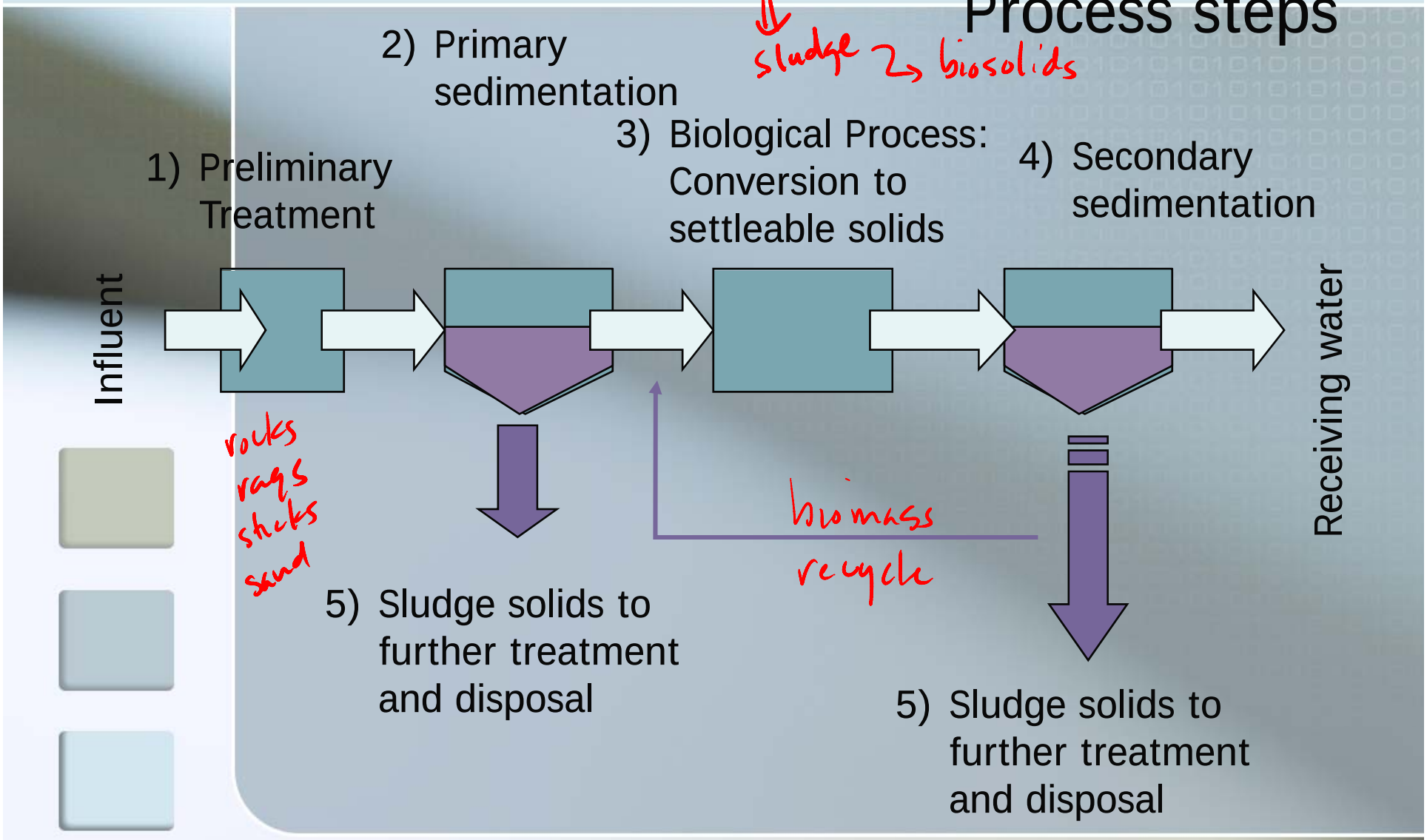


concentrate pollutants into settleable solids

sludge → biosolids

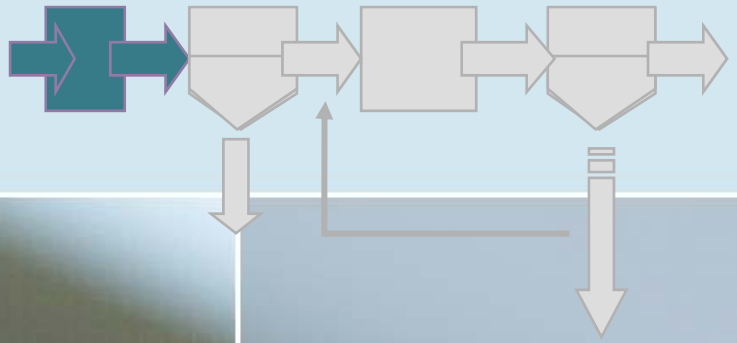
Wastewater Treatment

Process steps



Four levels of wastewater treatment

- PRELIMINARY
  - Screens ✓
  - Grit removal ✓
- PRIMARY
  - Solids settling
- Secondary
  - Biological treatment
  - Settling of biological solids
- Tetiary
  - Filtration

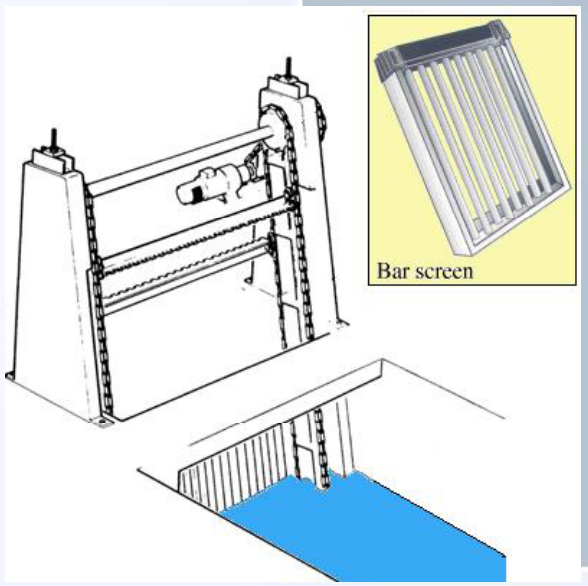


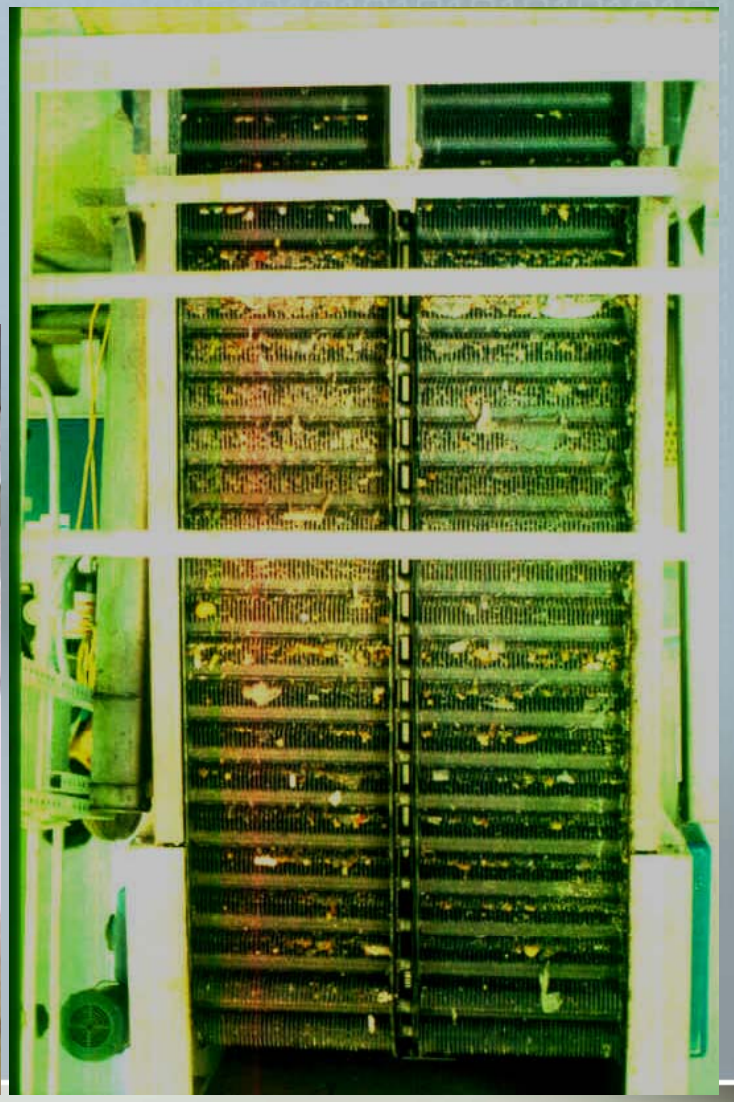
Preliminary Treatment

- Screens:
  - sticks, rocks, logs, shoes, dead animals, etc.
- Grit Removal:
  - grit causes undue wear downstream unit processes

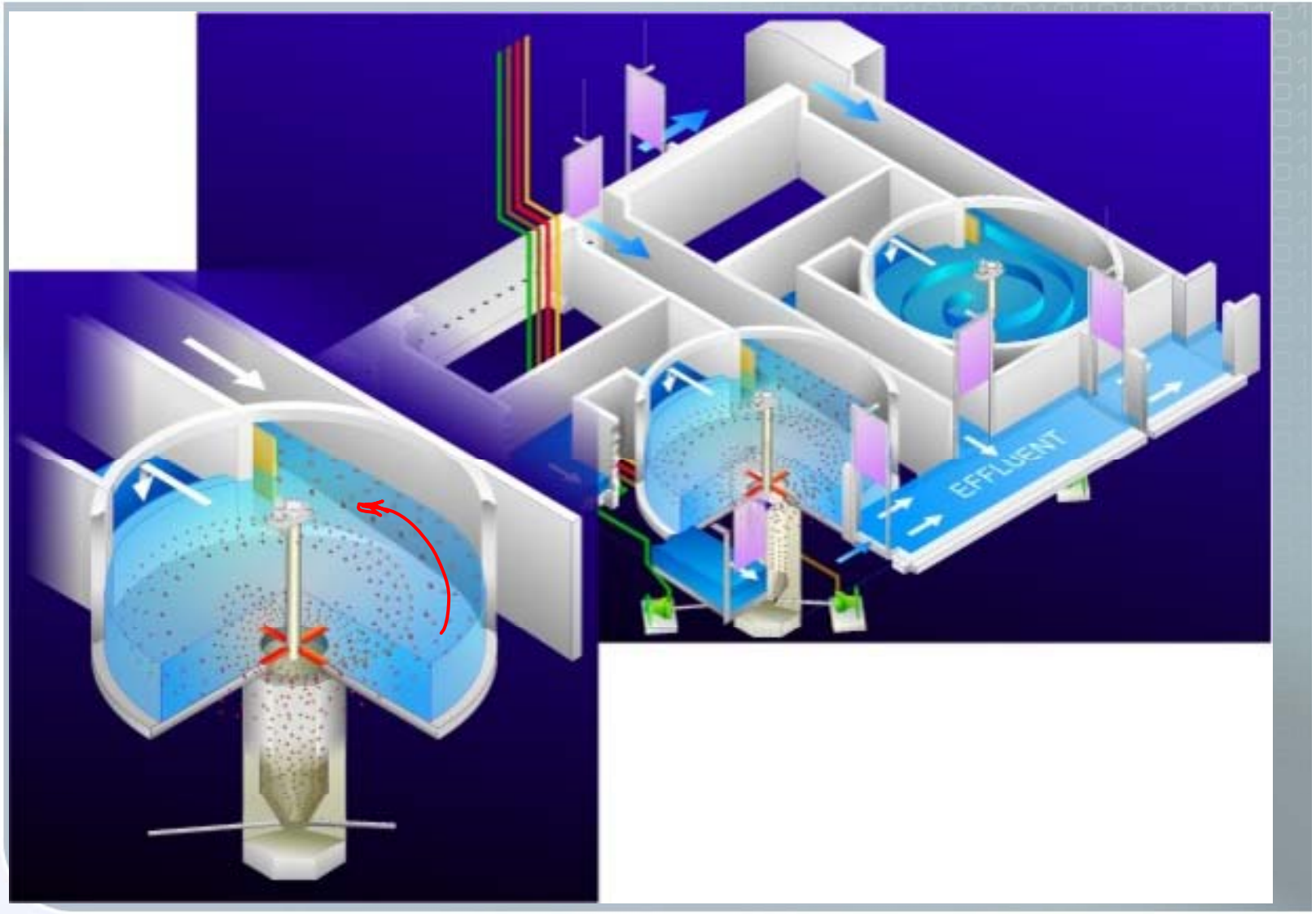
Preliminary Treatment: Screens

- Bar Screens
- Bar Racks





Preliminary Treatment: grit removal



Secondary Treatment

- **Biological treatment**
  - **Classification of microorganisms by their c_____ and e_____ source.**

Secondary Treatment

- Heterotrophs
  - Utilize organic matter to supply their carbon and energy needs.
  - These are the predominant organisms in biological wastewater treatment plants, responsible for converting organic pollutants to
    - carbon dioxide,
    - water, and
    - additional heterotrophic biomass.

carbonaceous BOD → CO_2 + H_2O + biomass

Secondary Treatment

- A Autotrophs
  - get their energy from an inorganic source and
  - their carbon from carbon dioxide.
  - An example of autotrophs in wastewater treatment is nitrifying bacteria.
  - Nitrifiers use ammonia for energy and carbon dioxide for a carbon source.
  - End products of nitrification are
    - nitrate,
    - water, and
    - hydrogen ions
    - additional nitrifying (autotrophic) biomass.

$NH_4^+ + O_2 \rightarrow NO_3^- + H^+$

Biological Treatment

- **Classification of microorganisms by their terminal electron acceptor**

Terminal electron acceptor

- **Aerobic:**
  - microorganisms transfer electrons from the energy source to oxygen, O_2.
  - In the process oxygen and organic matter is converted to carbon dioxide, CO_2, and water, H_2O.
  - Oxygen is termed the terminal electron acceptor or TEA.

ATP - energy currency for microorganisms

Terminal electron acceptor

- **Anoxic _____:**
  - microorganisms utilize some other oxidized compound to accept electrons.
  - In the case of denitrifying microorganisms, nitrate, NO_3^-, serves as the TEA, as nitrate is converted to nitrogen gas, N_2

aerobic: glucose + O_2 → CO_2 + H_2O

anoxic: glucose + NO_3^- → CO_2 + H_2O + N_2

Terminal electron acceptor

- **A anaerobic _____:**
  - utilize CO_2 and organic compounds as terminal electron acceptors.
  - In this process, organic compounds are converted to fermentation products and carbon dioxide.
  - In anaerobic digestion of wastewater solids, the fermentation products are converted to
    - methane, CH_4 →
    - ~~CH_4~~
    - and carbon dioxide

Terminal Electron Acceptor (TEA)

Examples:

Process	TEA	Predominant Reactions	Example
Aerobic	O_2	organic matter + O_2 → CO_2 + H_2O	CBOD removal ✓
Aerobic	O_2	$NH_3 + O_2$ → NO_3^-	nitrification ✓
Anoxic	NO_3^-	organic matter + NO_3^- → $N_2 + CO_2 + H_2O$	denitrification
Anaerobic	CO_2	organic matter → $CH_4 + CO_2 + H_2O$	anaerobic digestion

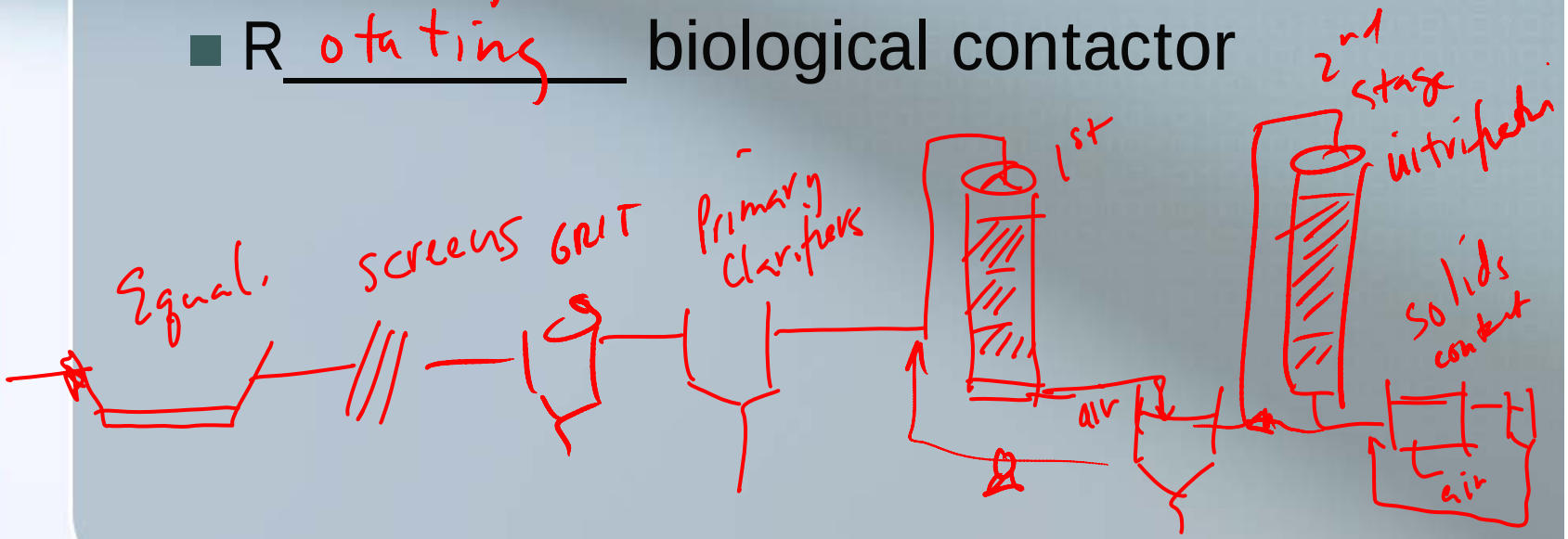
Classification by temperature

- psychrophiles philes
  - grow at temperatures below 25°C.
- meso philes
  - grow at temperatures between 25 - 45°C.
- thermo philes
  - grow at temperatures between 45 and 60°C.

most anaerobic

Classification by growth environment

- Attached growth
  - activated sludge
- Suspended growth
  - Trickling filter
  - Rotating biological contactor



Ten Growth Requirements

1. C arbon source
2. E nergy source
3. Terminal e lectron acceptor — O_2
4. M acro nutrients: C, N, H, O, P, K, S
5. M icro nutrients: Fe, Ni, Co, Mb, Zn, etc.

required for electron carriers e.g. anaerobic processes

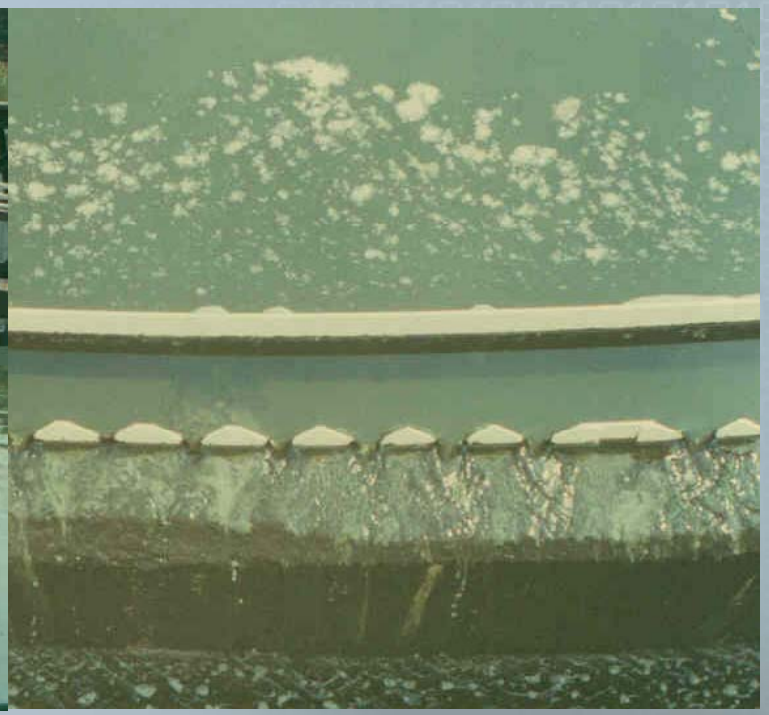
Ten Growth Requirements

6. M oisture
7. Appropriate t emperature
8. Appropriate p H 6-8
9. Absence of i nhibition
10. Mixing/c ontact

Boone wastewater treatment plant

Boone wastewater treatment plant

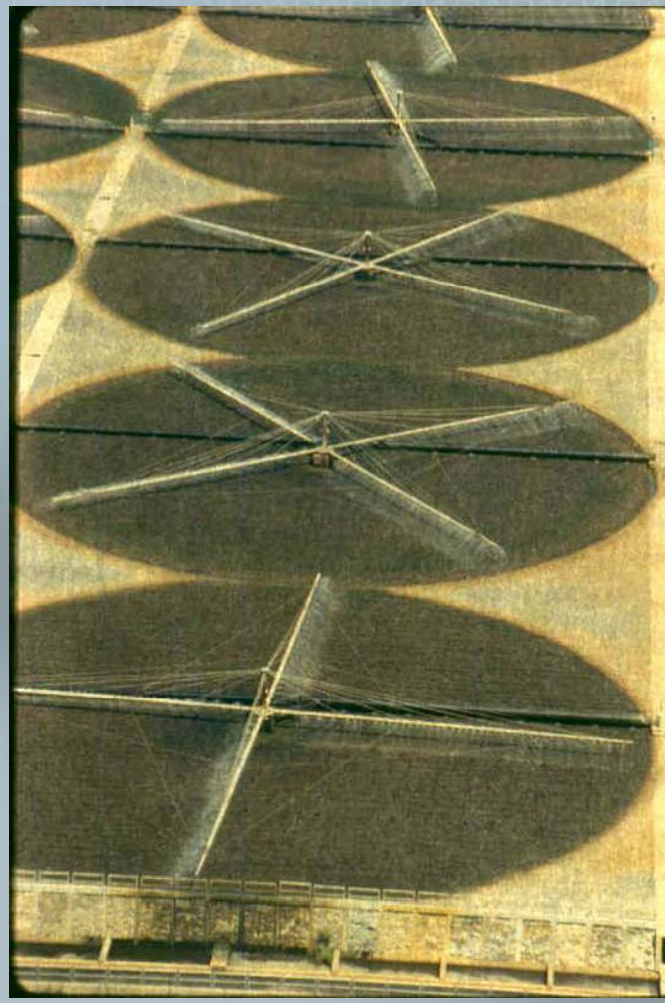
Wastewater treatment plants



Wastewater treatment plants

Back River WWTP

Back River WWTP



Back River WWTP

Back River WWTP

Abu Dhabi WWTP

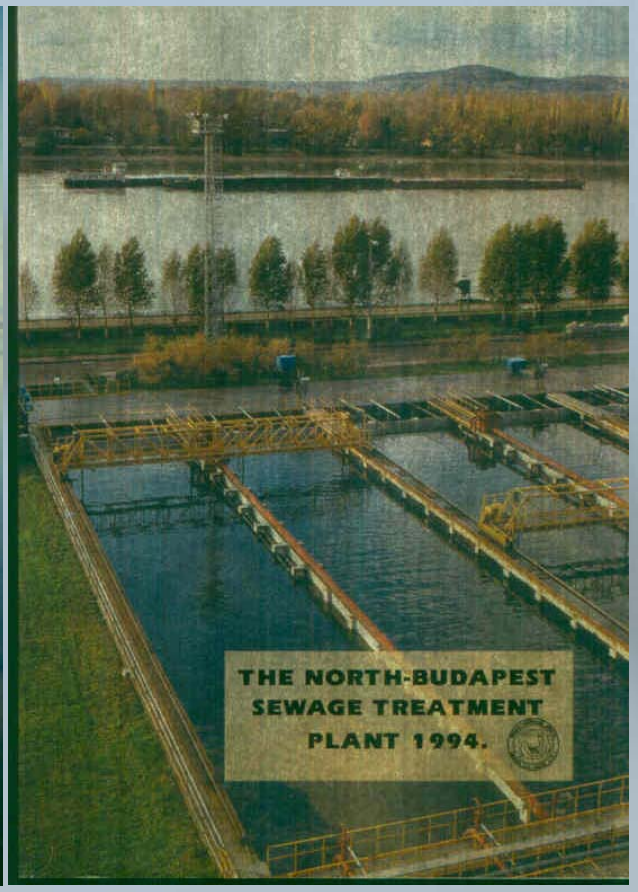
Abu Dhabi WWTP

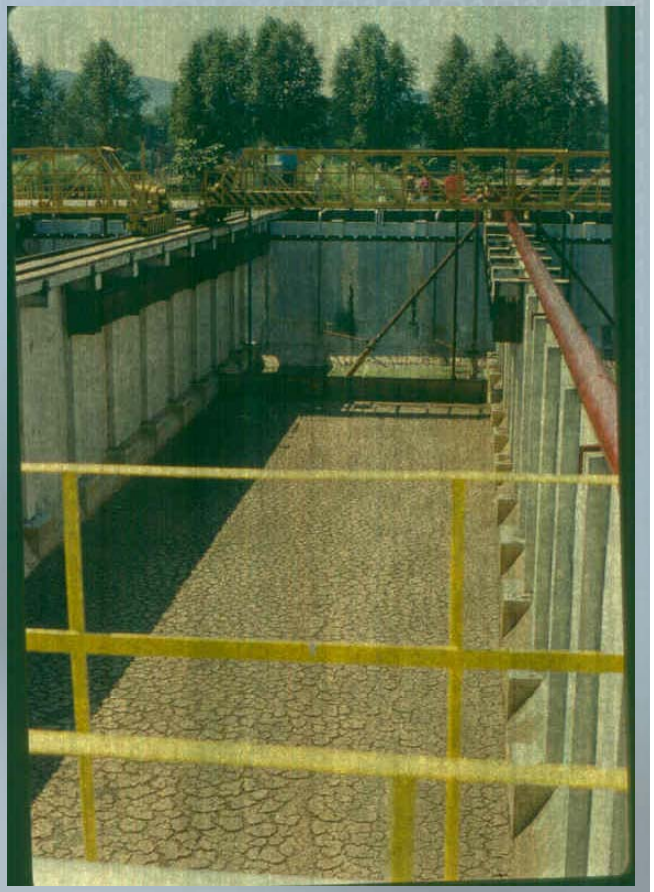
Abu Dhabi WWTP

Abu Dhabi WWTP

Abu Dhabi WWTP

Budapest WWTP





Lake Balaton WWTP

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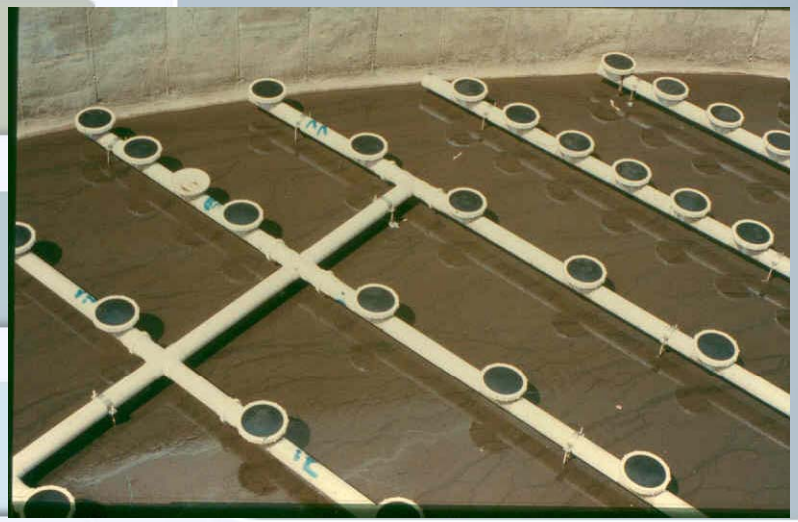

Lake Balaton WWTP

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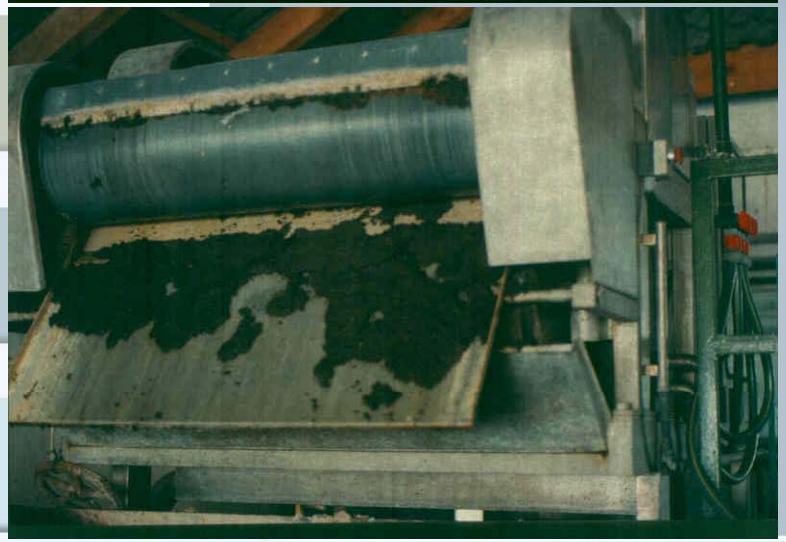
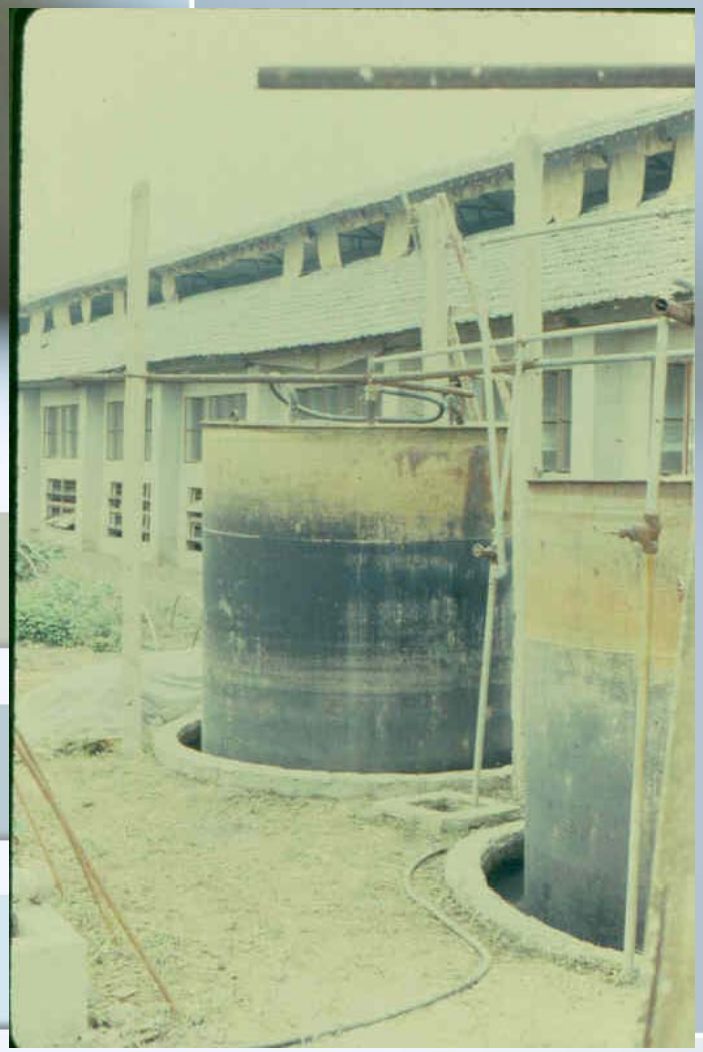


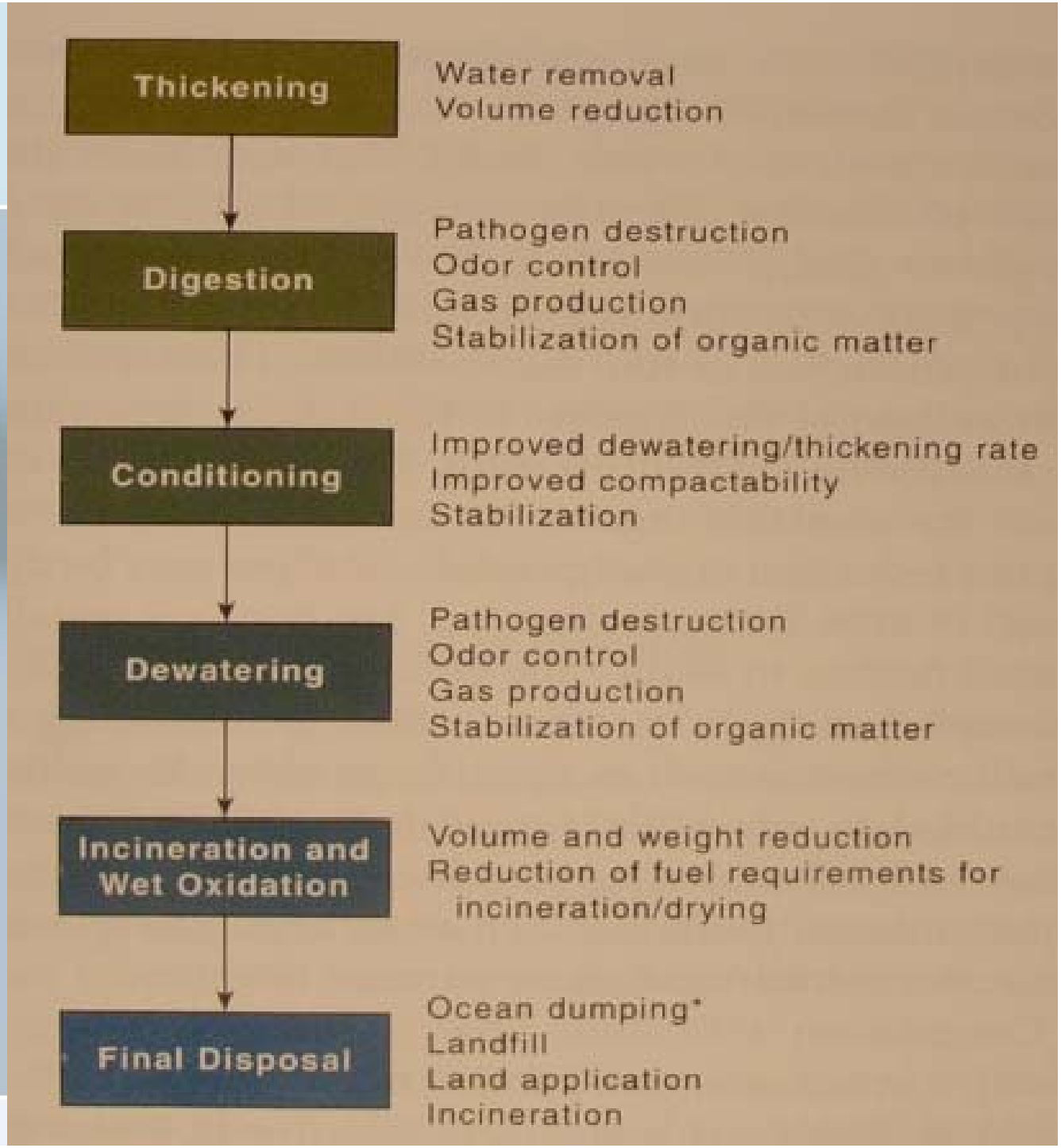
Wastewater Treatment in Developing Countries

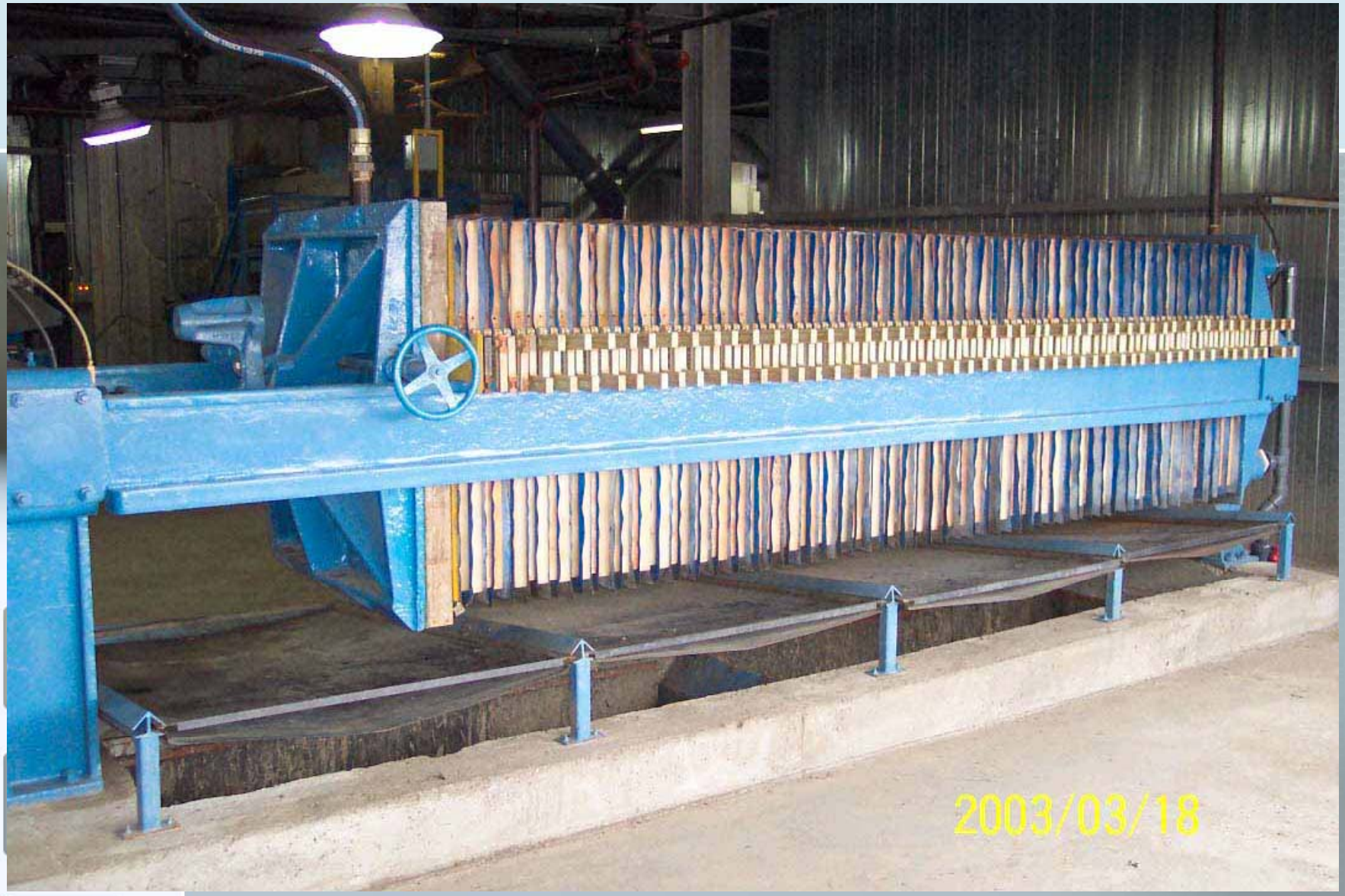


Community Biogas Plant in China

Settling Problem in Activated Sludge

Summary of sludge processing



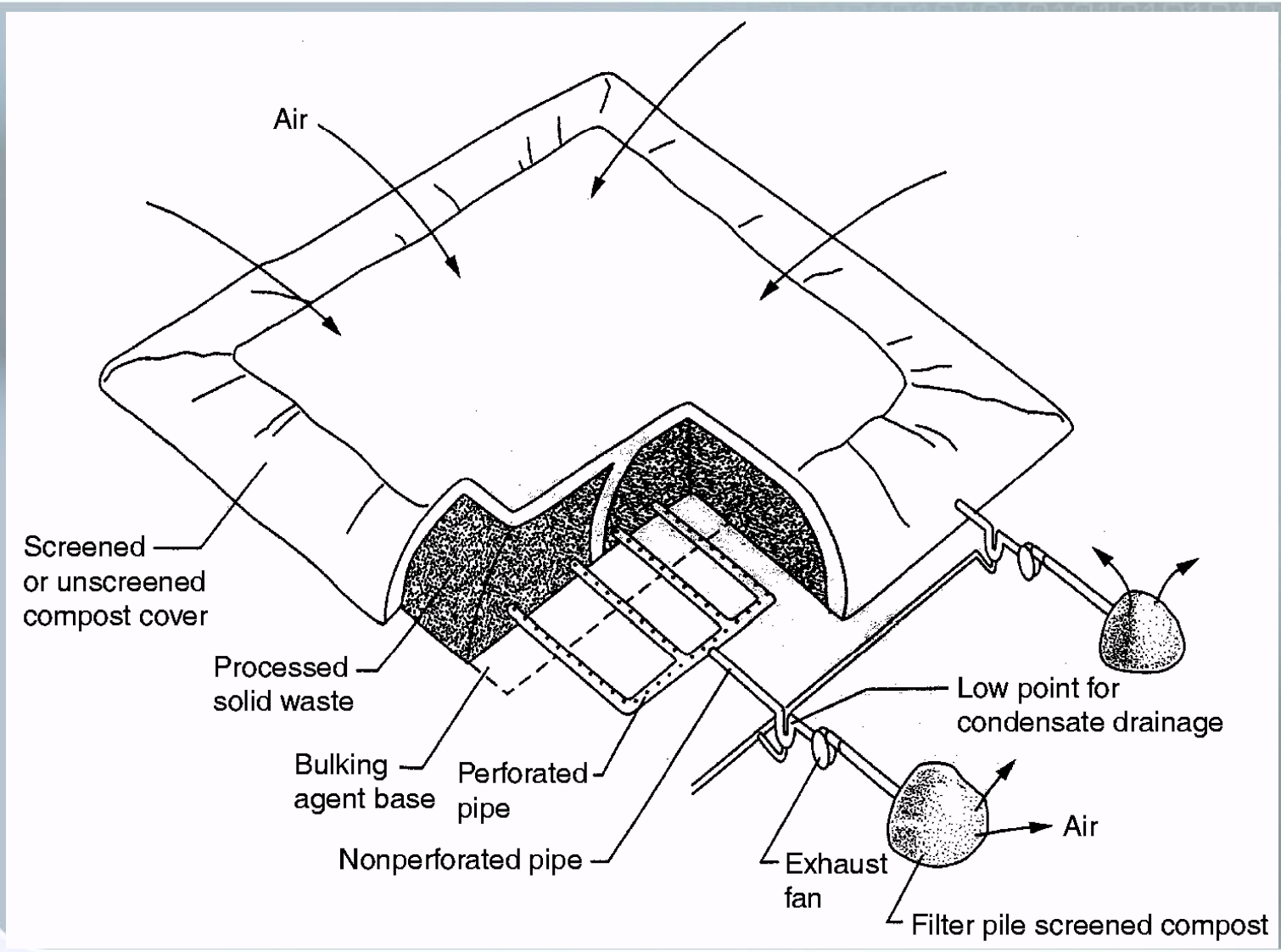


Filter Press http://www.metlabsolutions.com/Shriver%20Press%20-%20side.JPG

View of machine used to aerate compost placed in windrows.

Overview of windrow composting operation

Schematic of static aerated compost pile



Biosolids land application

Placement of geomembrane liner in area-type landfill