ES 200 ENVIRONMENTAL STUDIES

Module-C

Anthropogenic effects on ecosystem, water quality & health, water & wastewater treatment

Lecture-6

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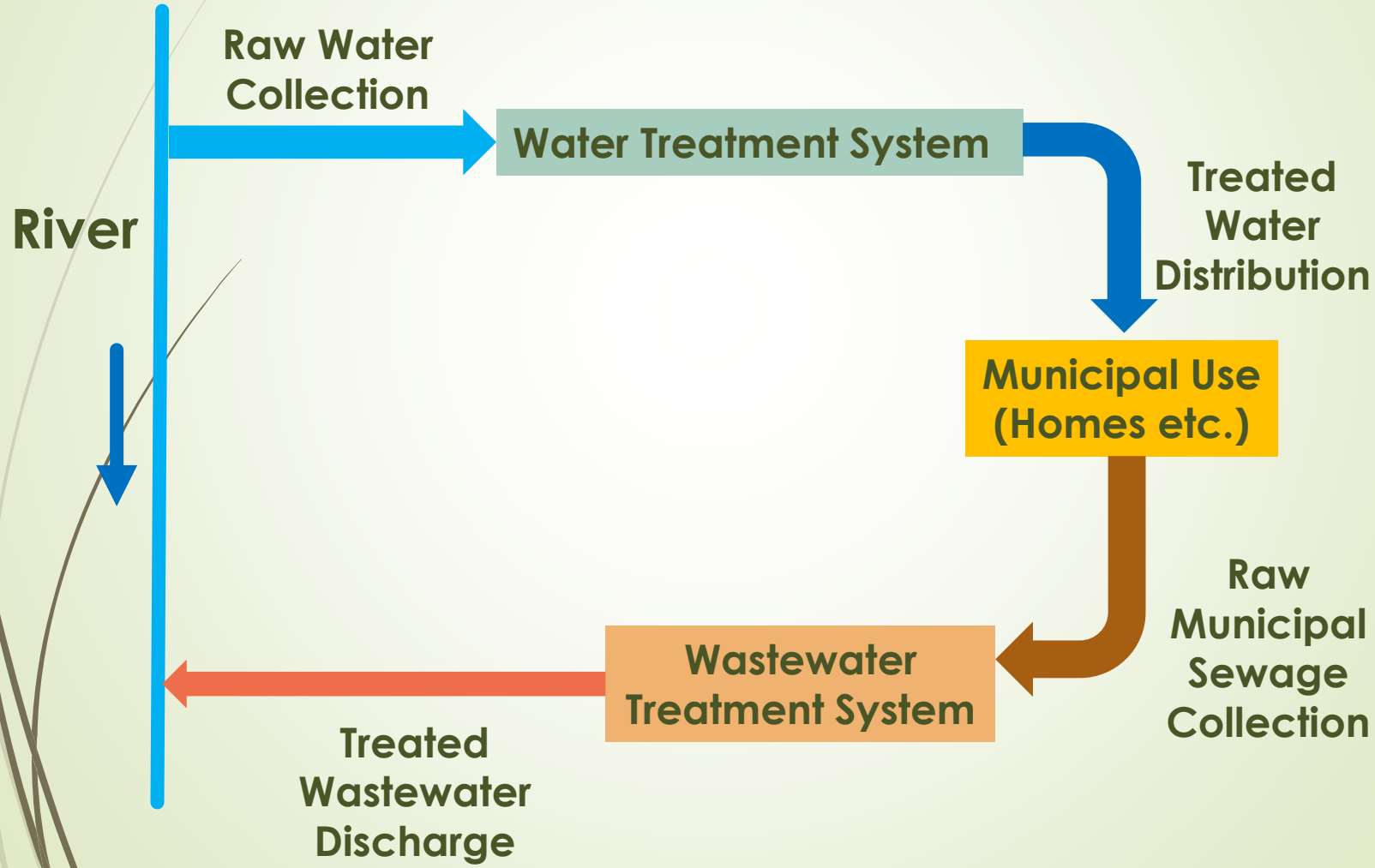
Learning Objectives

Conventional Municipal Wastewater Treatment System

- Conventional municipal wastewater collection, treatment, and discharge

Water Use


Raw Water Collection
Water Treatment System
Treated Water Distribution
River
Municipal Use (Homes etc.)
Raw Municipal Sewage Collection
Wastewater Treatment System
Treated Wastewater Discharge

Municipal Wastewater Generation

- Approximately 80% of the water used is converted to wastewater during municipal applications.
- WW generation is not uniform. It encounters daily and seasonal variations.
- These variations along with the increase due to populations are to be accounted for in planning and design of collection and treatment systems.
- The design period of 30 years is usually specified for collection and treatment systems ***(meaning a system should be able to handle the amount of WW generated after 30 years from the date of commissioning)***.

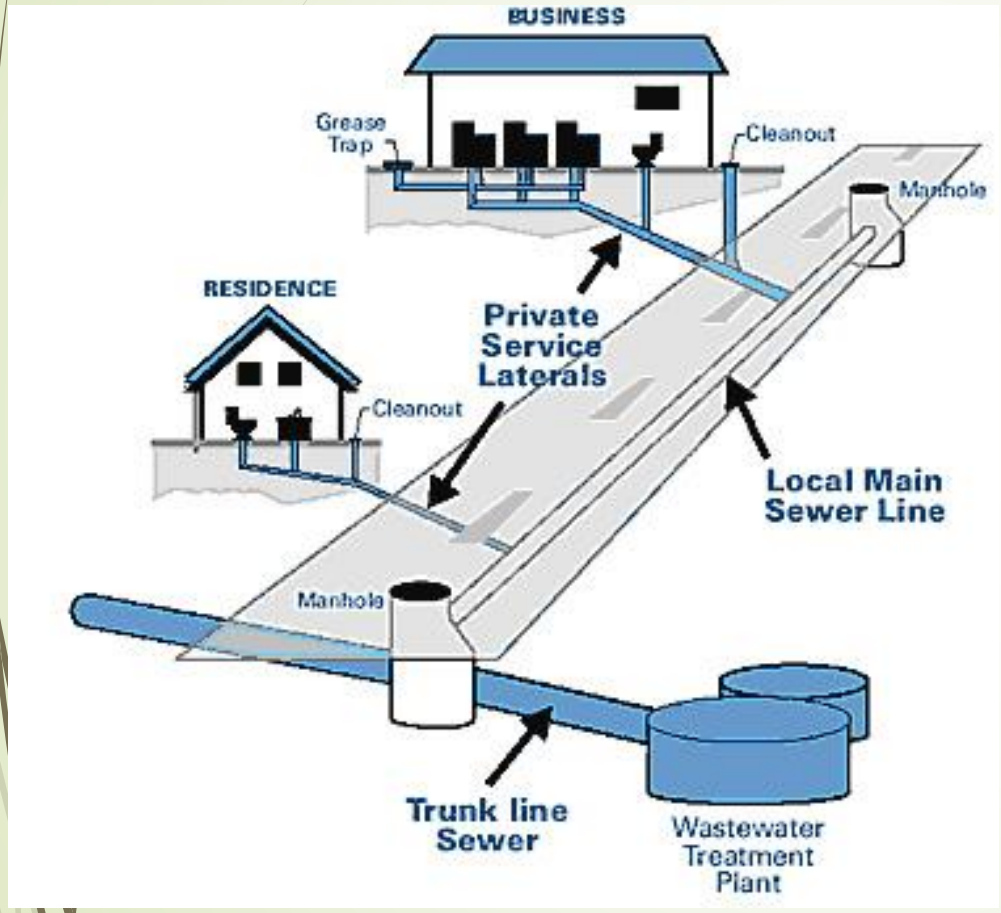
Municipal Wastewater Generation

Typical Contributions into Domestic Wastewater

Item	*Range of values contributed in wastes (g/capita per day)*
Biochemical oxygen demand, 5 days, 20°C (BOD_5)	45–54
Chemical oxygen demand	1.6–1.9 × BOD_5
Total organic carbon	0.6–1.0 × BOD_5
Total solids	170–220
Suspended solids	70–145
Grit (inorganic, 0.2 mm and above)	5–15
Grease	10–30
Alkalinity (as calcium carbonate, $CaCO_3$)	20–30
Chlorides	4–8
Total nitrogen N	6–12
Organic nitrogen	~ 0.4 × total N
Free ammonia	~ 0.6 × total N
Nitrite	—
Nitrate	0.0–0.5 × total N
Total phosphorus, P	0.6–4.5
Organic phosphorus	~ 0.3 × total P
Inorganic (ortho- and polyphosphates)	~ 0.7 × total P
Potassium (as potassium oxide K_2O)	2.0–6.0
Micro-organisms present in wastewater	(per 100 ml wastewater)
Total bacteria	10^9–10^{10}
Coliforms	10^9–10^{10}
Faecal Streptococci	10^5–10^6
Salmonella typhosa	10^1–10^4
Protozoan cysts	Upto 10^3
Helminthic eggs	Upto 10^3
Virus (plaque forming units)	10^2–10^4

Arceivala and Asolekar, 2007

Municipal Wastewater Collection and Transport



https://www.conshohockensa.com/media/3358/Sewer-System-Diagram.jpg

- Critical for **Centralized Treatment**
- Usually sewerage costs account for about 80% of the total cost, while treatment may account for only 20% of the total cost.

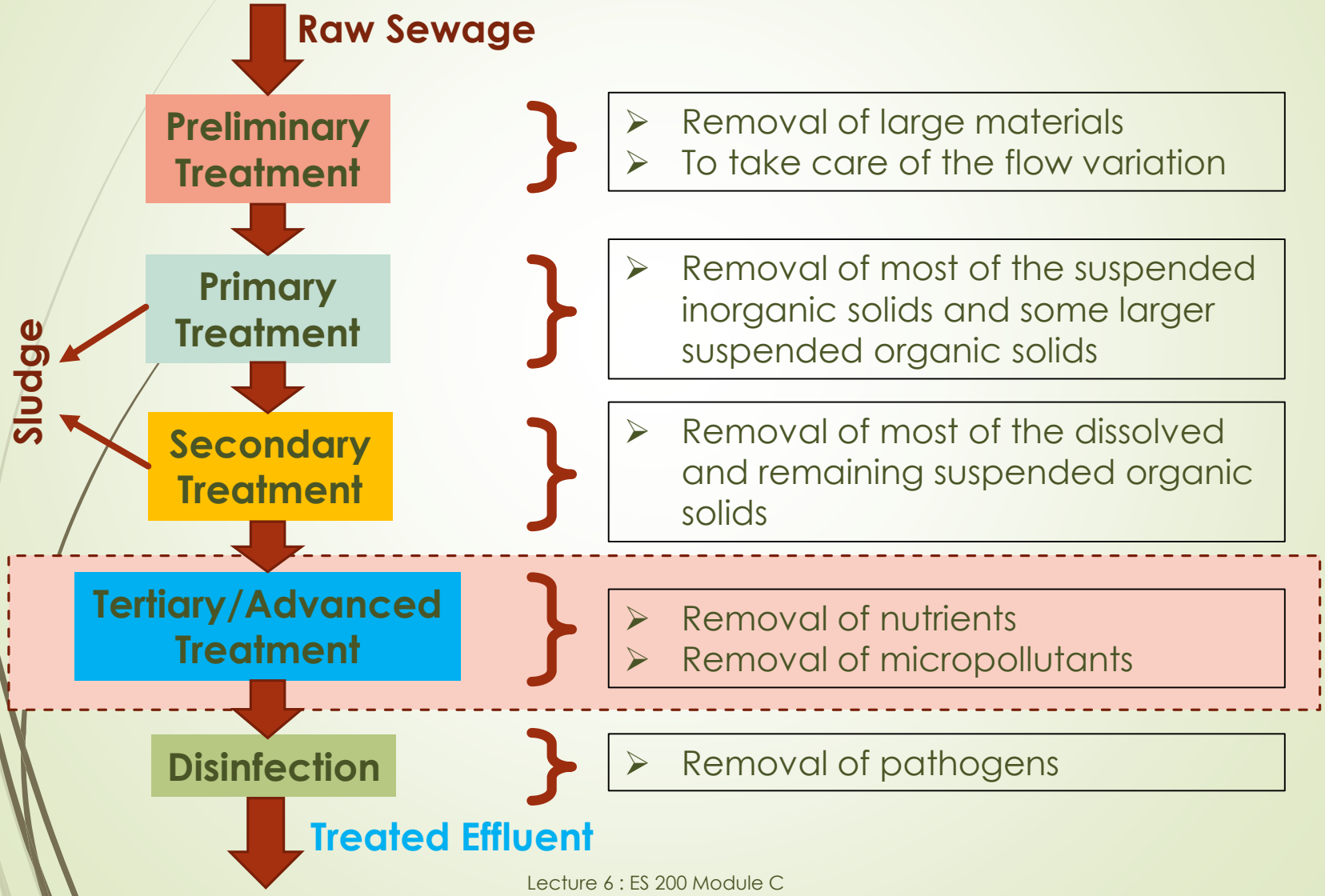
Arceivala and Asolekar, 2007

Conventional Municipal Wastewater Treatment

Composition of Municipal Wastewater (Sewage)

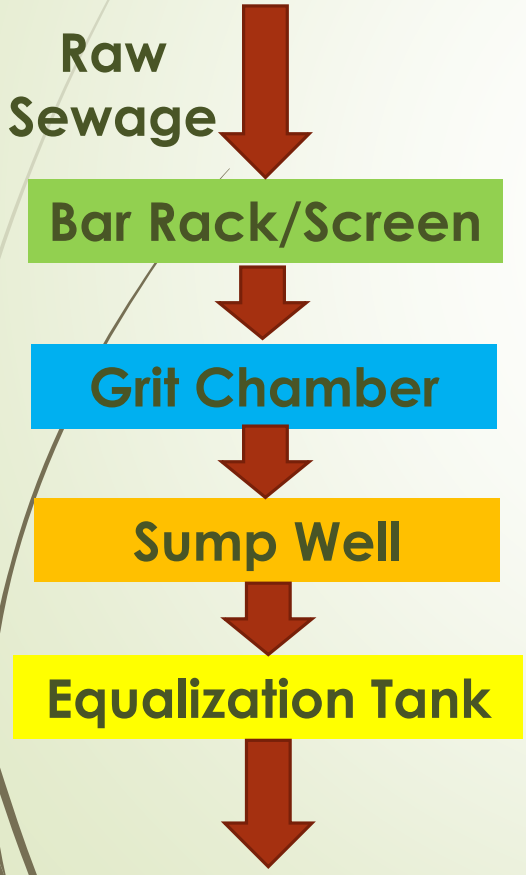
- Large solid objects (animal/vegetable matter, paper, plastic etc.)
- Inorganic solids (sand, silt, clay): (a) > 0.2mm (Grit), (b) FSS, (c) FDS
- Organic solids: (a) VSS, (b) VDS (may include nutrients, oil, grease etc)
- Nutrients
- Pathogens
- Micropollutants

Conventional Municipal Wastewater Treatment



Conventional Municipal Wastewater Treatment

Preliminary Treatment



Removal of large objects by physical separation

Removal of inorganic particles (dia. > 0.2 mm, sp.gr. = 2.65) by settling

Pumping of the sewage to the plant level

Flow regulation

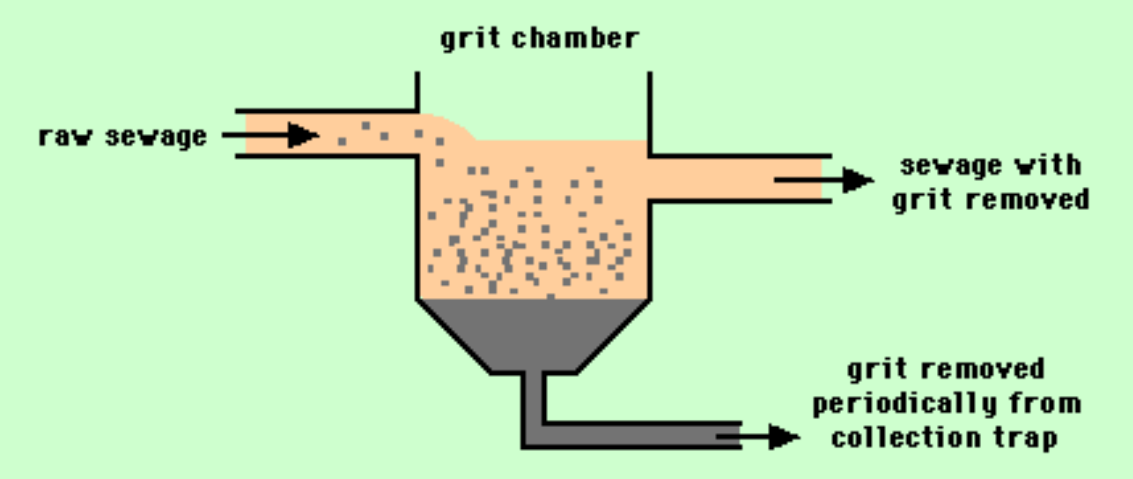
Conventional Municipal Wastewater Treatment

Preliminary Treatment: Bar Rack/Screen

https://www.google.co.in/imgres?imgurl=http%3A%2F%2Ffsinet.fsid.cvut.cz%2Fcz%2FU218%2Fpeoples%2Fhoffman%2FPREDMETY%2FCOVP%2FCOV%2FFoto-COV%2FKralupy15-COV%2520rucni%2520cesle.jpg&imgrefurl=http%3A%2F%2Fecompendium.sswm.info%2Fsanitation-technologies%2Fpre-treatment-technologies&docid=sZ_czDlJtDnhIM&tbnid=Oxa5CwnAI7odZM%3A&vet=10ahUKEwjWmbTyplHWAhUMn5QKHUAOB2YQMwiDASgGMAY..i&w=2272&h=1704&client=firefox-b&bih=947&biw=1920&q=bar%20screen&ved=0ahUKEwjWmbTyplHWAhUMn5QKHUAOB2YQMwiDASgGMAY&iact=mrc&uact=8

Conventional Municipal Wastewater Treatment

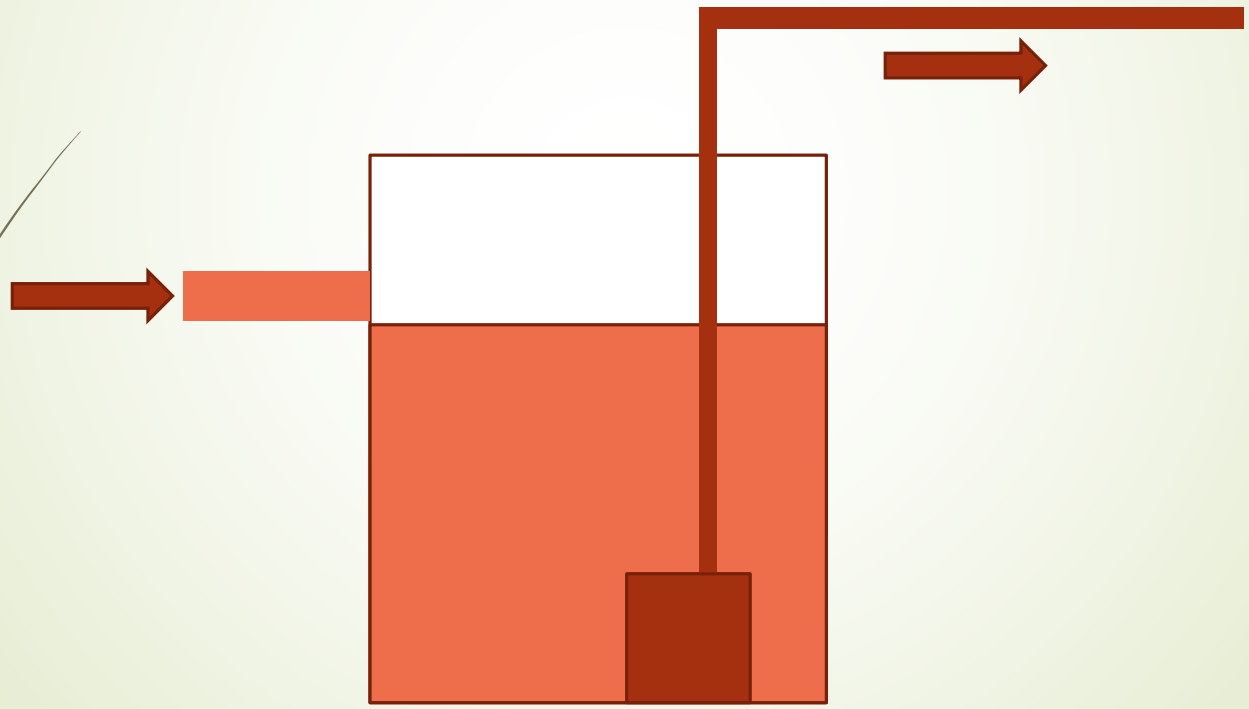
Preliminary Treatment: Grit Chamber



http://legacy.chemgym.net/environmental_chemistry/topic_5b/images/grit_chamber.gif

Conventional Municipal Wastewater Treatment

Preliminary Treatment: Sump Well



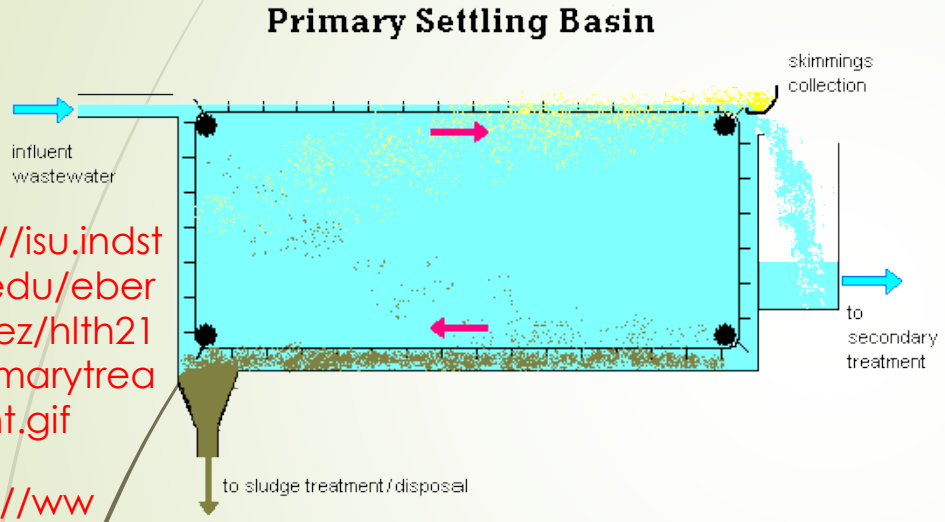
Conventional Municipal Wastewater Treatment

Preliminary Treatment: Equalization Tank

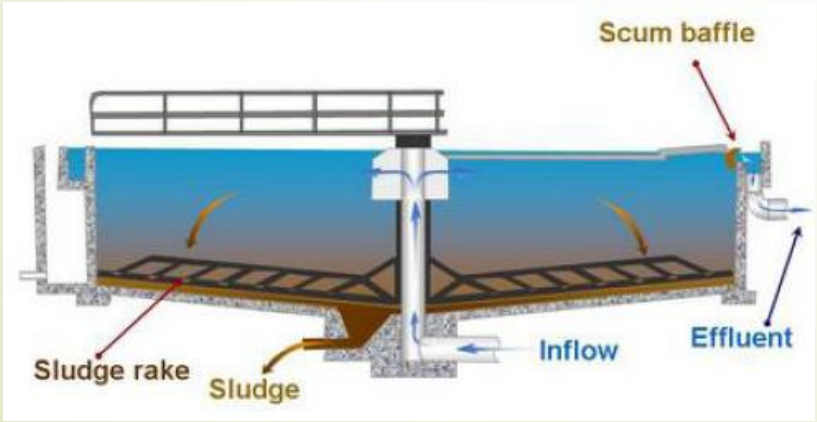
https://image.slideshare cdn.com/l-8equalizationandproportioning-150311205130-conversion-gate01/95/l-8-equalization-and-proportioning-17-638.jpg?cb=1426107930

Conventional Municipal Wastewater Treatment

Primary Treatment



http://isu.indstate.edu/ebermudez/hlth210/primarytreatment.gif



http://www.ewisa.co.za/eWISAWaterworks/misc/eWISAFactSheets/Images/wwt_images/scumbaffle.png

- Oil, grease removed by skimming at the top (scum removal)
- ~35% BOD_5 removal
- ~65% TSS removal
- After primary sedimentation: Organic (~ 1.2 – 60 µm); inorganic (~1.2 – 20 µm) in addition to all dissolved remain in WW
- 1° sludge: ~2% solids by wt.

Conventional Municipal Wastewater Treatment

Secondary Treatment

After primary treatment, most of the inorganic suspended solids, and sufficient organic suspended solids are removed.

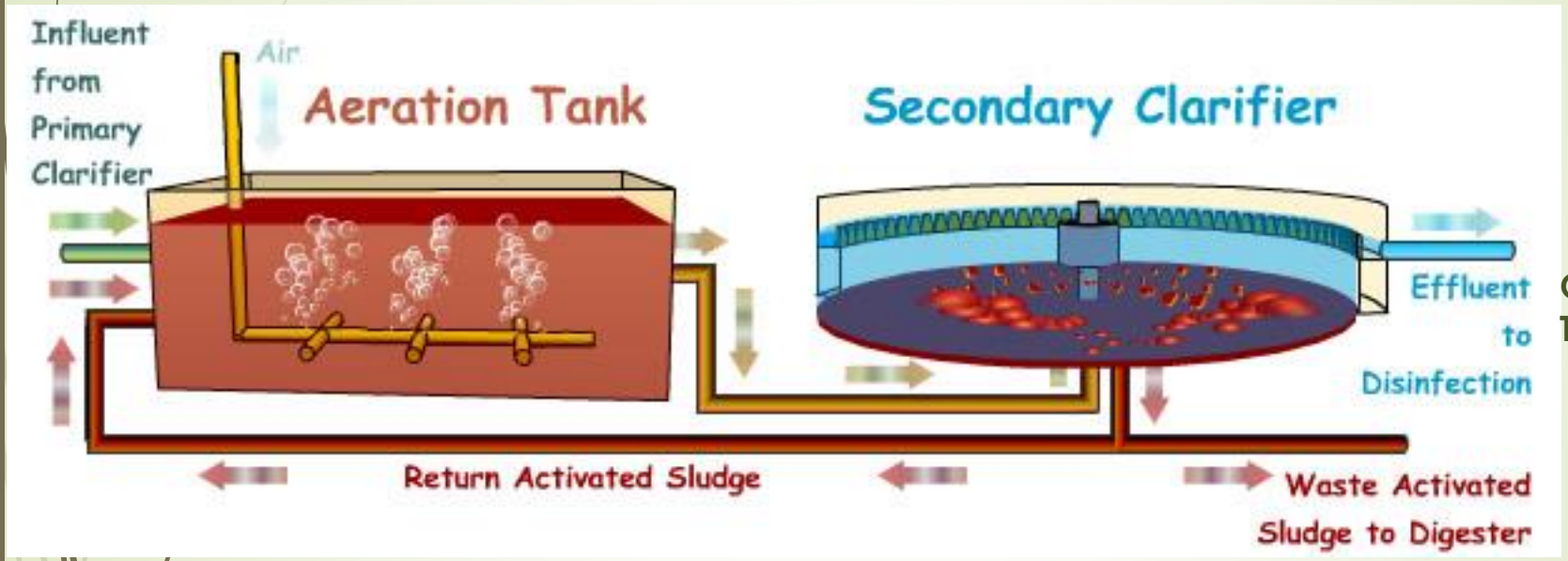
WW still contains:

- Dissolved organic matter + Remaining suspended organic matter
- Dissolved inorganic matter
- Nutrients **??**
- Micropollutants
- Pathogens

Food for microorganisms

Conventional Municipal Wastewater Treatment

Secondary Treatment: Activated Sludge Process



Or Tertiary Treatment

http://techalive.mtu.edu/meec/module21/images/WastewaterAeration.jpg

- Removal of remaining dissolved and suspended organic material
- Almost all suspended solids (organic + inorganic) are removed in 2° sedimentation
- 2° sludge: ~1.5% solids by wt.

Conventional Municipal Wastewater Treatment

Secondary Treatment: Activated Sludge Process

http://www.aqua-aerobic.com/default/cache/file/6F1E8BBC-FEC3-434F-AAC584B784B93CB8.jpg

https://5.imimg.com/data5/MS/JN/MY-3569866/secondary-clarifier-500x500.jpg

Conventional Municipal Wastewater Treatment

Tertiary Treatment

After Secondary Treatment, WW still contains:

- Dissolved inorganic matter
- Nutrients (N, P)
- Micropollutants
- Pathogens

Conventional Municipal Wastewater Treatment

Tertiary Treatment: Nitrogen Removal

- ✓ In municipal sewage, N is predominantly present as NH_3/NH_4^+.
- ✓ The conventional treatment tries to convert the N present into N_2 gas and bubble it out of the WW.
- ✓ Such conversion is a complex process and is achieved in distinct steps.
- ✓ First, all NH_3/NH_4^+ is oxidized to NO_2^- with distinct group of nitrifying bacteria (viz. Nitrosomonas) under aerobic condition.
- ✓ Second, NO_2^- is oxidized to NO_3^- by another group of nitrifying bacteria (viz. Nitrobacter) under aerobic condition.
- ✓ Lastly, NO_3^- is reduced to N_2 gas by denitrifying bacteria under anoxic condition, which is removed from the WW by aeration.

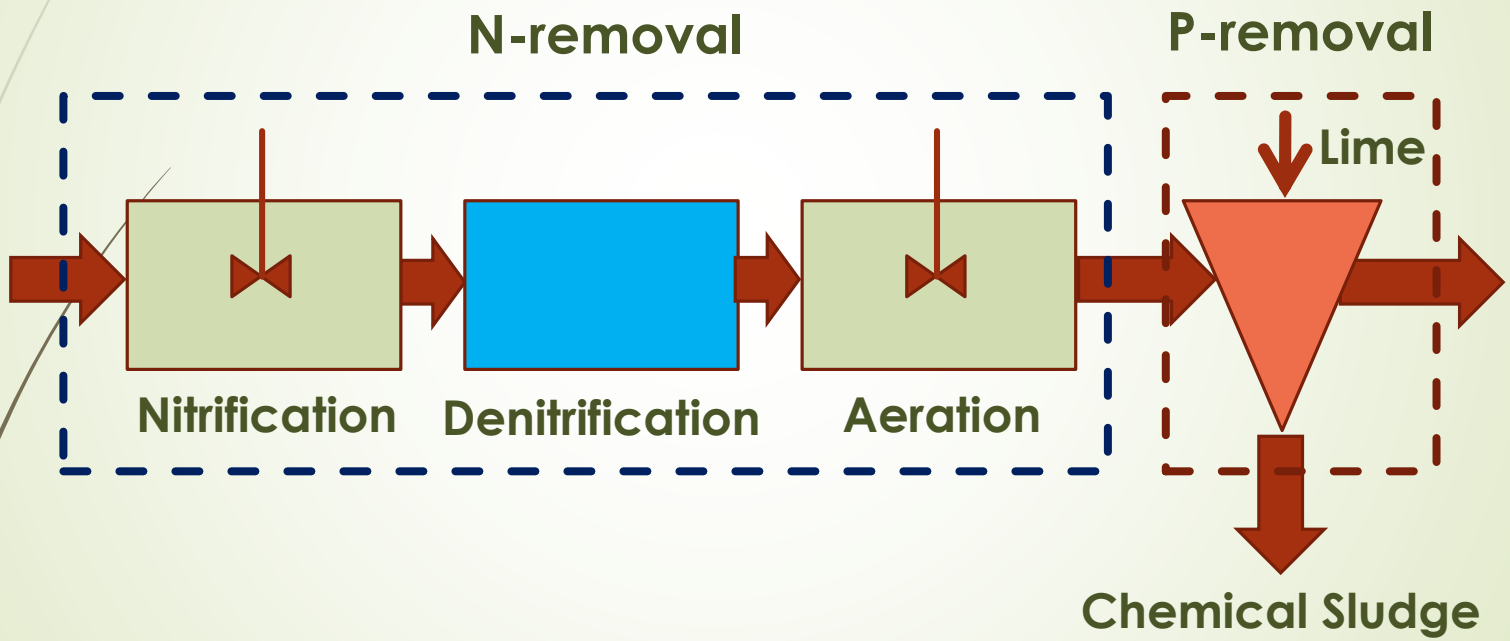
Conventional Municipal Wastewater Treatment

Tertiary Treatment: Phosphorus Removal

- ✓ In municipal sewage, P is predominantly present as orthophosphate.
- ✓ Since P can not be converted to gaseous form, it is converted to solid phase for removal.
- ✓ Some chemicals (viz. Lime $Ca(OH)_2$) are added to form precipitate of Phosphate.
- ✓ Such precipitates are then allowed to settle at the bottom of a settling tank, and the clear (treated) sewage is collected from the top.

Conventional Municipal Wastewater Treatment

Tertiary Treatment



Conventional Municipal Wastewater Treatment

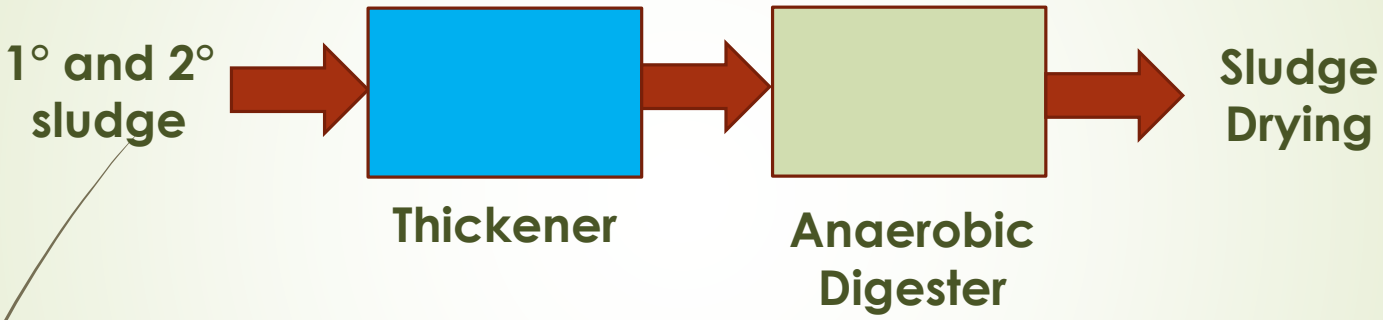
Disinfection

Free Chlorine Disinfection: Break Point Chlorination

- 6-log (99.9999%) pathogen removal
- 4-log (99.99%) virus removal
- 3-log (99.9%) cyst removal (parasite ova and others)

Conventional Municipal Wastewater Treatment

Sludge Handling

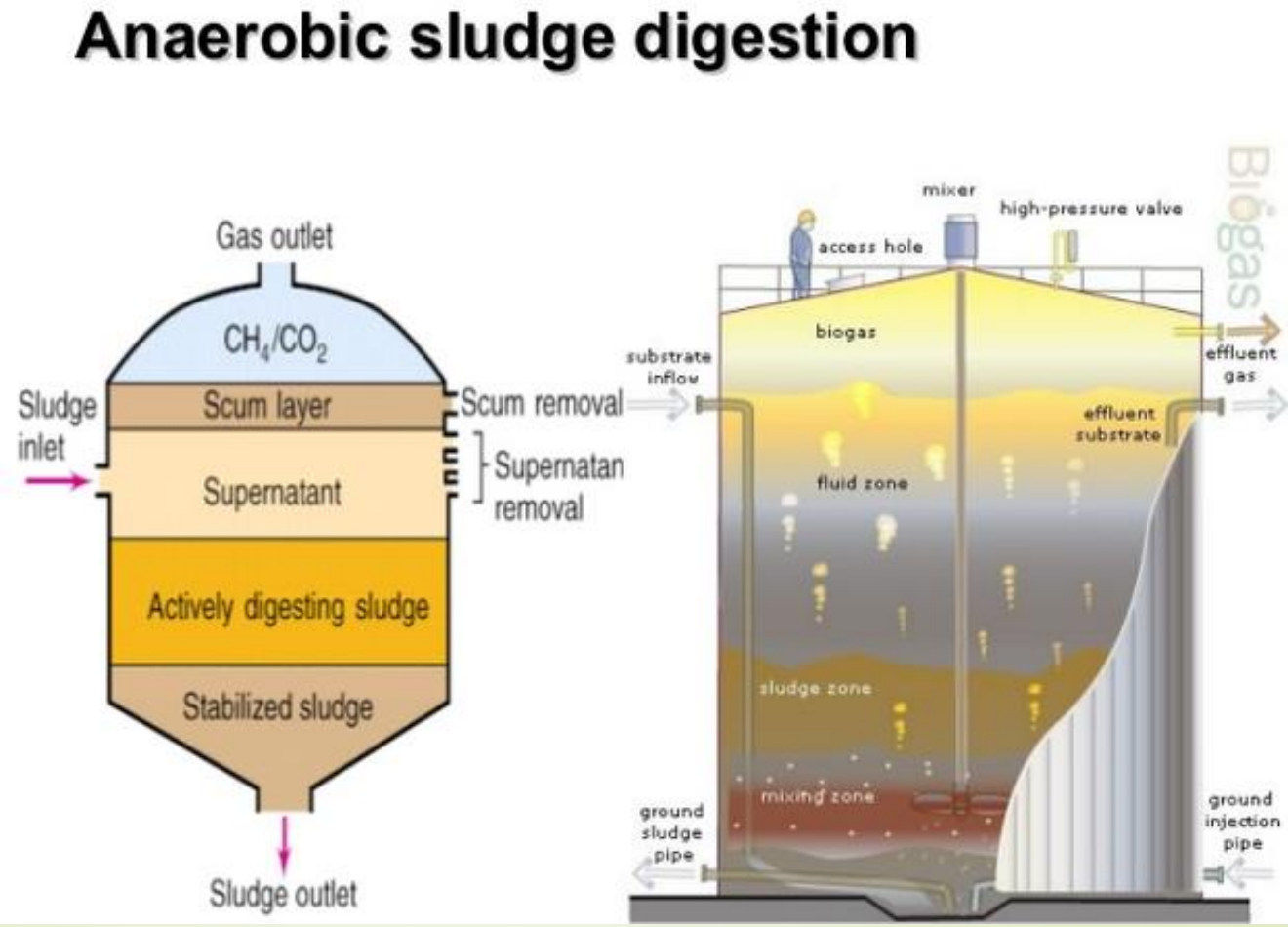


- 1° and 2° sludge is thickened to ~4% solids by wt. in thickener
- After thickening anaerobic digestion for ~40 days
- Considerable reduction in volume of sludge to be handled
- After digestion, remaining solids are dried and disposed

Conventional Municipal Wastewater Treatment

Anaerobic Digester

http://static.wixstatic.com/media/ca4d30_7761324d880549deb6c19026a5bd6679.png/v1/fill/w_620,h_445/ca4d30_7761324d880549deb6c19026a5bd6679.png



Conventional Municipal Wastewater Treatment

Reading Assignment

What are the limitations of different unit processes in such treatment?

Next Lecture:

Alternate Water & Wastewater Treatment