Trainers Training Program on Waste Management in Textile & Garment Industry in BGD

Promotion of Sustainability in the Textile and Garment Industry in Asia - FABRIC

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

GIZ FABRIC – Waste Management Course

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Presentation 5: Conditioning & Reducing sludge quantity

Contents

- Sludge generation
- Sludge digestion & maturation
- Thermal sludge drying
- Sludge incineration

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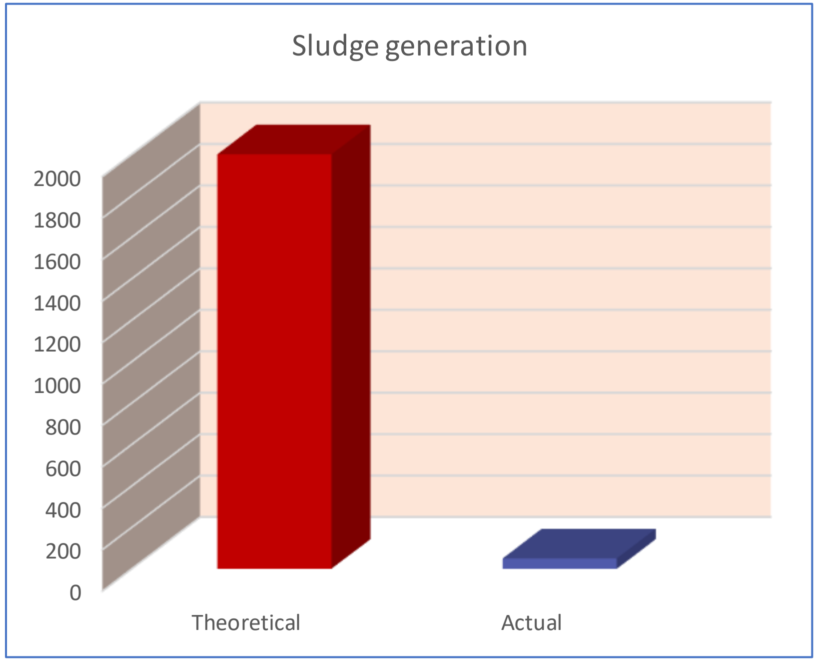
Quantity of sludge generation

- Quantity varies : ETP scheme, Effluent type, ETP process
- Primary ETPs generate sludge @ 1.2-1.5 kg/m3 of effluent treated
- Secondary ETP generate sludge @ 0.3-0.5 kg/m3, Combined ETP generates sludge @ 1.3-1.5 kg/m3
- Actual quantity is much less in Bangladesh.
- Daily production of sludge from BD ETP



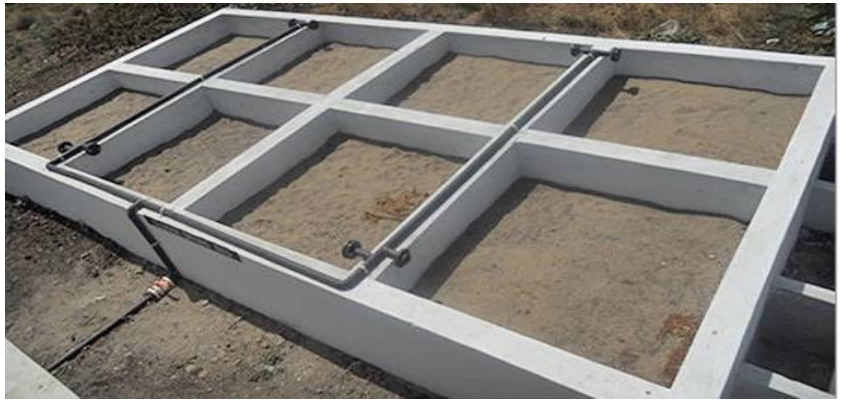
Theoretical: 2000-4000 tons/day

Actual reported: 50-100 tons/day

Purpose and basic approaches

Purpose for reducing sludge quantity

- Reducing size of ETP units
- To reduce cost for handling and disposal



Basic ways

- By reducing the organic content
- By reducing the moisture

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Purpose and basic approaches

Common methods

- Replacement or reduction of chemicals in ETP
- Anaerobic sludge digestion
- Aerobic sludge digestion
- Incineration
- Thermal drying of sludge
- Sludge maturation through storage

Replacement or reduction of treatment chemicals

Replacement or reduction of chemicals

Jar test apparatus

Optimization of chemical use

Basic approaches

- **Select** good **treatment chemicals**
- Determine **correct dosing** using jar test
- In combined ETP use chemical **treatment to maintain steady level of organic**s in aeration tank inlet

Replacement or reduction of chemicals

Jar test apparatus

Optimization of chemical use

Basic approaches - chemical use

- Ferrous sulphate only when reactive dyes present in effluent
- Pre-hydrolyzed inorganic coagulants based on aluminum and iron:
  - ✓ aluminum chloro-hydrate
  - ✓ poly-aluminum chloride
  - ✓ poly-aluminum sulfate chloride and mixes with polymers

Replacement or reduction of chemicals

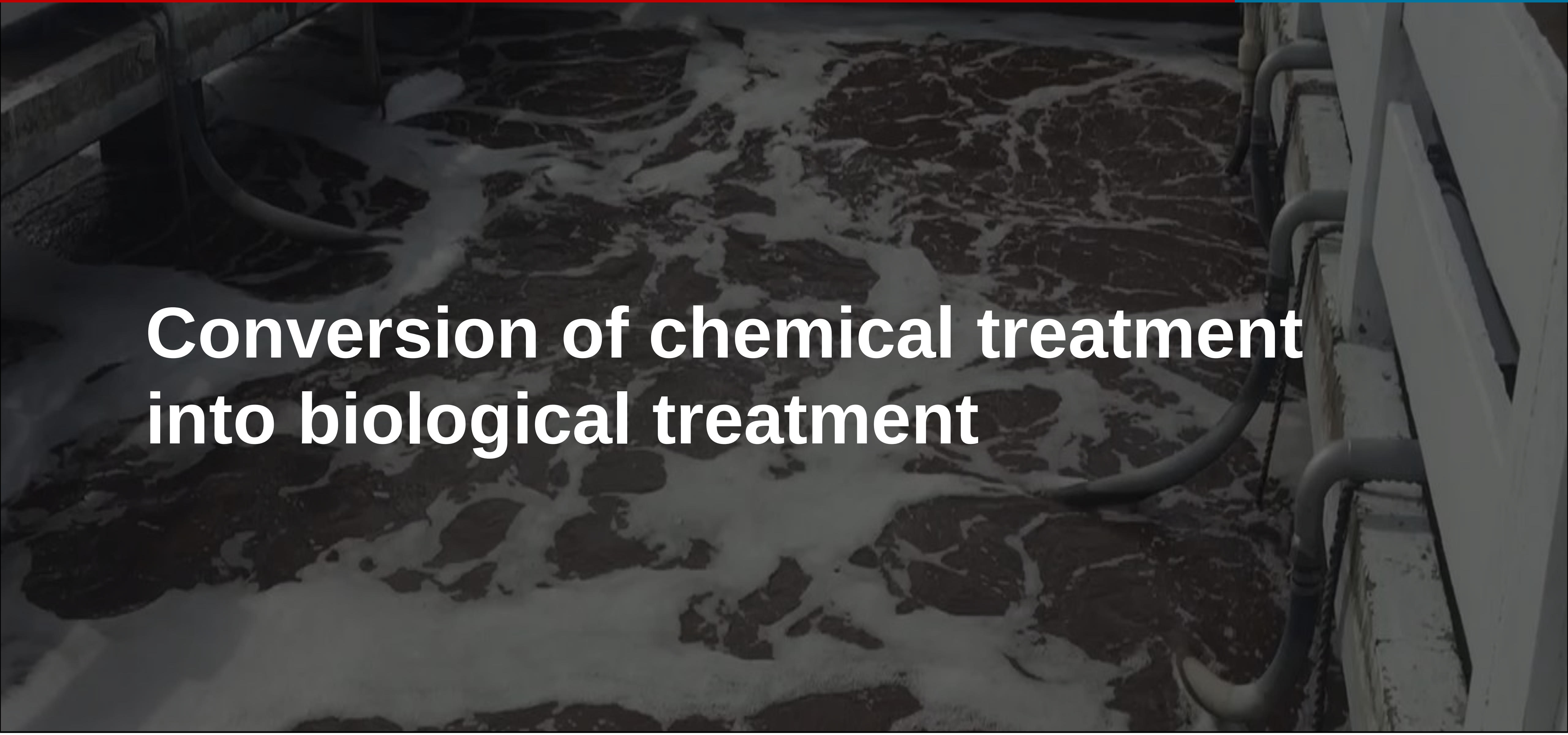
Ferrous sulphate

Ferric chloride

Optimization of chemical use

Basic approaches – chemical use

- Different coagulants and flocculants resulting in different quantities of sludge
  - Sulphate-based chemicals (alum, ferrous sulphate etc.) with lime produces calcium sulphate and adding to sludge
  - Chloride-based chemicals (poly aluminum chloride or ferric chloride)
    - Only fully soluble calcium chloride is generated: not adding to sludge
    - However slight increase of TDS in supernatant



Conversion of chemical treatment into biological treatment

Replacement or reduction of chemicals

- **Less sludge generation in all-biological treatment** compared to primary chemical treatment
- Conversion of primary ETP into all-biological treatment already done in Bangladesh

  - ✓ Be aware of **costs**
  - ✓ All-biological treatment requiring **more space**
  - ✓ Parts of primary treatment (e.g. screening, equalisation, sludge dewatering) usable in new ETP

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Replacement or reduction of chemicals

Conversion of primary to biological treatment

- All physical treatment upto equalization remains same.
- Primary clarifier can be used as secondary unit if:
  - ✓ unit is of sufficient volume
  - ✓ Hydraulic levels not at limit

- **No use for**
  - × flash mixer/flocculator
  - × chemical preparation/dosing

- **Additional units needed**
  - + Cooling tower & pH correction before aeration tank
  - + Additional electricity power requirements

Replacement or reduction of chemicals

Conversion of primary to biological treatment

Advantages

- Higher efficiency of 75 - 85%
- Simpler and easier to operate
- Cleaner since no risk of chemical spillage
- 50% less sludge quantity compared to primary ETP
- Cheaper in operation and maintenance
- Less cluttered since no need for chemical storage and mixing area

Replacement or reduction of chemicals

Conversion of primary to biological treatment

Disadvantages

- Need for professional engineering guidance in planning
- Higher power consumption (about 50 - 60 HP) though overall cost lower
- Additional capital cost for implementation of aeration system (e.g. blowers, diffusers, piping)
- Shutdown of existing ETP or interim arrangement required during implementation (2 - 3 months)
- More space required (abut 1.5 – 2 times more)

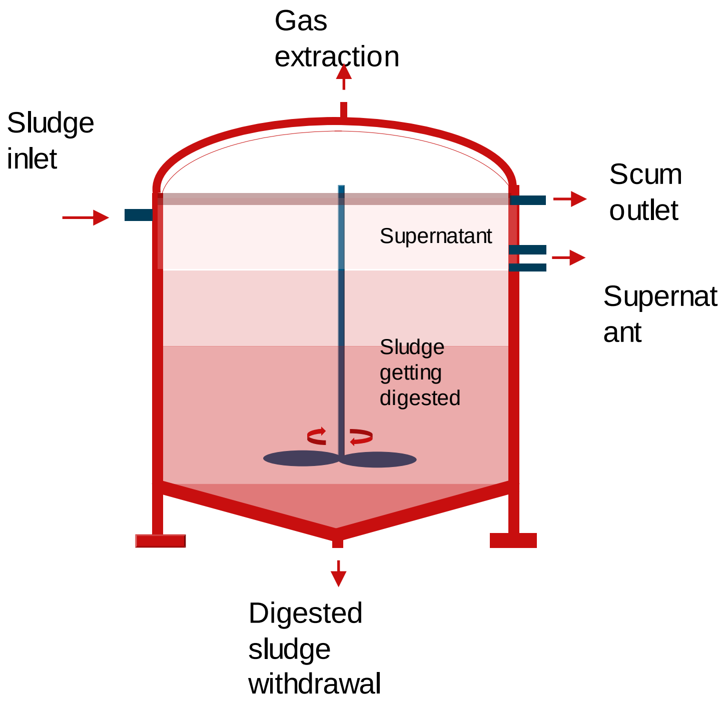
Sludge digestion to reduce sludge quantity

Sludge digestion

Anaerobic sludge digestors

- Most common unit in ETPs, mainly for handling primary sludge
- Good option to reduce quantity of organics and overall quantity of sludge
- Mostly provided with heater:
  - ✓ higher bacteria efficiency
  - ✓ not needed in tropical climates (e.g. Bangladesh)
  - ✓ biogas partly usable for heating

Sludge digestion

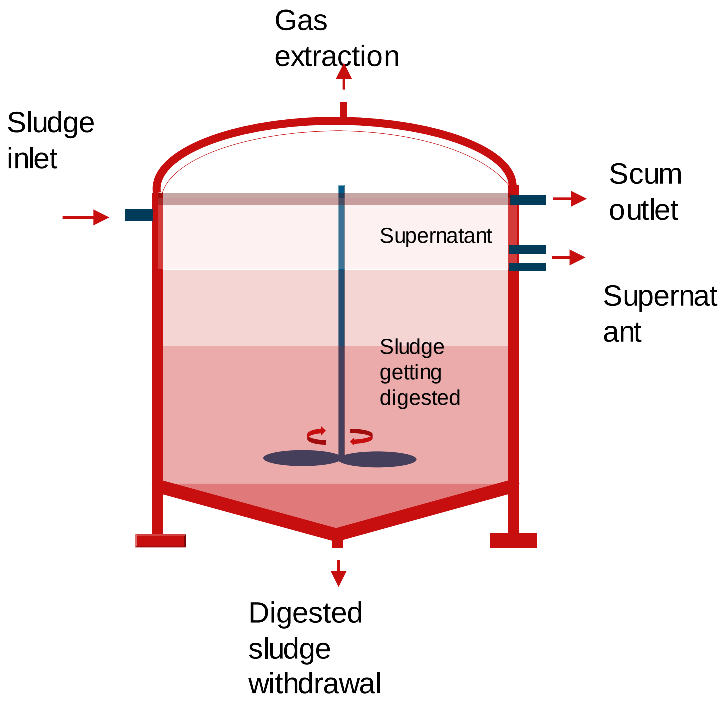


Anaerobic sludge digestors

Operational concept

- Organic material degraded into carbon dioxide and methane
- Supernatant returned to equalisation tank
- Produced biogas collected and re-used (e.g. as fuel in boilers and electricity)

Sludge digestion



Anaerobic sludge digestors

Operational concept

- **50 - 75% reduction in organics/ and sludge volume**
  - ✓ depending on organics concentration and nature in sludge
- **Size of digestor for efficient use**
  - ✓ Most digestors for textile ETP sludge too small
  - ✓ Inadequate biogas quantity for proper use, instead escape or burned off in flare
  - ✓ Mixer not must but helpful

Sludge digestion

Anaerobic sludge digestors

Operational steps with unheated batch reactor

- Stop mixer for 15 minutes, drain out scum and supernatants
- Drain digested sludge by opening bottom valve
- Switch on digestor mixer and collect sample
- Check gas pressure and operation of emergency release valve
- Ensure continuous running of agitator/mixer in sludge holding tank
- Pump liquid sludge upto designed stop level
- Add nutrients as needed @BOD: N: P at 100:2.5:0.5
- Leave digestor to operate

Sludge digestion

Aerobic sludge digestors

- Process used to reduce both organic content and volume of sludge
- Organic matter in sludge oxidized biologically by microorganisms to carbon dioxide and water
  - 50-70% reduction in solids content
- Flow operations:
  - Continuous
  - In batch with sludge added to reaction tank while contents continuously aerated

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Sludge digestion

Aerobic sludge digestors

Operational aspects

- Continuous **aeration for long period** (≈ 2 weeks), depending on frequency of sludge wasting in ETP
- **Feeding** aerobic digestor:
  - in **batch units** at least **every week**
  - In continuously operated digestors small portion of sludge wasted every day
- After aeration separation of solids and liquids
  - In batch reactor clarified liquid supernatant decanted and recycled to ETP

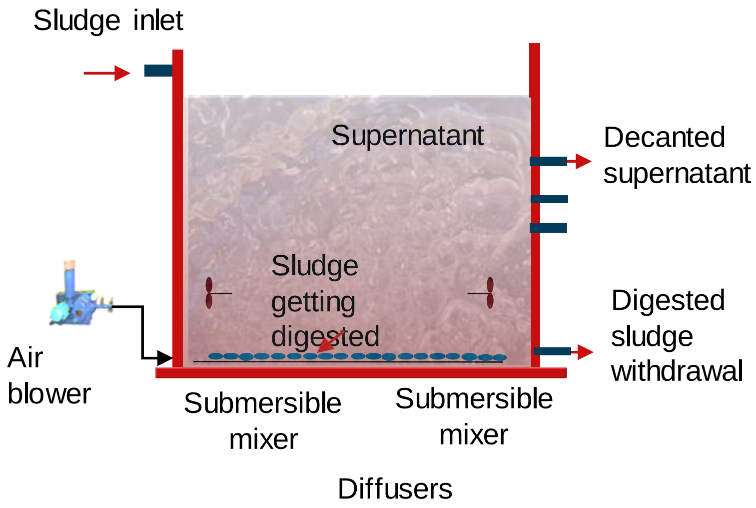
Sludge digestion

Aerobic sludge digestors

Operational aspects

- In continuous flow system normal aeration tank used with sometimes with higher density of diffuses followed by settling tank
    - ✓ Some units equipped with extra submersible mixers
- Aerobic sludge digestion **usually for biological sludges** from secondary treatment units
- In endogenous respiration microorganisms utilizing own cell contents for metabolic purposes with remaining sludge mineralized

Sludge digestion



Aerobic sludge digestors

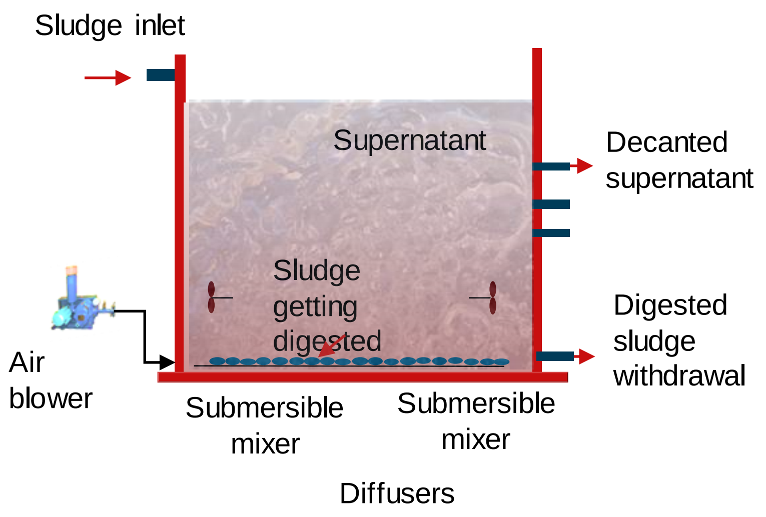
Operational steps

1. Switch off blower for 2 hours and observe settling in level tubes
2. Once sludge settling below bottom of drain channel, open top drain valve
3. Once draining slowing open lower drain until all supernatant drained
4. Start air blower and aeration

Sludge digestion

Aerobic sludge digestors

Operational steps



4. Open bottom drain valve and withdraw digested sludge
5. leave about one-fourth of tank volume to preserve needed biomass for digestor.
6. Once draining complete pump fresh sludge into digestor.
7. Sludge not to be held in collection tank for long time and turn anaerobic in nature.

Sludge digestion

Aerobic sludge digestors

Advantages

- Simplicity of operation and maintenance
- Lower capital costs
- Lower levels of biochemical oxygen demand (BOD) and phosphorus in supernatant
- Fewer effects from upsets (e.g. presence of toxic interferences or changes in loading and pH)
- Less odor and nonexplosive
- Shorter retention periods
- Suitable for small wastewater treatment plants

Sludge digestion

Aerobic sludge digestors

Disadvantages

- Higher operating costs, especially energy costs
- No useful by-products such as methane gas
- Less reduction in volatile solids
- Too costly option for larger wastewater treatment plants

Sludge Calculation for Primary ETP

The sludge generation depends on kind & purity of chemicals used and efficiency of primary treatment. A rule of thump calculation of sludge from primary textile ETP is:

Total Sludge (TS), kg/d dry wt = flow (m^3) x [{TSS removed (g/m^3)/1000} + {Total chemicals dosed (g/m^3) x 0.3)/1000}]

If the flow is 800 m^3/d, TSS at inlet of primary treatment is 350 mg/l, outlet is 75 mg/l, and ferrous sulphate dosed is 300 mg/l + lime dosage is 250 mg/l.

Then, TS, kg/d = 800 x [{(350-75)/1000} + {(300+ 250) x 0.3}/1000 = 352 kg/d dry wt. This, in turn, means about **11.7 m^3/d** of liquid sludge at 3% or **880 kg/d** of dewatered sludge at 60% moisture (i.e., 40% solids).

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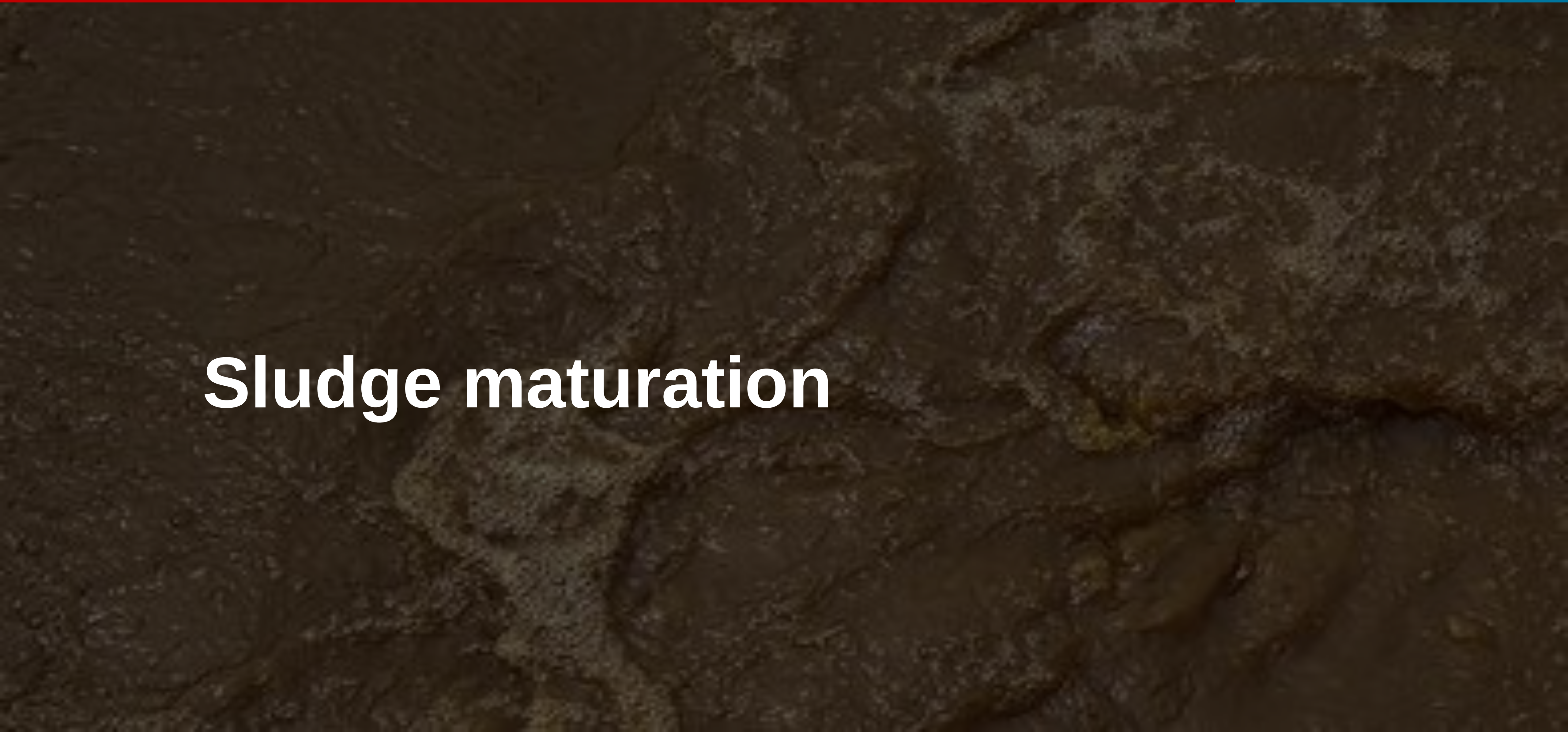
Sludge Calculation for biological ETP

Sludge generation depends on the volatile portion of the solids. A rule of thump calculation of sludge from an all-biological textile ETP is:

Total Sludge (TS), kg/d dry wt = flow (m^3) x [{TSS removed (g/m^3) x 0.4/1000} + {COD removed (g/m^3) x 0.2)/1000

If the flow is 1200 m^3/d, TSS at inlet of biological treatment is 270 mg/l, outlet is 50 mg/l, and COD at inlet is 850 & outlet is 200 mg/l.

Then, TS, kg/d = 1200 x [{(270-50) x 0.4/1000} + {(850-200) x 0.2}/1000 = 261.6 kg/d dry wt. This, in turn, means about **13.1 m^3/d** of liquid sludge at 2% or **654 kg/d** of dewatered sludge at 60% moisture (i.e., 40% solids).



Sludge maturation

Sludge maturation

- Storage of sludge for long time
  - ✓ Normal practice in Dhaka
- Natural drying of sludge using air-drying
- Sludge commonly transferred to open shed protected with roof
- Duration of maturation about 6 - 8 months before final disposal

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Sludge maturation

- Adequate ventilation to prevent any anaerobic condition and odour problem
- Normally, sludge moisture reduced to less than 20-30% moisture
  - ✓ dried up sludge is like powder than sludge cake
- Suitable for small ETPs with very small quantity of sludge

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Thermal drying of sludge

Thermal sludge drying

- Reducing **moisture content to less than 10%**
- Sludge in **powder form**
- **Pathogens destroyed**
- Often done by paddle dryer
  - ✓ sludge not forming lumps
  - ✓ final product dry powdered sludge
- Fork like discs ensuring even drying and avoiding pasting of sludge

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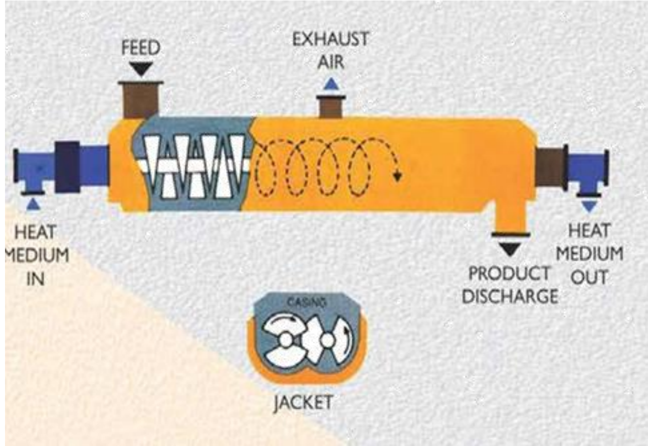
Thermal sludge drying



Components

- **Feeding system** using hopper or screw conveyor for large ETPs
- **Paddle Dryer** with VFD enabled TEFC motor to rotate dual inter-meshing shafts for mixing, heating and drying
- **Steam or thermic fluid heater** as heat source
- **Dried sludge powder handling system**
  - direct collection to bags in small plants
  - belt conveyor for large units

Thermal sludge drying

Components

- Paddle dryer transfers heat from heating medium to sludge
- Efficient drying of sludge through direct contact with revolving hollow paddles (no gas required)
- In most factories in Bangladesh boilers with extra steam possibly used to paddle dryers

Thermal sludge drying

Operational concept

- Trough uniformly heated by passing heating medium through jacket
- Constructed from thick plates and heavy shafts (heavy and sticky sludge)
- Revolving paddles compressing and expanding materials through constant agitation
- Paddle dryers generally of totally enclosed construction
- Entire heat transfer through conduction

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Thermal sludge drying

Advantages

- Lower final disposal cost
- Reduction in volume of sludge
- No manual handling during sludge storage required
- No landfilling required
- No spillages of sludge in ETP area
- No smell or nuisance odor of sludge
- No need for sun drying of sludge required
- No storage shed or space required

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Thermal sludge drying

Disadvantages

- Sludge already quite dry in case of maturation
- Additional operation and maintenance costs for one more unit in ETP
- Need for external heat
- High capital investment costs
- Quantity of sludge in many ETPs too small to warrant installation of paddle dryer

Sludge incineration

- Usually regarded as disposal option
- Allowing for largest volume reduction to less than 4 - 10% of original volume
- Destruction of organic substances and microorganisms
- Sophisticated filter systems needed to reduce pollutant emissions!
- Sludge co-processing in cement factories option, if in-situ incineration not warranted

Sludge incineration

Advantages

- Lowest quantity of residual sludge for disposal
- Environmentally clean option
- Low land requirements

Disadvantages

- High cost of installation
- Very high operating cost
- High level of technical skills needed

To Conclude

- There are methods to reduce quantity of sludge for less problematic disposal
- Consider optimization of chemical use in all primary ETPs
- Consider sludge digestion for sludge from all-biological ETPs and not primary ETPs
    - ✓ Sludge digestors for large ETPs
    - ✓ Aerobic digestion suitable option in Bangladesh
- Thermal sludge dryer suitable for medium to large ETPs
- For small ETPs sludge maturation with periodical mixing and spreading of sludge suitable

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