Sludge treatment and disposal

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

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Sludge Treatment and disposal

Helmut Krist
GIZ Consultant

on behalf of GIZ FABRICS and adelphi consult GmbH Berlin

Agenda

- ✓ Background and Importance of Sludge Management
- ✓ Stages of Sludge Handling and Pretreatment
- ✓ Sludge Storage, Sampling and Preservation
- ✓ Transportation of Sludge
- ✓ Sludge management plan

Classification of ETP Sludge

Sludge Characterization

The parameters for the conventional characterization of sludge can be grouped into physical, chemical, and biological.

- Physical parameters give general information on sludge in terms of ease of processing and handling
- Chemical parameters are relevant to the presence of nutrients and toxic/ dangerous compounds
- Biological parameters provide information on microbial activity and organic matter or pathogens presence

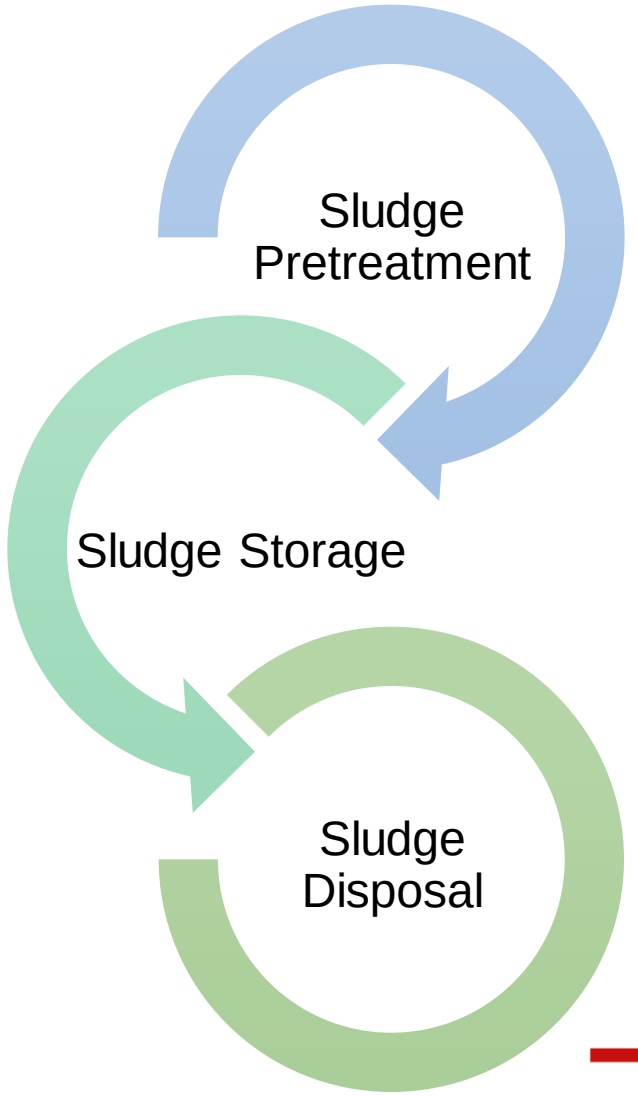
Sludge Characterization

Parameters needed to be tested before deciding on any sludge disposal application

Priority	Parameters
Primary Parameters	Total Organic Carbon (TOC) Moisture Content Calorific Value Heavy metals: Cr, Cd, As, Pb, Cu, Ni, Hg, Zn Sulphur Content
Secondary Parameters	Organohalogen Polychlorinated biphenyl (PCB) Polychlorinated dibenzodioxin (PCDD) Polychlorinated dibenzofuran (PCDF)

Stages of Sludge Handling

- ETP sludge needs to go through several stages till its final disposal
- The main stages of Sludge Handling are
  - Sludge Pretreatment
  - Sludge Storage
  - Sludge Disposal
- These stages are again divided into serval sub-stages



Sludge Pretreatment

- Textile ETP sludge can vary in terms of physical and chemical properties based on the ETP scheme and the pre-treatment options
- Sludge pretreatment is the preliminary stage of sludge management
- Pre-treatment mainly includes three stages sludge thickening, conditioning, and dewatering.
- There are multiple options for each of the stages
- The selection of these processes depends on the cost and suitability of the sludge

Solid Recovery During Sludge Pretreatment

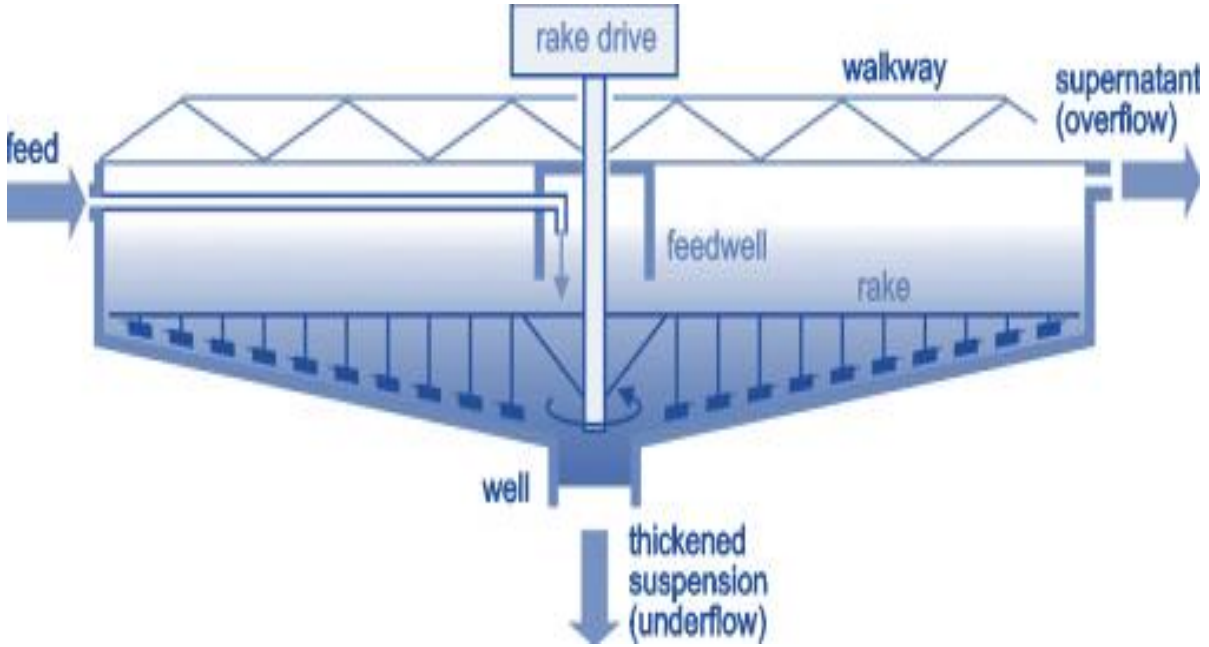
Process		Solid Recovery rate
Sludge thickening	Gravity thickening	80-90%
	Centrifugal thickening	85-95%
	Air floatation thickening	> 95%
	Gravity belt thickening	> 95%
Sludge digestion		30-40%
Sludge dewatering	Pressure-type screw press dewatering	> 95%
	Rotary pressure dewatering	> 95%
	Belt press dewatering	90-95%
	Centrifugal dewatering	> 95%

Guideline and Manual for Planning and Design in Japan. 2009

Sludge Pretreatment

Sludge Thickening:

- Can be broadly classified into three types gravity, centrifugal, and floatation
- When the thickening of sludge is inadequate, the filtrate from dewatering will have large amounts of suspended solids
- These solids returning to the ETP will affect the effluent water quality



Solid/Liquid Separation: Equipment Selection and Process Design, Elsevier. 2007

Sludge Pretreatment

Sludge Thickening:

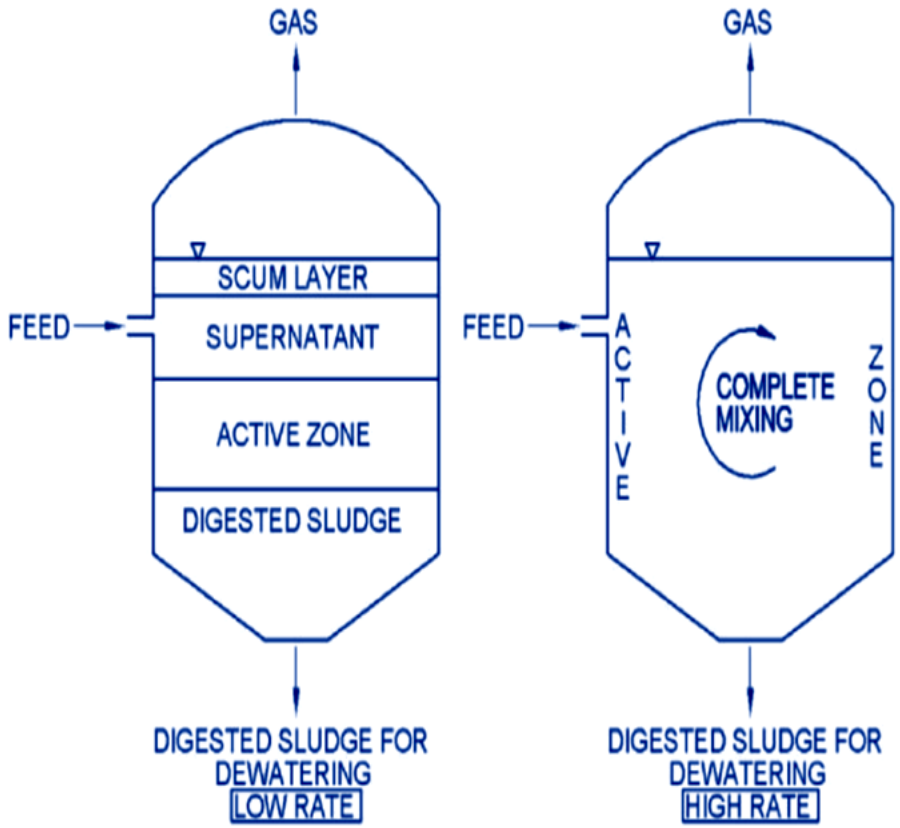
Comparative Evaluation of Different Sludge Thickening Processes

Evaluation criteria	Gravity thickening	Dissolved air floatation	Centrifugation	Gravity belt
Space requirement	High	Medium	Low	Medium
Operation and maintenance	Simple	Medium	High	Medium
Typical application	Primary and combined	Waste activated sludge	Waste activated sludge	Waste activated sludge
Conditioning chemicals	None	High	High	Medium
Power requirement	Low	High	High	Medium
Capital cost	Low	High	High	Medium
Operation cost	Low	High	High	Medium
Thickened sludge solid concentration	Medium	Low	High	Medium to High
Building corrosion if closed	High	Medium	None	Medium
Odour problem	Serious	Moderate	Low	Moderate

Sludge Pretreatment

Sludge Digestion

- Two types based on the presence or absence of oxygen: aerobic and anaerobic
- Anaerobic digestion converts organic waste to methane, carbon-dioxide, and water
- Anaerobic sludge digestion is of two types low rate and high rate
- In this process, the final quantity of sludge reduces by 60-70% and is cheaper in operation



Anaerobic digestion

Manual on Sewerage and Sewage Treatment Systems(CPHEEO), *India*. 2013

Sludge Pretreatment

Sludge Digestion

- However, anaerobic sludge digestion has high installation cost and requires additional area in ETP.
- Aerobic digestion is useful for stabilizing sludge if the organic load is moderate.
- About 50% to 65% of volatile solids are destroyed in aerobic digestion in 10 to 12 days at a temperature of 25°C.
- The operating cost in terms of the power cost is much higher for aerobic digestion.
- In addition, it requires a lower capital cost and has fewer operational problems.

Sludge Pretreatment

Sludge Dewatering/ Solar Drying

- Most popular unit for small ETPs.
- Uses gravity drainage of water & surface drying.
- Easily constructed with locally available materials.
- Simple and often cheaper to construct.
- However, they require a lot of area, the output during rainy seasons drops considerably, there is problem of malodour, they are not easy to clean and made ready for the next batch etc.

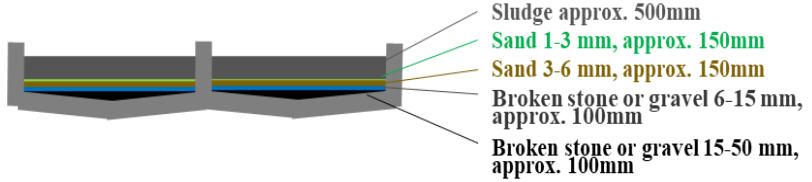


Image courtesy: GIZ presentations

Sludge Pretreatment

Sludge Dewatering

- Sludge dewatering can be achieved naturally by drying on a drying bed.
- The dewatering of digested sludge on a sludge drying bed can reduce the moisture content to below 70%.
- However, mechanical equipment can be effective in case of space scarcity.

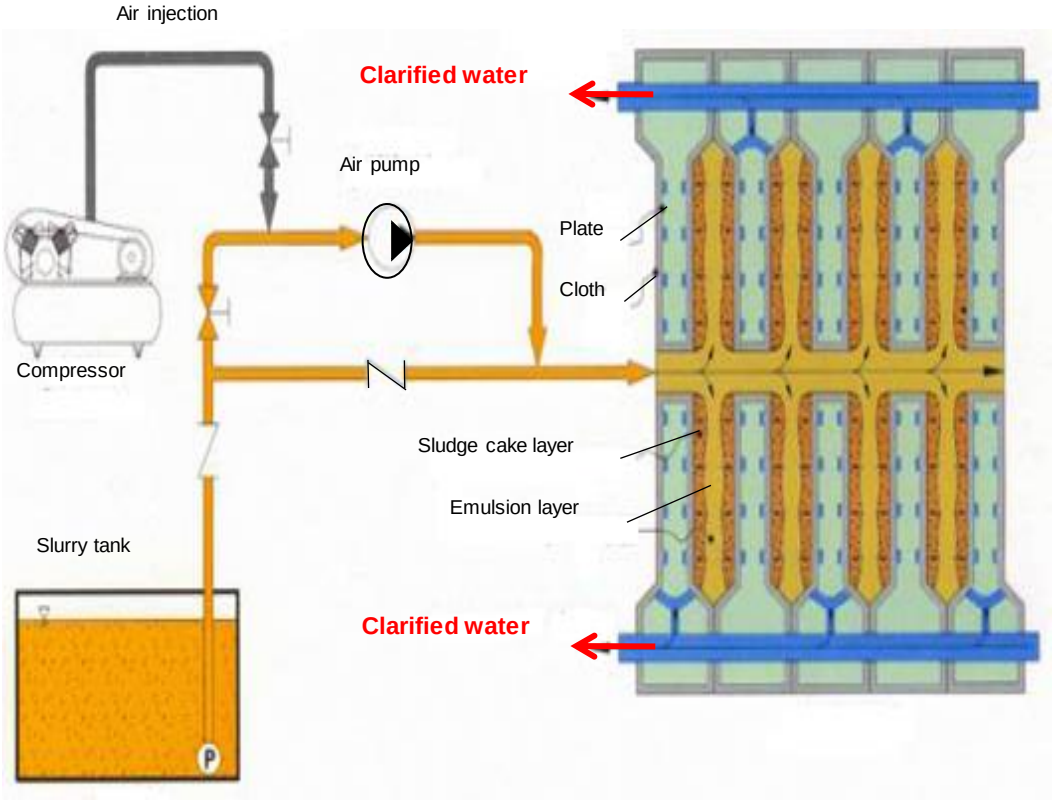


Image courtesy: UNIDO

Sludge dewatering and drying

- **Sludge characteristics**

  - Liquid sludge generally of 3 - 4% solids;
  - Wasted liquid sludge from aeration tank usually about 1% solids and 2 - 3% after thickening;
  - Dewatered sludge usually 25 - 35% dry solids content

Sludge dewatering and drying

- **Dewatering methods**
- Dewatering in **sludge drying beds:**
  - In **small ETPs**
  - Mainly by **water percolation** and some **solar drying**;
  - minimum of **7 days retention** cycle needed.

Sludge dewatering and drying

- **Dewatering methods**
- **Mechanical dewatering**:
  - **Sludge centrifuge** most popular in medium to large ETPs.
  - **Chamber filter press** popular since no requirement of sludge conditioning.
  - **Belt filter presses**

Sludge Pretreatment

Sludge Dewatering

- Dewatering methods include *filtration* and *mechanical separation*
- Filtration may be performed by pressure filtration or by belt press filter, vacuum filter and screw press dewatering equipment.
- The dewatering performance, operability and maintainability of pressure filter and vacuum filter are inferior

Image courtesy: UNIDO

Sludge Pretreatment

- **Dewatering methods**
- **Mechanical dewatering**:

Chamber filter press

Sludge centrifuge

Sludge Pretreatment

Sludge Dewatering

Dewatering Mechanism	Advantages	Disadvantages
Filter press	• Produces drier cake than other dewatering mechanisms • It is cost effective for more than 35% solid in cake • Produce high quality filtrate • Can adapt a wide range of sludge characteristics	• Relatively high operating and maintenance cost • Needs periodic cleaning to remove adhered solid • Required significant energy to pressurize the unit • Often treatment chemical is required
Belt press	• Simple maintenance but belt replacement is a major cost • Manpower requirement is relatively less • Energy requirement is relatively low • Can be started and turned off quickly	• Potential source of odor and spray • Belt washing is time consuming and requires more water • Difficulties with higher oil and grease • Special care needed for varying feed rate
Screw press	• Low maintenance and noise • Low energy consumption • Containment of odor and aerosol • Low wash water and pressure than belt press • Simple operation with less operator attention	• Larger footprint, more space required • Relatively less local supplier • Require wash water • Lack of local support delays repair

Sludge dewatering and drying

- For consideration
- **Disposal logistics and costs**
  - Often **dewatered sludge is hazardous** and requirs **disposal in secured landfill sites**
  - Not many plants adopting **cost-effective sludge digestion** to reduce sludge volume
  - **40 - 70% less disposal cost** with reduced volume for disposal

Dewatered sludge

Sludge dewatering and drying

- For consideration
- **Disposal logistics and costs**
  - **maturation of sludge** common, keeping over **6 months** period.
  - Alternative maturation by using **thermal dryer** fueled by either steam from boiler or hot oil from a thermic-fluid system.
  - Ideally, aim for disposal of sludge with **moisture content less than 30%**

Matured sludge

Sludge disposal requirements

- Disposal requirements for contaminated sludge

  – **Secured landfill** with multiple layers of liners, leachate collection & treatment, capping on filling; costly, land requirement, non renewable.

  – **Incineration** feasible, but costly, need for disposal of ash, logistics arrangements.

  – **Co-processing** of contaminated sludge making construction materials (cement kilns).

Sludge incinerator

Sludge Storage

Sludge Storage

- Textile sludge usually contains high moisture content making it difficult to handle and transport.
- Industries are required to keep the sludge for a sufficiently long time before it can be sent for landfill.
- The present stipulation is to keep it for a **minimum period of six months** to ensure maximum drying and stabilisation before disposal.

Aged (>3 months) sludge

Manual for Sludge Management in Bangladesh Textile Sector. 2016

Sludge Storage

Recommendations

- Storage Duration from **3 to 6 months**
- Store in **sealed and labelled** basin/container/pit under the shade
- Ensure **no contact** to water/rain/flooding/agricultural land
- Masonry construction with **HDPE/LDPE lining** at the bottom
- Provision for the **safety of designated staff**
- Prevent **un-authorised access** to people and animal
- Store in areas with good **access to workers** for safe store
- Pack dried sludge in a **labelled storage container**

Sludge Sampling

Sludge Sampling

Basic considerations for a Sampling Plan

- **Consistency:** all the samples are taken in the same way from the same location for every sampling event
- **Communication:** ensure the laboratory understands the proper methods to run, types of the sample, and key details regarding the facility
- **Proper sampling activity documentation:** includes proper sample labelling, sampling method, and deviation from protocol, if any, and a log book of sampling activities
- **Data handling:** involves proper reviewing of the collected information before the data gets submitted.

Sludge Sampling

Important Elements of a Sampling Plan

- Sampling points
- Volumes to be drawn
- Days and times of collection
- Required equipment
- Instructions for labelling samples
- Chain of custody
- A list of contacts in case of unexpected difficulties, etc.

Sludge Sampling

Selection of Sampling Point Based on Purpose

- For direct disposal of raw or wet sludge, sampling should be done before any pre-treatment
- To evaluate a disposal option for pre-treated sludge, sampling should be performed from the pre-treated sludge
- Sampling of sludge before and after pre-treatment is required to track changes in sludge quality

Sludge Sampling

Selection of Sampling Point Based on Type of Process

- For continuous processes, multiple grab samples should be collected from a single location within the process over time
- Sampling sludge from the batch process requires collecting a number of grab samples from different areas throughout the sludge volume
- A composite sample should be generated from the predetermined number of grab samples at random points for both batch and continuous sampling

Sludge Sampling

Examples of Sludge Sampling

Stainless Steel Scoop

Shovel

EcoMetrix, Textile Sludge Study in Bangladesh. 2011

Sludge Sampling

Examples of Sludge Sampling

Coring Device

Stainless Steel Bucket

EcoMetrix, Textile Sludge Study in Bangladesh. 2011

Sludge Sampling

Examples of Sludge Sampling

Latex Gloves

Personal Protective Equipment

EcoMetrix, Textile Sludge Study in Bangladesh. 2011

Sludge Sampling

Twelve Important Steps for Practical Sampling

1. Ensure sludge is in appropriate format(dewatered) several days before sampling

2. Check that the laboratory performing the analysis is ready for sampling

3. Assemble and check the sampling equipment a day before sampling

4. Arrange sufficient ice for use in sample coolers to facilitate sample transportation in cold condition

5. Review Operational procedure for sludge handling before conducting sampling

Sludge Sampling

Twelve Important Steps for Practical Sampling (cont'd)

6. Always use the appropriate PPE

7. At least 8 grab samples, roughly equal in volume (~ 250 mL) need to be collected sequentially using a 500 mL glass beaker and a stainless steel trowel

8. For sludge dispenser, after the first grab sample, another grab sample should be collected every 30 minutes and placed in the stainless steel bucket until all 8 grab samples have been collected.

9. For sludge storage, after the first grab sample, 7 other grab samples should be collected from random locations of the storage and placed in a stainless steel bucket

Sludge Sampling

Twelve Important Steps for Practical Sampling (cont'd)

10. Upon collection of the last grab sample, all material accumulated in the stainless steel bucket should be mixed thoroughly with a stainless steel trowel to produce a homogeneous sample.

11. After mixing, all sample containers should be labelled with relevant information

12. Each sample container should be filled with portions of the homogenized material in the stainless steel bucket

Sludge Preservation

Sludge Preservation

Sludge samples are generally preserved by cooling and maintaining samples at 4°C, if possible but not for too long before analysis

Parameters to be tested	Maximum storage time before analysis
Most metals And Heavy metals: Al, As, Cd, Cr, Cu, Pb, Ni, Zn	6 Months
Hg, Nitrogen compounds, Phosphorus, Chloride, Sulfur compound, Organic Carbon	28 Days
Volatile organic compounds	14 Days
Total solids and volatile solids	7 Days
Biological parameters such as Salmonella and Helminth Ova, coliform, pathogen	24 Hours

NEIWPCC, *The Wastewater Treatment Plant Operators Guide to Biosolids Sampling Plans*. 2006

Sludge Transportation

Sludge Transportation

- Samples are generally hand delivered once the proper sampling and documentations are done.
- Samples can also be sent through postal service or courier provided that the parameters to be measured are not very time sensitive.
- Transportation by truck is the most convenient method for larger samples, however, this process may cause leakage and emission problems.
- Exposure to extreme temperatures may compromise collected samples, and testing results may not accurately reflect the true field conditions.

Sludge Transportation

Recommendations for Sludge Transportations

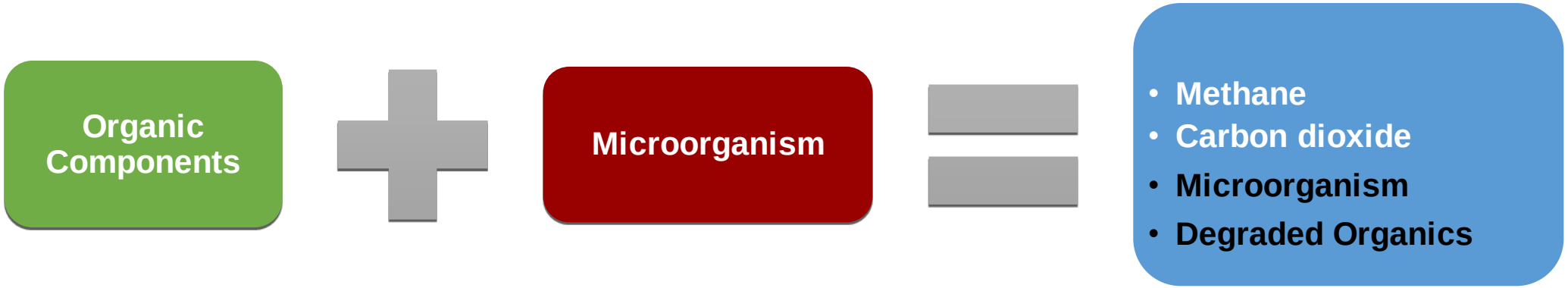
- Create a double liner by putting two large plastic trash bags into a cooler or large insulated container. Immediately before packing the cooler, put two plastic bags filled with ice inside another bag to prevent leakage.
- Pack each individual sample container into the plastic bag and seal properly before putting into the cooler
- Close the cooler lid properly and ensure that the horizontal joints are sealed with duct or packing tape before transportation
- Label the container properly with the sufficient details of the sampling procedure, name of the relevant personnel, etc.

Brainstorming

Suppose a new ETP produces 10 tons of sludge per day. There is no laboratory nearby to perform the analysis of the sludge. Based on sludge analysis data of similar sludge from nearby ETP, the operator estimates that the sludge produced will contain almost no biological materials, however, the total volatile solids will be quite high based on the type of chemicals used and sludge also has a foul smell. How will you proceed with the sludge preservation and transportation?

Anaerobic Digestion (Biogas)

Anaerobic Digestion(Biogas)



Anaerobic Digestion(Biogas)

- Suitable for high moisture content and high TOC sludge
- Applicable for non-hazardous sludge only
- Benefits include stabilization of sludge and generation of biogas

Econewsnetwork.org. *Anaerobic Digestion Solves Food Waste and Energy Challenges*. 2016

Aerobic Digestion (Composting)

Aerobic Digestion(Composting)

- Composting aims at biologically stabilizing sludges while controlling pollution risks and exploiting the nutrient or organic value of sludges.
- Benefits include lowering sludge moisture content and killing harmful pathogens.
- Composting cannot reduce heavy metal content and is thus applicable for non contaminated sludge only.

© Omaha World Herald, 2018

Thermal Incineration and Co-incineration

Thermal Incineration and Co-incineration

- The purpose of incineration is to destroy the organic material from any type of sludge.
- Conventional incineration process generally consumes more energy than it produces.
- Not a good disposal option for sludge with high moisture content and low calorific value.
- Drying sludge and mixing it with other waste is a viable option for generating energy.
- High incineration temperature prevents generation of toxic chemicals such as dioxin and furan.

© www.waterleau.com

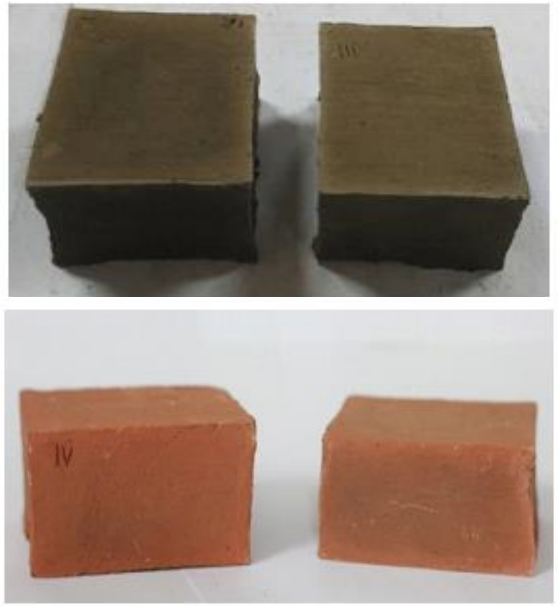
Thermal Incineration and Co-incineration

- Co-incineration of textile sludge in the cement industry is popular over the world where wastes are destroyed at a higher temperature and longer residence time.
- It makes the incineration more cost cost-effective and reduce the chances of forming toxic gases.
- Geocycle, in collaboration with LafargeHolcim Bangladesh limited, has initiated sludge co-incineration in Bangladesh in 2012.
- Basic sludge requirements for co-incineration are the same as thermal incineration.

Recycling in Brick Manufacturing

Recycling in Brick Manufacturing

- The use of sludge in the construction industry is environment friendly and reduces the usage of topsoil.
- Sludge with decent heating value also reduces the energy consumption compared to the regular brick making process.
- Lower moisture content and lower organic content are required for this application.
- Due to presence of heavy metals in textile sludge, leachate study is necessary for optimum mixing.



Utilization of textile sludge and public health risk assessment in Bangladesh. Sustainable Environmental Research, 2016

Direct Land Application and Controlled Landfill

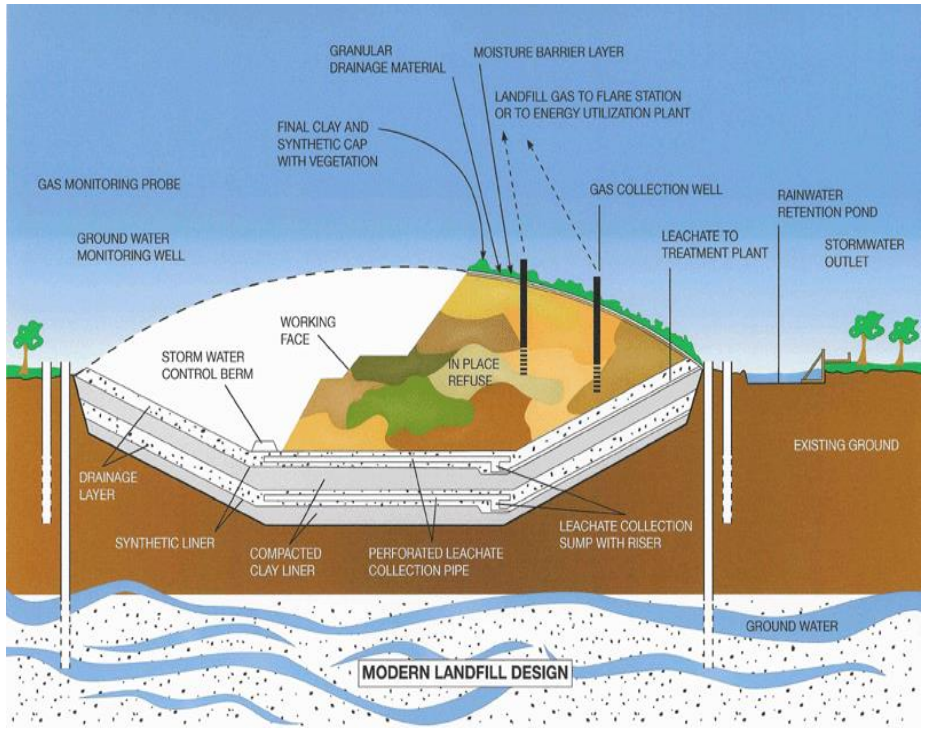
Direct land application and Controlled Landfill

- Land application (uncontrolled land filling) refers to a wide variety of uses such as filling material for flood prevention, material/ substrate for re-cultivation of mining sites, or covering landfill sites.
- This is mostly suitable for non contaminated sludge.
- Any specific land application of sludge requires prior permission from the Department of Environment (DOE).

© Nogales International. *No flags raised by landfill sludge study.*, 2015

Direct land application and Controlled Landfill

- Controlled landfill is suitable for all categories of sludge.
- Although isolated from the surroundings, some degree of subsurface pollution might occur.
- To establish a controlled landfill site, it is necessary to obtain prior approval from the DoE.
- As it is expensive and has strict requirements it has to be the last option for sludge management.



© Leatherpanel.org. *Safe Landfill for Disposal of Sludge from Tannery Effluent Treatment Plants.* 2018

Direct land application and Controlled Landfill

Controlled landfill location requirements

- The over flooding level should be > 2.0 m of the maximum expected water level of the surrounding water bodies
- > 500 m distance to populated areas
- No construction in protected areas
- No construction in flood plains and areas with a high risk of natural disasters
- The underground has to resist mechanical stresses, has to hold back or prevent leachate and pollutants
- Water impermeability
- Buoyancy safety has to be considered

Direct land application and Controlled Landfill

Major points to be considered during the design and construction of a landfill site

- There should be a proper leachate barrier system including suitable lining, ground barrier, and leachate draining system
- There should be suitable leachate storage and disposal system near the landfill site
- There should be an adequate monitoring system to assess leachate water quality and gas emission levels
- Ground water and surface water near the landfilled facility should be tested on a regular basis to detect any failure of the landfill leak protection facilities

Direct land application and Controlled Landfill

Major points to be considered during the design and construction of a landfill site

- Emission of nuisance dust and other particulate matter beyond the landfill boundaries must be minimized
- The landfill must not adversely affect amenity in the locality, in terms of offensive odour, noise, etc.
- Landfilled waste must be covered to minimise odour, dust, litter, the presence of scavengers, the risk of fire, rainwater infiltration, and the emission of landfill gas
- It can take many years after closure for the waste to become physically, chemically, and biologically stable, therefore, development on or near closed landfills should be avoided.

Sludge Management Plan

Sludge Management Plan

Currently, the producer of the sludge is required to submit a sludge management plan to the DoE as part of the

- environmental clearance information required for ETP
- in case of any modification from the existing condition

The sludge management plan should help to select the appropriate disposal options depending on the pollutant concentrations found from the results of the analysis.

Local service providers shall be able to assist in the preparation of a Sludge Management Plan and officials from DoE shall be able to assess the plan.

Contents of the Sludge Management Plan

1. General information on the sludge producer

- Company name, address and contact person of the factory producing the wastewater/sludge; and
- Name, address and contact person of the (Central) Effluent Treatment Plant where the sludge is generated

2. Estimated annual sludge amounts

- Estimated amount of sludge to be expected per year in tonnes dry matter (t DM/yr)
- Proven amount of sludge produced in previous year in tonnes dry matter (t DM/yr)

Contents of the Sludge Management Plan

3. Classification of the sludge

- General sludge category
- Origin of the wastewater

4. Interim storage of the sludge

- Storage duration of sludge (in months)
- Capacity of sludge storage tank (in tons)
- Tank sizes (area in m^2, height/depth in m)

Contents of the Sludge Management Plan

5. Analysis of the sludge

- Detailed sampling method
- Main sludge properties including moisture content, texture (solid, slurry, pasty, etc.) and a lab analysis of at least the primary parameters.
- Secondary parameters shall be included as much as possible; additional parameters to be tested depending on disposal option

Priority	Parameters
Primary Parameters	Total Organic Carbon (TOC) Moisture Content Calorific Value Heavy metals: Cr, Cd, As, Pb, Cu, Ni, Hg, Zn Sulphur Content
Secondary Parameters	Organohalogen Polychlorinated biphenyl (PCB) Polychlorinated dibenzodioxin (PCDD) Polychlorinated dibenzofuran (PCDF)

- *If an external laboratory is chosen*: Company, address and contact person of the laboratory accredited by the appropriate authority commissioned to conduct any analysis
- *If an internal laboratory is chosen*: Evidence of sufficient, qualified and appropriate independent laboratory facilities