Cleaner Production Training for EPD Punjab

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

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

2. Linking Resource Wastages with Pollution Loading and Environmental Impacts

11:15 – 12:00

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on behalf of GIZ FABRICS and Espire Consult

Overview

- Water consumption and Wastewater (+Calculation on Pollution Loading)
- Energy Consumption and Air Emissions (+Calculation on GHG emissions from Boiler)
- Solid Waste and Sludge

Water consumption and Wastewater

THE ENVIRONMENTAL IMPACT
OF TEXTILES

79
billion
cubic metres
of water

was used by the textile and clothing industry in 2015

2,700
litres of water

is needed to produce **one t-shirt**

=

enough **drinking water** for one person **for 2.5 years**

Sources: EPRS (2019, 2020)

europarl.eu

Textile waste water - benchmarks

Product		Benchmark
Yarn finishing (wool)	l/kg	35 - 45
Yarn finishing (cotton)	l/kg	100 – 120
Yarn finishing(synthetic fibres)	l/kg	65 – 68
Finished Knitware (Wool)	l/kg	60 - 70
Finished Knitware (Cotton)	l/kg	60 – 135
Finished Knitware (synth. fibres)	l/kg	35 - 80
Finished woven (Wool)	l/kg	70 – 140
Finished woven (Cotton)	l/kg	50 - 70
Finished woven plus printing (Cotton)	l/kg	150 + 80
Finished woven (synth. fibres)	l/kg	100 – 180

Source: IFC EHS Guidelines

Chemicals in waste water

Process	Typical pollutants
Desizing	Sizes, enzymes, starch, wax, ammonia
Bleaching	hydrogen peroxide, AOX, sodium silicate, organic stabilizers, high pH
Mercerising	High pH, sodium hydroxide
Dyeing	Dyes, metals, salts, auxiliaries, formaldehydes
Printing	Solvents, dyes, pigments, metals
Wet finishing	resins, waxes, chlorinated compounds, solvents, plasticizers, softeners

Parameter	Quanity in mg/l
BOD5	120 - 400
COD	300 - 1100
TDS	200 - 5000
TSS	50 - 120
pH	8 - 11

Water

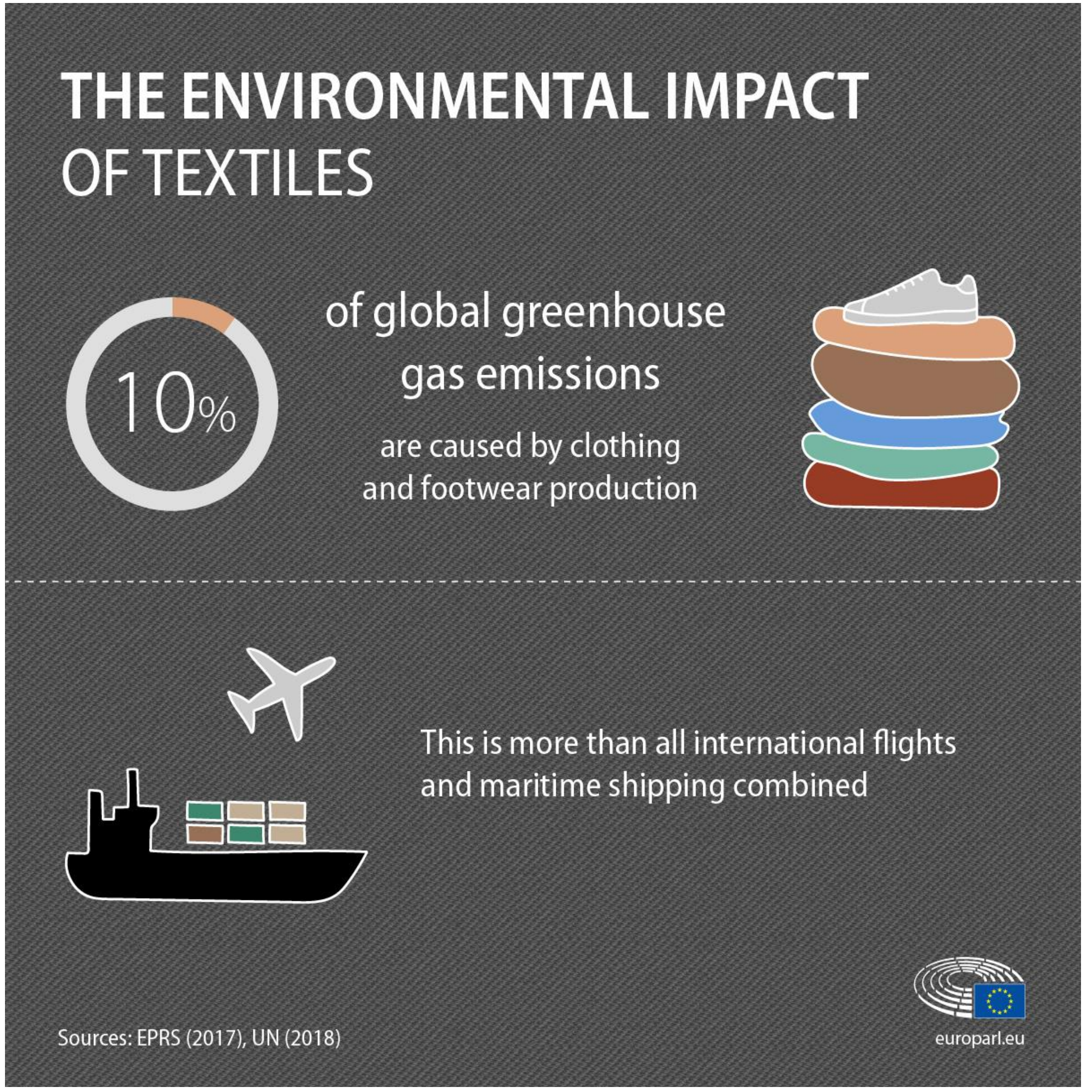
Textile mills generate **one-fifth of the world's industrial water pollution**

The total load is calculated as **the sum of the daily loads that are obtained by multiplying the measured or estimated daily concentration by the total daily discharge**. The goal of chemical sampling under this approach is to accurately characterize the relationship between flow and concentration.

Practical Load Estimation

The most accurate approach to estimating pollutant load would be to sample very frequently and capture all the variability. Flow is relatively straightforward to measure continuously, but concentration is expensive to measure and, in most cases, impossible to measure continuously. It is therefore important to choose a sampling interval that will yield a suitable characterization of concentration.

There are three important considerations involved in sampling for good load estimation: sample type, sampling frequency, and sample distribution in time.



THE ENVIRONMENTAL IMPACT
OF TEXTILES

10% of global greenhouse gas emissions are caused by clothing and footwear production

This is more than all international flights and maritime shipping combined

Sources: EPRS (2017), UN (2018)

Air Emissions from Textile Processes

Process	Source	Pollutants
Energy production	Emissions from boiler	Nitrogen oxides (NOx), sulphur dioxides (SO_2) (SOx)
Drying and curing	Emission from high temperature ovens	Volatile organic compounds (VOCs)
Cotton handling activities	Emissions from preparation, carding, combing and fabrics manufacturing	Particulates
Sizing	Emission from using sizing compound (gums, PVA)	Nitrogen oxides, sulphur oxide, carbon monoxide
Bleaching	Emission from using chlorine compounds	Chlorine, chlorine dioxide
Dyeing	Disperse dyeing, carriers sulphur dyeing	Carriers
		H_2S
Printing	Screen printing, rotary printing	Hydrocarbons, ammonia
Finishing	Resin finishing, heat setting of synthetic fabrics	Formaldehyde
		Carriers - low molecular weight
		Polymers - lubricating oils
Chemical storage	Emissions from storage tanks for commodity and chemicals	VOCs
Wastewater treatment	Emissions from treatment tanks and vessels	VOCs, toxic emissions

Typical source of air emissions in textile and leather sector

Type of pollutants	Sources in textiles industry
Dust	Fiber (especially cotton) handling and storage
Air pollutants	Regenerated fibers (viscose) and synthetic polymers (nylon and acrylic fibers) production processes (of chemicals (e.g. release of carbon disulfide, hydrogen sulfide, hexamethylene diamine, and nitric acid).
Volatile organic Compounds (VOC) and oil mists	Organic solvents in activities such as printing processes, fabric cleaning, wool scouring and heat treatments Exhaust air from stenter frames and printing processes
Exhaust gases	Combustion sources for power generation (generator sets) and process heating (fired boilers), transport vehicles
Odors	Dyeing and other finishing processes (e.g. oils, solvent vapors, formaldehyde, sulfur compounds and ammonia

Options to Reduce Air Pollution

- Decreasing emissions of organic solvents by changing to water-based products.
- Using scrubbers to collect particulate matter.
- Optimizing boiler operations to reduce the emissions of nitrous and Sulphur oxides.
- Pre-screening chemicals using the material safety data sheets to ensure that chemicals are not toxic.
- Identifying sources of air pollution and quantifying emissions.
- Designing and manufacturing products that do not produce toxic or hazardous air pollutants.
- Avoiding fugitive air emissions from chemical spills through improved work.

Good Housekeeping

- Equipment maintenance and operations audit
- Clean and maintain thermal treatment equipment (such as stenters) at regular intervals (at least once a year). Remove residue from the waste air channels and deposits from the burner air intake pipes.
- Minimisation/ optimisation of the chemical input
- Employ chemicals and auxiliary materials with good biodegradability/bio eliminability, low human and eco toxicity, low volatility and odour intensity
- Use vapour recovery systems (vapour return) when filling volatile compounds.

Yarn – Singeing as pre-treament before weaving

Singeing: the burning-off of loose fibers not firmly bound into the yarn and/or fabric structure.

Air emissions from Singeing

The quality and quantity of air emissions in singeing depend strongly on:

- kind of substrate to be treated,
- position of burners (angle and distance to the textile; one-sided or double-sided singeing),
- kind of emission abatement installed.

Main air emissions are:

- dust from the fibres burned-off,
- organic-C from volatile substances on the substrate and/or crack-products and methane from incomplete combustion of burner gases,
- formaldehyde from burner gases.

Control Air Emissions – Local Exhaust Ventilation (LEV)

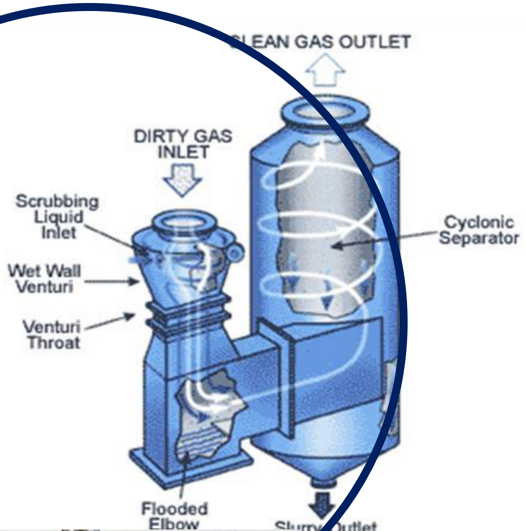
- Connect local exhaust ventilation (LEV) at the source of the emission. There should be a sufficient airflow to capture the dust or vapor before it disperses in the workplace. For dust, airflows greater than 1 m/s will generally be needed and for vapours, airflows greater than 0.5 m/s. The airflow should be measured at the origin of the dust or vapor with an anemometer. Provide an easy way of checking that the LEV is working such as a ribbon strip attached to the output side.

- Contain the source of dust or vapor as much as possible to stop it from spreading. Keep the hood as close as possible to the source of exposure

Control Air Emissions – Local Exhaust Ventilation (LEV)

- Don’t allow the workers to get in between the source of exposure and the LEV; otherwise they will be in the path of the contaminated air.
- Where possible, locate the work away from doors and windows to stop draughts from interfering with the LEV and spreading dust or vapours.
- Keep extraction ducts short and simple and avoid long sections of flexible duct.
- Discharge extracted air in a safe place away from doors, windows and air inlets. Be careful that extracted air does not affect your neighbours.

CONTROL AIR EMISSIONS



Source: GIZ CHS

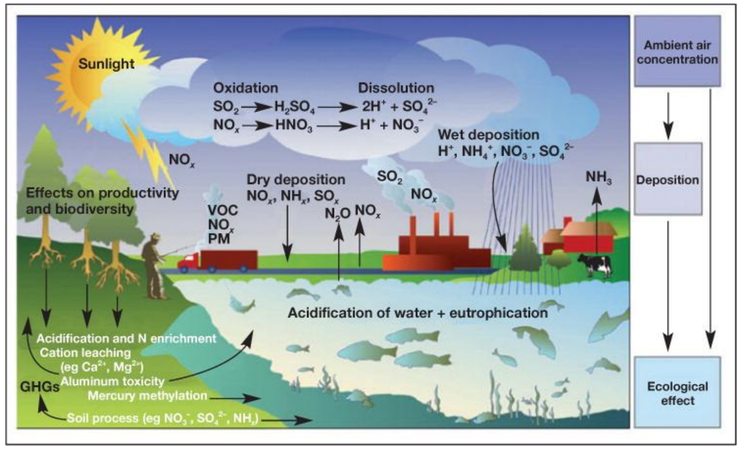
The trapped contaminants are conveyed by ducts to a collector (cyclone, filter house, scrubbers or electrostatic precipitators) where they are removed before the air is discharged into the outside environment.

This is accomplished by a special exhaust System or by increasing the general ventilation.

For consideration:

Substitution of hazardous chemicals and process changes (see BATs) significantly reduce the need of such end-of-pipe treatment facilities.

Air emission abatement techniques



Description

The following off-gas abatement techniques can be used in textile finishing:

- oxidation techniques (thermal incineration, catalytic incineration)
- condensation techniques (e.g. heat exchangers)
- absorption techniques (e.g. wet scrubbers)
- particulates separation techniques (e.g. electrostatic precipitators, cyclones, fabric filters)
- adsorption techniques (e.g. activated carbon adsorption).

Quiz!

What is the required airflow to capture the dust or vapor with a Local Exhaust Ventilation before it disperses in the workplace?

- 3 m/sec
- 1 m/sec
- 0,1 m/sec

Stack gas emissions from power generation and boilers

Stack gas emissions from boilers

The main sources of air pollution from textile production are boilers, and diesel generators which generate gaseous pollutants as suspended particular matter (SPM), sulphur di-oxid gas and oxide of nitrogen gas.

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

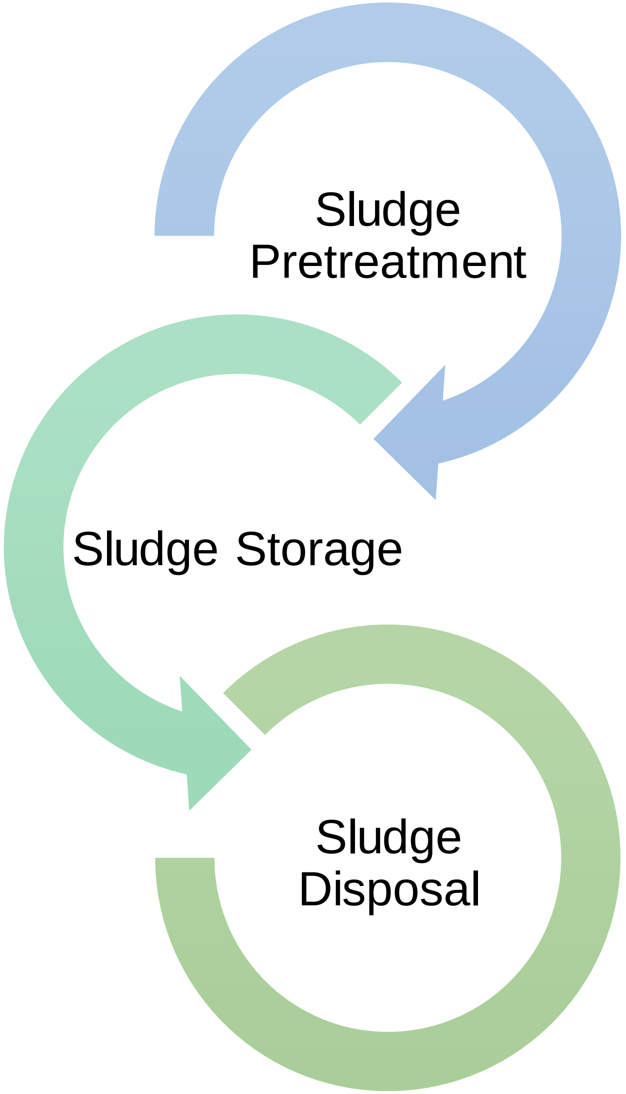
Sludge Characterization

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

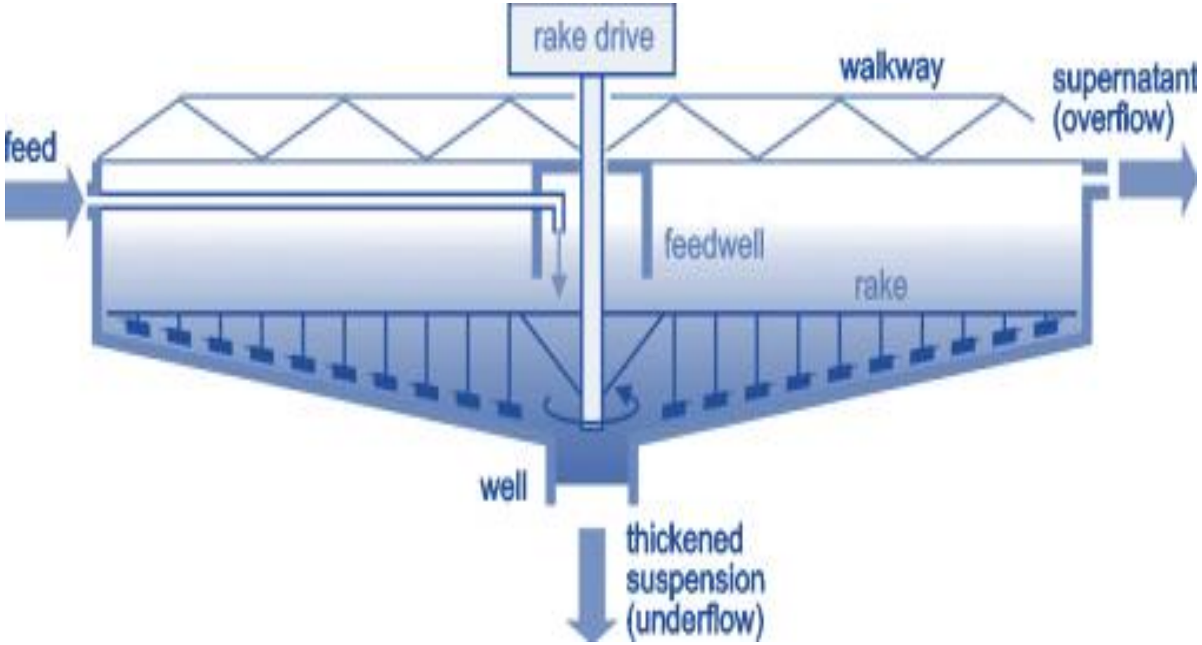
Process		Solid Recovery rate
Sludge thickening	Gravity thickening	80-90%
	Centrifugal thickening	85-95%
	Air floatation thickening	> 95%
	Gravity belt thickening	> 95%
Sludge digestion		30-40%
Sludge dewatering	Pressure-type screw press dewatering	> 95%
	Rotary pressure dewatering	> 95%
	Belt press dewatering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

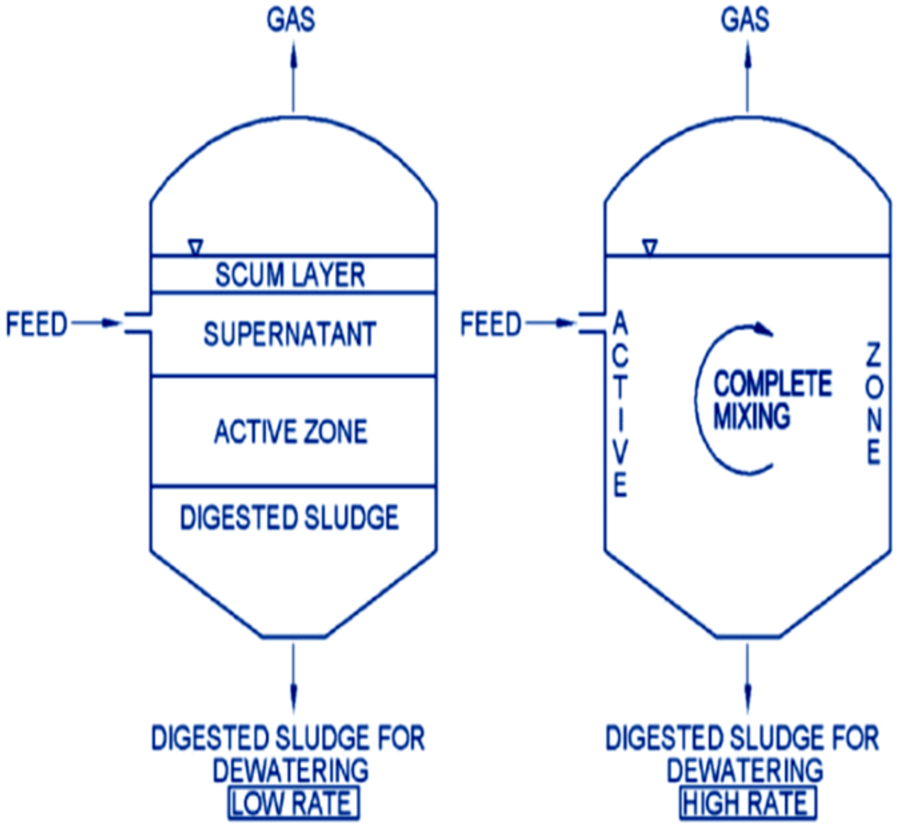
Comparative Evaluation of Different Sludge Thickening Processes

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 is problem of malodour, they are not easy to clean and made ready for the next batch etc.

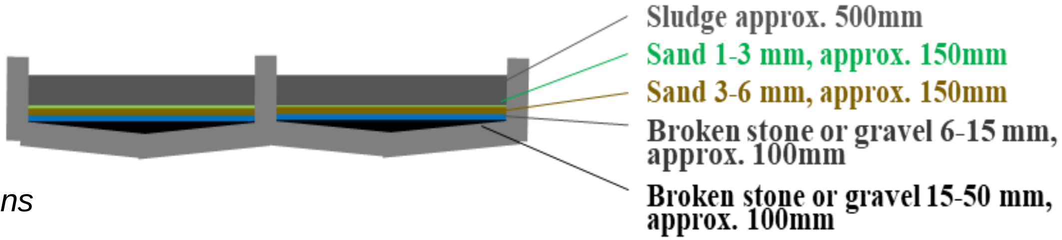


Image courtesy: GIZ presentations

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.

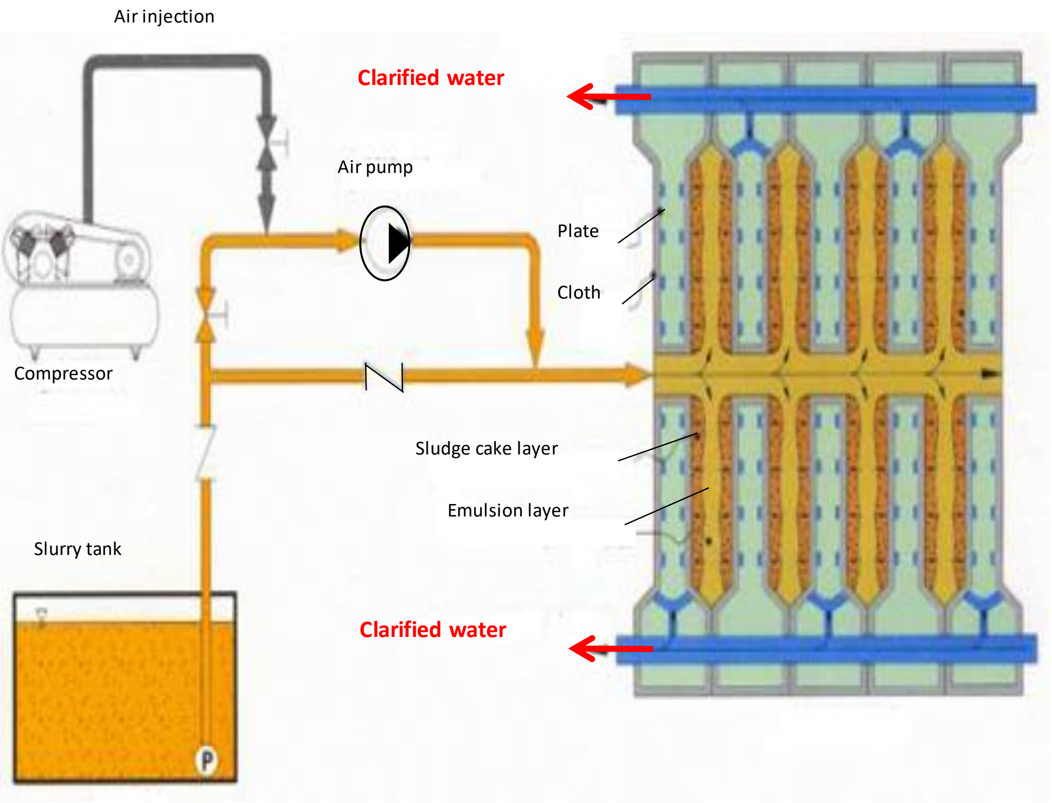


Image courtesy: UNIDO

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 dewatering and drying

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

Chamber filter press

Sludge centrifuge

Sludge dewatering and drying

- For consideration
- Disposal logistics and costs
  - Often dewatered sludge hazardous and requiring disposal in secured landfill sites
  - Not many plants adopting cost-effective sludge digestion to reduce sludge bolume
  - 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.

Sludge incinerator

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

Example – Sludge management disposal

1 – 5 kg sludge per m3 (1000 ltr) treated wastewater

Challenges

- Effluent treatment sludge dewatering (climatic, technical)?
- Effluent treatment sludge disposal (guidelines, infrastructure)?

Widespread implementation of sustainable chemistry and best practices in the textile industry to protect consumers, workers and the natural environment

Goals

1. Eliminate or substitute priority hazardous chemicals in products and their manufacture
2. Implement a transparent screening process to promote safer chemistry
3. Implement common tools, best practices and training that advance chemical stewardship
4. Partner with stakeholders to promote transparency of chemical use and discharge
5. Promote scaling of best practices through engagement with key stakeholders

Four Key Focus Areas

- MRSL and Conformity Guidance
- Research
- Audit Protocol
- Wastewater Quality

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