TRAINING PROGRAMME FOR ETP OPERATORS IN TEXTILE INDUSTRY

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

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Introduction to sludge management

GIZ FABRIC – ETP Operator Course

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Contents

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Basic concept of sludge

Basic concept of sludge

- **ETP sludge**
  - –solid, semisolid or slurry residual material
  - –**by-product** of wastewater treatment processes
- **Types of sludge**
  - –Differentiation **by treatment stage**
  - –**Primary** sludge
  - –**Secondary** sludge
  - –**Tertiary** sludge

Basic concept of sludge

- **Primary sludge**
  - With or without chemicals
  - Generated from chemical induced
    - Coagulation
    - Flocculation
    - Sedimentation
- **Secondary sludge**
  - Excess activated waste biomass after biological treatments
  - Generated from:
    - Inorganic portion of suspended solids
    - Residuals of COD removed in biological treatment

Basic concept of sludge

- **Tertiary sludge**
  - Result of tertiary chemical precipitation from treatment processes
    - softening
    - colour removal
- In most of ETPs sludges **combined** for further treatment and disposal
- **Secondary sludge** separated from others for its use if not deemed hazardous
  - Considered hazardous because of heavy metal presence

Basic concept of sludge – Hazardous elements

Heavy metals	Possible sources
Antimony (Sb)	▪ Cotton ▪ Caustic soda: – Made by ‘mercury cell process’ in synthetic fibres – Used in polyester synthesis as residues ▪ Antimony trioxide: Used as catalyst for application of certain flame retardants
Arsenic (As)	▪ Not contained in high-quality dyes and auxiliaries
Barium (Ba)	▪ Synthetic fibres
Cadmium (Cd)	▪ Pigments and dyes ▪ Particularly red, orange, yellow and green ▪ Not contained in high-quality dyes and auxiliaries
Chromium (Cr)	▪ Dyes and pigments ▪ In metal-complex dyes: Blue, navy, turquoise, green and grey shades ▪ Not released if correctly bound to textile ▪ Used as oxidants in sulphur and vat dyeing processes ▪ Chrome present in chrome mordant dyeing (after chrome dyes)

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Basic concept of sludge – Hazardous elements

Heavy metals	Possible sources
Lead (Pb)	▪ Dyes and pigments though not contained in high-quality dyes and auxiliaries
Mercury (Mg)	▪ Low risk of containing mercury. Not contained in high-quality dyes and auxiliaries.
Cobalt (Co)	▪ Found in metal-complex dyes; blue, navy, turquoise, green and grey shades; not released if correctly bound to textile
Copper (Cu)	▪ Dyes and pigments. Found in metal-complex dyes – blue, navy, turquoise, green and grey shades; not released if correctly bound to textile. ▪ Some copper compounds improve the light-fastness of polyamide-based carpets
Zinc (Zn)	▪ Preservatives, finishing chemicals
Nickel (Ni)	▪ Blue, navy, turquoise, green and grey metal-complex dyes ▪ Turquoise and brilliant green shades in reactive dyes for cellulose

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Characteristics of different sludge types

Primary sludge

(1) Sludge or solids from **preliminary treatment**

– Screenings

– Grit separated from grit removers

(2) Residual **sediments** from tanks:

– Sludge removed during emptying and cleaning of tanks, manholes, pits

(3) Sludge from **physical treatment**

– Generated from pre-settling units where raw effluent held for medium duration (10-20 min)

(4) Pre-settling not common in textile effluents

– except where high suspended solids present

Primary sludge

- **90%** of primary sludge generated in **chemical treatment**
  - **Suspended solids** in effluent treated in primary treatment
  - **Precipitated mass** from chemicals
- Separated from primary treatment operations in ETP

  Example: Lime + Alum → Aluminium hydroxide + Calcium sulphate
- Portion of soluble material metals:
  - Converted into their insoluble forms (hydroxides)
  - Precipitate in the primary treatment → Primary sludge

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Primary sludge

Characteristics

- Sludge from **preliminary treatment** mostly **dry**
  - After draining 30-40% moisture content
- **Sediments** cleaned from tanks (e.g. equalisation tank during emptying) **thick**
  - Mechanically scooped if not pumped
- **Pre-settler sludge** medium thick with **2 - 3%** concentrations
- **Chemical sludge** from primary sedimentation tank about **3-4%**

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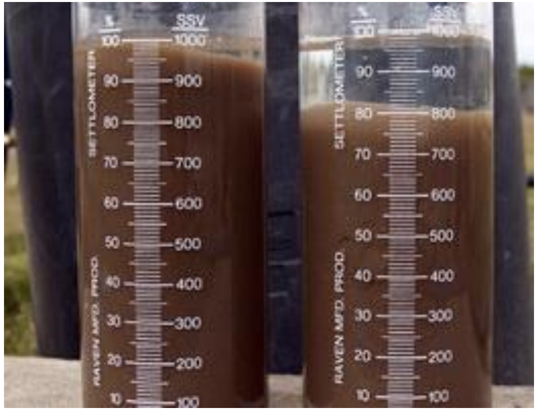
Biological sludge

- From **biological treatment**
  - micro-organisms degrading organic materials in effluent
- Creation of **bio-solids intermittent** process stage
  - micro-organisms accumulate on biosolids (MLSS)
  - MLSS providing ‘housing’ and food for bacteria
- **MLSS** degraded continuously by micro-organisms, resulting in more ‘**mineralized’ sludge**.
  - Once mineralized microbial activity reducing
- For maintaining microbial MLSS to be refreshed by wasted MLSS

Biological sludge

- **Excess bio-sludge** = **secondary sludge**
  - mineralised organics and non-degraded suspended solids
- Part of MLSS flowing out with effluent as suspended solids in treated effluent
- Partial withdrawal as ‘wasted activated sludge usually necessary



Biological sludge

Characteristics

Wasted sludge generally from activated sludge recirculation line

- **Concentrations**
  - MLSS in aeration tank: 3000-5000 mg/l or 0.3-0.5%
  - Returned sludge from settling tank 6000-10000 mg/l 0.6%-1%
- Solids concentration after withdrawing wasted sludge about 1%
  - Watery compared to primary sludge
  - Mostly dark-brown further degrading
  - Waste MLSS anaerobically putrefying and generating gas
    - sludge rising after 1-2 days

Sludge treatment and handling

Sludge treatment and handling

- Sludge generated like **watery slurry**
  - Make fit for handling before discharge or disposal
- **Reduce** sludge **moisture content** by
  - Sludge **thickening**
  - Sludge **dewatering** to turn into **dry cake**

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Sludge treatment and handling

(1) Sludge thickening

- **Gravity thickening**
  - Most common
  - Simple operation
  - Low operating cost
- **Mechanical thickening**
  - ‘Preliminary’ mechanical dewatering

Gravity thickener

Proprietary mechanical thickener

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Sludge treatment and handling

(2) Sludge dewatering and drying

- Dewatered sludge still containing > 60% moisture
- Need for further drying:
  - Thermal drying to less < 10% moisture
  - Natural drying
    - Exposing sludge to air drying to < 20% moisture
    - Lengthy process (depending on season!)
    - Maturation process

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Sludge treatment and handling

(2) Sludge dewatering and drying

- Natural drying in sludge **drying beds**
  - Simple process by draining water and drying in sun
  - High land requirement
  - Inefficient during rainy periods

Sludge treatment and handling

(29 Sludge dewatering and drying

- **Mechanical** sludge **dewatering systems**
  - Sludge filter press
  - Sludge centrifuge
  - Belt filter press
  - Screw compressors

Sludge filter press

Sludge disposal

Dewatered/matured sludge to be disposed safely

- Most textile ETP sludge to **secure landfilling**
  - Land availability and costs challenging
- Other options:
  - **Composting**
  - **Bricketing**
  - **Direct incineration**
    - High costs
    - Need for disposing ashes

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Sludge disposal

Handling and disposal option depending of **classification of sludge**

- **Textile** effluent and **sludge** containing hazardous substances
  - sludge considered **hazardous** by most environmental protection agencies
  - sludge **utilisation within safe limit**
    - specified for different heavy metals
    - presence of carcinogens

Sludge disposal

Classification in many developing countries:

- Any sludge from industrial ETP effluent considered hazardous, even not containing any toxic or hazardous materials (!)
- Reason:
  - To avoid need of checking or permitting

BUT

- In reality, textile effluent of different quality (e.g. dyeing or washing)

Sludge disposal

Secondary (biological) sludge (in some countries)

- allowed to be processed in composting or converted to construction material
- Subject to **tolerance limits**:
  - Specified for hazardous substances
  - Disposal options depending on concentrations

In Bangladesh:

- **Textile ETP sludge** deemed **hazardous** as per DoE because of heavy metals

Determining sludge quantities

Determining sludge quantities

Sludge quantity depending on

- **Technology** used
- **Type of effluent**
- **Size** of ETP
- Operational parameters
  - –**dosages** maintained
  - –**sludge age** kept

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Determining sludge quantities

Estimated **sludge generation from screenings and grit:**

- ETP with capacity of 1 MLD (1000 m3 per day)
- 15 - 20 kg per day (50% solids content)

Challenges

- **Seasonal sediments** from tank desludging not regular sludge
- **Primary sludge** generation depending on **suspended solids** and **chemical dosages**
- **Combined sludge** based on **chemical dosages, suspended solids and COD removed**
- **Biological sludge** based on **COD removed** in aeration and suspended solids in inlet/outlet.

Determining sludge quantities

Sludge from primary treatment (Example 1)

- Primary ETP with capacity 1 MLD
- 400 mg/l TSS
- Dosages maintained as
  - 200 mg/l ferrous sulphate
  - 100 mg/l of lime
  - 1 mg/l of PE

Source & assumptions	Quantity (kg/day)	Measure
From TSS (≈80% TSS removal)	320	Dry wt.
From chemicals used (assuming best quality chemicals)	120	Dry.wt
From precipitated material (incl. metals)	20	Dry.wt
Total	**460**	Dry.wt

Primary liquid sludge: 15.3 m^3/d, ≈3% solids content

Dewatered sludge: 1.15 tons per day, ≈40% solids

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Determining sludge quantities

Sludge from combined (Example 2)

- Primary ETP with capacity 1 MLD
- 400 mg/l TSS
- Dosages maintained as
  - 200 mg/l ferrous sulphate
  - 100 mg/l of lime
  - 1 mg/l of PE
- COD
  - Inlet to aeration tank as 800 mg/l
  - Outlet at 200 mg/l

Source & assumptions	Quantity (kg/day)	Measure
From TSS (≈80% TSS removal) + precipitated metals	340	Dry wt.
From chemicals used (assuming best quality chemicals)	120	Dry.wt
Aeration tank excess sludge (SS removed * 0.3 + COD removed* 0.2)	132	Dry.wt
Total	**592**	Dry.wt

Primary liquid sludge: 19.7 m3/d, ≈3% solids content

Dewatered sludge:1.48 tons per day, ≈40% solids.

Determining sludge quantities

Sludge from biological ETP (Example 3)

- Primary ETP with capacity 1 MLD
- 400 mg/l inlet TSS
- Treated effluent 40 mg/l
- COD
  - Inlet to aeration tank as 800 mg/l
  - Outlet at 200 mg/l
- Colour removal agent dosage 50 mg/l

Source & assumptions	Quantity (kg/day)	Measure
Contribution of sludge from TSS removed (TSr *0.3)	108	Dry wt.
Contribution of sludge from endogenous respiration based on COD removed (CODr * 0.2)	120	Dry.wt
Contribution from colour removal agent ≈50%	25	Dry.wt
Total	**253**	Dry.wt

Liquid sludge : 25.3 m3/d, ≈1% solids content

Dewatered sludge: 0.63 tons per day, ≈40% solids

Actual quantity based on actual COD/TSS

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Sludge generation in Bangladesh

- Sludge quantity **expected** 0.5 - 3 kg per cubic meter of effluent treated, depending on the nature of treatment
  - Minimum sludge generation in Bangladesh from **4000 MLD** of textile **effluent** about **2000 tons per day**!
- Sludge quantity **reported** by industry **100 tons/day only!!!!**

Possible explanation:

- ETPs not taking out sludge as needed
- Underreporting of part of sludge generated only
- Clandestine sludge dumping

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Wasting of biological sludge

Situation

Many ETPs i.e. biological treatment ETPs not taking out sludge

Important

1. Microbial population in aeration tank to be taken out to **avoid**
   - **bio-sludge** becoming more **mineralised** and **losing activity**
   - **microbial** population **dying**
   - **treatment collapsing**

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Wasting of biological sludge

Important

2. **Accumulation of inorganic portion** of suspended solids entering aeration tank and contributing to mineral portion.

- Avoid build-up of mineralised sludge:
  - Septic and black
  - Heavier and tending to settle more => breaking diffuser sheets
  - ETP eventually collapsing

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Determining sludge quantities

Deciding on how to **minimize sludge quantity**

▶ **Cost reduction!**

Ways forward

(1) Reduce sludge volume through **organic content destruction**

(2) Reduce moisture in sludge as much as possible

– The drier the sludge the less quantity for disposal

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Determining sludge quantities

Sludge volume reduction

- Biological digestors
- Incinerators

Moisture reduction

- Natural and heat assisted drying operations possible.
  - Using steam as a drying agent
  - Solar assisted drying

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To remember

- Sludge management important operation in ETP not be ignored
- Suppressing sludge generation resulting in treatment collapse
- Sludge thickening pre-requisite for better dewatering
- Plan sludge dewatering method to optimize dryness also considering costs (e.g. chemical, energy, personnel)
- Minimize sludge management costs by further reducing sludge volume and moisture
- Proper sludge disposal responsibility of ETP manager and operator

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