# 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 effluent treatment

GIZ FABRIC – ETP Operator Course

# Contents

# Basic terminologies and concept

# Wastewater and effluent treatment – Basic terms

- Wastewater treatment = removal/reduction of contaminants/ undesired components in spent water from an operation to ensure its **safe release to environment or reuse.**
- **Domestic wastewater** (also called municipal wastewater or sewage) treated in sewage treatment plant (STP)
- Wastewater (effluent) from industrial operations treated **industrial wastewater treatment plan**t or **effluent treatment plant** (ETP)
- Effluent treated in
  - **individual ETPs** or
  - **common ETPs** (CETP), often for a cluster of industries.

# Some of the largest municipal wastewater treatment plants in the world

# Effluent treatment – Concepts

**Other types of ETP:**

- Grey water treatment plants
- Agricultural runoff treatment plants,
- Landfill leachate plants, etc.

# Effluent Treatment – Concepts

- In most part of world, **pre-treated effluent discharged into municipal sewer** for combined treatment in sewage treatment plants (STP)
- Some wastewater further treated and reclaimed as recovered water → ultimate of recovery = **zero liquid discharge** (ZLD).
- Main purpose of effluent treatment:
  - Treated wastewater to be safely disposed or reused.
  - Effluent from textile processing operations considered as highly polluting warranting high level of treatment

# Impact of untreated effluent

# Possible impacts of untreated effluent

**Water = Very valuable resource** AND **Wastewater = wasted water**

- Effluent from textile processing containing various types of contaminants such as organic, inorganic and toxic.
- Discharge of untreated effluent → adverse impacts on receiving environment
- Organic matters most common pollutant
  - major contaminant in most industrial effluents such as from distilleries, paper mills, textile factories, tanneries, breweries, fertilizer plants



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# Possible impacts of untreated effluent

- **Damage to aquatic life,** threatening availability of food for people and affecting livelyhood of farmers
- **Spoilt groundwater** becoming unfit for domestic usage from effluent discharged to land and percolating down
- **Adverse effects on fertility** and **yield** of crops and vegetation from effluent discharged on to land for irrigation
- **Contamination of fresh surface water** from discharge to water bodies, making unfit for further use

# Treating organic and inorganic contaminants

# Overview of effluent treatment – organic and inorganics

## Organic contaminants

- Organic contaminants more predominant, except electroplating effluent with high level of inorganic contaminants
- Common treatment methods:
  - Chemical precipitation
  - Biological degradation
  - Chemical oxidation.
  - Lower concentration of organics treated by adsorption too.



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# Overview of effluent treatment – organic and inorganics

## Organic contaminants

- Newer treatment technologies:
  - thermal treatment
  - membrane based separation
  - plasma advanced oxidation
- Very high organic effluents (e.g. spent wash from distilleries) treated for
  - energy generation (e.g. bio-methanation)
  - co-composting.

# Overview of effluent treatment – organic and inorganics

## Inorganic contaminants – Heavy metals

- Vast variety of inorganic pollutants e.g. salts and heavy metals. most relevant in textile production
- Common treatment of **metals through precipitation**
  - Possible for most heavy metals as their insoluble salts (such as hydroxides)
  - Precipitated by addition of lime and alum/ ferrous salts aided by polyelectrolytes.
  - Disadvantage: Metals transferred from liquid effluent to sludge and posing sludge disposal problem




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# Overview of effluent treatment – organic and inorganics

## Inorganic contaminants – Salts

- **Not possible to precipitate** and remove salts, particularly that of sodium.
- Removal of salts by membrane technologies such as **using Reverse Osmosis** (RO).
  - Membrane technologies leaving concentrated saline stream to be handled separately.
  - Saline reject further concentrated by evaporation/ distillation to separate it out in solid form.

# Overview of effluent treatment – organic and inorganics

## Inorganic contaminants – Salts

- Concentration salt solutions (especially single salt solutions) to required levels for re-use
- Less common technologies
  - Ion-exchange
  - Electrolysis
  - Membrane distillation
  - Forward osmosis
  - Electrodialysis reversal EDR
  - Vapor compression



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# Common unit operations in effluent treatment

| Unit operation | Functions | Common unit |
|---|---|---|
| **Screening** | • Removal of large particles (suspended or floating) | Manual/mechanical screens |
| **Grit Removal** | • Removal of sand like materials from the effluent. | Grit chamber |
| **Equalization** | • Homogenizing the characteristics of the effluent<br>• Flow balancing. | Equalization tank<br>Aerators, mixers |
| **Coagulation/ flocculation** | • Facilitating settling of colloidal solids & allowing the small solids to join together to form sludge. | Flash mixer & flocculator |
| **Primary settling** | • Removal of part organic/inorganic settleable solids | Primary clarifier/tube settler |



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# Common unit operations in effluent treatment

| Unit operation | Functions | Common unit |
|---|---|---|
| **Biological treatment** | • Removal of organics using microbial action | Aeration tank |
| **Secondary settling** | • Settling of bio-sludge, enabling biomass inventory | clarifier |
| **Tertiary treatment** | • Removes suspended solids/increase dissolved oxygen | Multigrade filter & aeration |
| **Sludge dewatering** | • Reducing moisture of liquid sludge to dried sludge | Sludge filter press/centrifuge |
| **Sludge maturation** | • Reducing moisture of dewatered sludge further | Sludge storage. |



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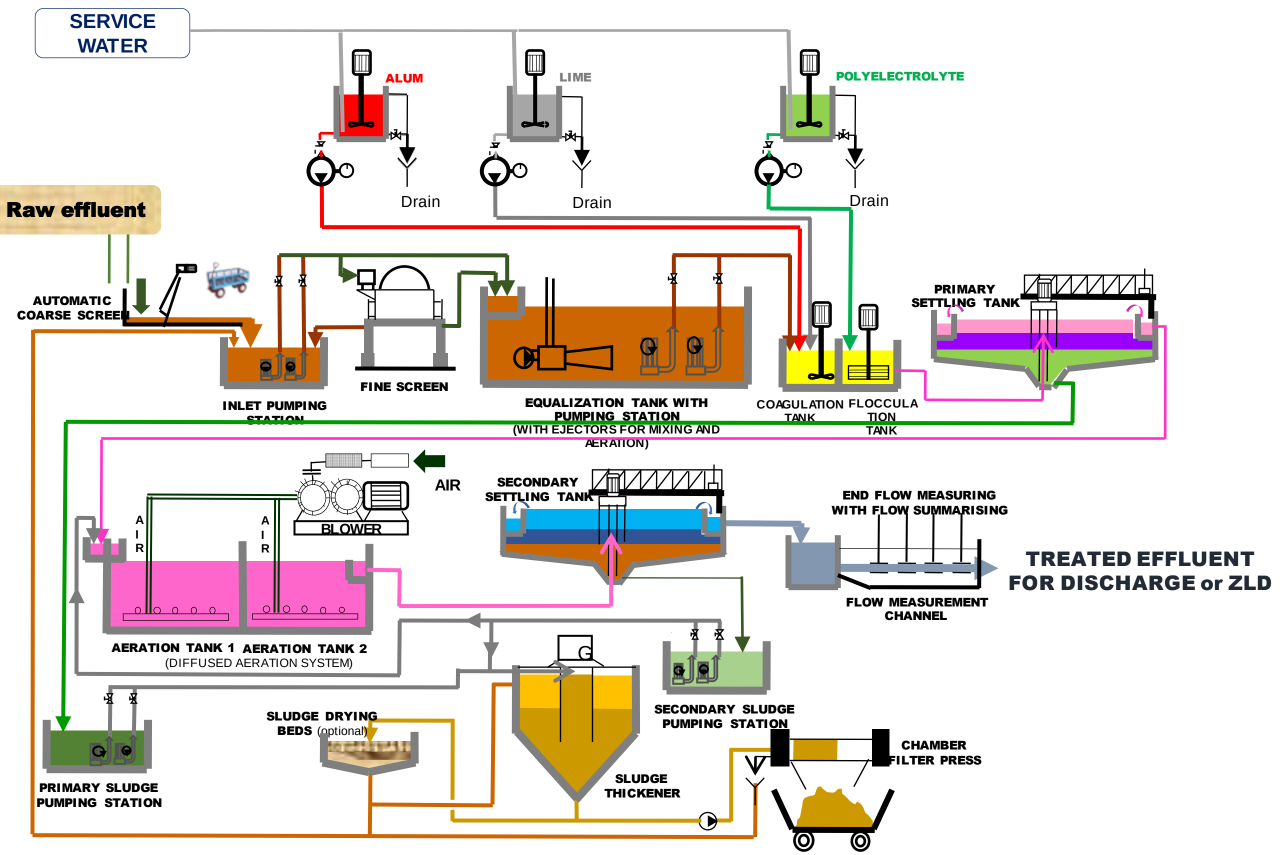
# Flow chart of composite textile CETP




Source UNIDO



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# Organic pollutant removal

# Organic pollution removal

## Chemical precipitation

- Targeting suspended and colloidal organics
- Involving coagulation, flocculation and solids separation for removal but not destruction of organics.
  - Commonly used coagulating agents: Metallic salts
  - Newer coagulation methods include electro coagulation.

# Organic pollution removal

## Chemical precipitation

Basic concept

- Coagulated colloidal particles very small.
- Combination of particles through flocculation to bigger flocs amenable to settling/flotation.
- Solids separation through sedimentation as well as dissolved air flotation & filtrations

# Organic pollution removal

## Biological treatment

- Most common method for organics
- Basic concept:
  - Micro-organisms used for ‘eating’ away pollutants, though actual metabolism complex.
  - Unlike in chemical treatment or filtration, organic compounds being destroyed

# Organic pollution removal

## Biological treatment

Treatment categories:

| Aerobic treatment | Anaerobic treatment |
|---|---|
| Surplus oxygen in tank needed | Working in absence of oxygen |
| Conversion of organic material into carbon dioxide and water | Conversion of organic material into carbon dioxide and methane |



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# Organic pollution removal

## Anaerobic biological treatment

Key features

- Anaerobic micro-organisms, mostly bacteria, **naturally degrading** (putrefying) organic matter
- Reactions mainly involving **fermentation and bio-methanation**
- **No need of air** or oxygen in wastewater; anaerobic treatment less effective with dissolved air..



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# Organic pollution removal

**Anaerobic biological treatment**

Key features (contd.)

- **End product = mixture of gases** (carbon dioxide and methane, other gases like hydrogen sulphide, if Sulphur containing compound in form of sulphide or sulphate).
- Mixture of gas used as **fuel for burning in boilers** and for electricity production.
- Anaerobic treatment **more suitable for readily degradable high organic effluents**

# Organic pollution removal

## Anaerobic biological treatment

Overview of systems

- Earlier anaerobic treatment units in form of **anaerobic lagoons** (ponds) storing effluent for long time (e.g. 30 - 40 days)
- Disadvantages: **Large areas needed** and odour issues; nowadays less common.



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# Organic pollution removal

## Anaerobic biological treatment

Overview of systems

- **Anaerobic filters** with media (synthetic media or even broken rubble chips)
- **High rate digestors** with high organic reduction and maximum biogas production.
- **Sludge digestors** with in built heating systems to make use of higher efficiency bacteria operating at higher temperature.



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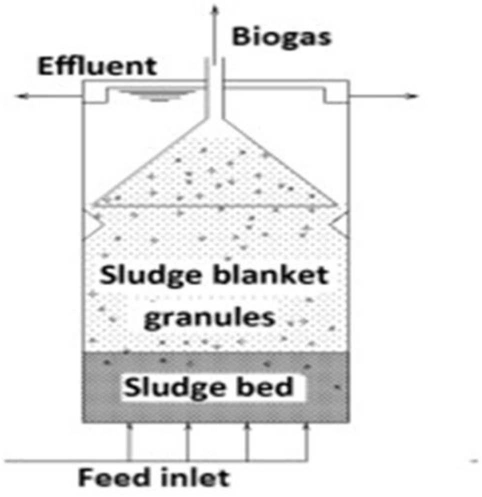
# Organic pollution removal

**Anaerobic biological treatment**

Emerging systems

- **Upflow anaerobic sludge blanket** (UASB) reactors working on suspended bio-sludge containing microorganisms.
  - Bio-sludge generated forming into granular shape after some time creating sludge blanket.
  - Kept in suspension due to upward flow of effluent in reactor.
  - Installed gas liquid solids separator at upper side of reactor to separate the bio-gas and to retain bio-sludge within reactor.



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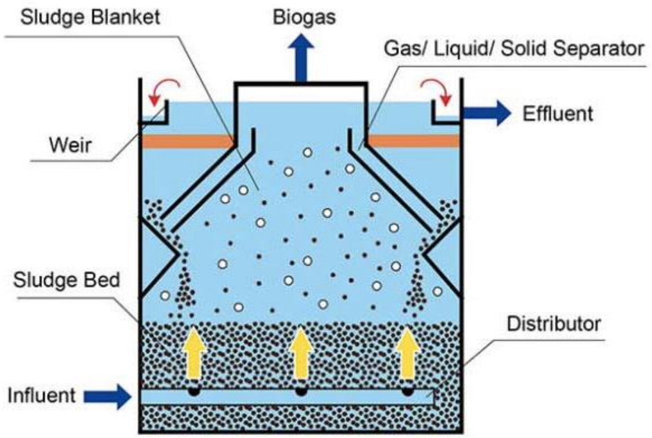
# Organic pollution removal

**Anaerobic biological treatment**

Emerging systems

- **Fluidized media bed reactors** and **hybrid reactors** (with fixed filter and moving bio-sludge).




Modified UASB process
(Source: ITRI, Taiwan)



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# Organic pollution removal

**Anaerobic biological treatment**

Applicability of anaerobic treatment in textile production:

- **For textile effluent treatment limited**
- Very **few anaerobic systems operating**



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# Organic pollution removal

## Aerobic biological treatment

Key features

- Aerobic micro-organisms, mostly bacteria, **degrading organic matter into basic compounds**.
- End product: Carbon dioxide and water.
- Once reaction completed **organic matters completely destroyed**.
- **Dissolved oxygen** (DO) in water **needed.**




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# Organic pollution removal

## Aerobic biological treatment

Key features (contd.)

- Aeration concept and requirement:
  - Organisms using up the oxygen; loss of oxygen to be compensated by external aeration
  - **Aeration systems increasing oxygen** in water through mixing water with air
  - Commonly done by either **bubbling air** into water or **splashing water** facilitating mixing of liquid and air at surface



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# Organic pollution removal

## Aerobic treatment

Common systems

- **Activated sludge process** with bio-mass maintained in aeration tank.
  - Sufficient quantity (inventory) of micro-organisms, mainly **bacteria to be kept in system**.
  - Depending on quality of inlet water, **small quantity of excess sludge** generated and to be disposed off.
  - Effluent with bio-sludge settled in clarifier
  - Settled bio-sludge returned back to aeration tank.

# Organic pollution removal

## Aerobic treatment

Common systems

- Depending on treatment duration activated sludge process:
  - Conventional aeration
  - extended aeration, where extra aeration time provided for digestion of excess sludge

# Example of common aerobic biological systems

Oxidation ditch


Conventional aeration tank

# Organic pollution removal

## Aerobic treatment

Older systems

- Being increasingly replaced
- Examples
  - Aerated lagoons, aerobic stabilization ponds due to high land area requirement and low efficiency.
  - Trickling filters with effluent being sprayed on media with wastewater trickling down sucking in atmospheric air for aeration.

# Organic pollution removal

## Aerobic treatment

Emerging systems

- **Upgraded trickling filters** with improved media
  - Earlier media replaced with lighter synthetic media and with high level of media uniformity coefficient.
- **Fluidized aerobic reactors** common for smaller ETPs;
- New ETPs using variant called as **moving bed biological reactors** (MBBR)

# Organic pollution removal

## Aerobic treatment

Emerging systems

- **Moving Bed Biological Reactors (MBBR):**
  - Aeration tank with special plastic media used for housing bacteria treating wastewater; sieves preventing escape of media.
  - Main advantages: **Less land required**, **lower operating cost.**
- **Hybrid MBBR** with suspended and attached growth systems.

MBBR

# Organic pollution removal

## Aerobic treatment

Emerging systems

- **Sequential batch reactor** (SBR):
  - Same tank used for both aeration and settling operations.
  - Automatic controls used for precise switching over between two tanks.
  - Used as batch process, usually with multiple units to continue operations.

SBR

# Sludge dewatering and drying

# 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 dewatering and drying

## Dewatering methods

**Mechanical dewatering**:

Chamber filter press

Sludge centrifuge



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# 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



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# Sludge dewatering and drying

For consideration

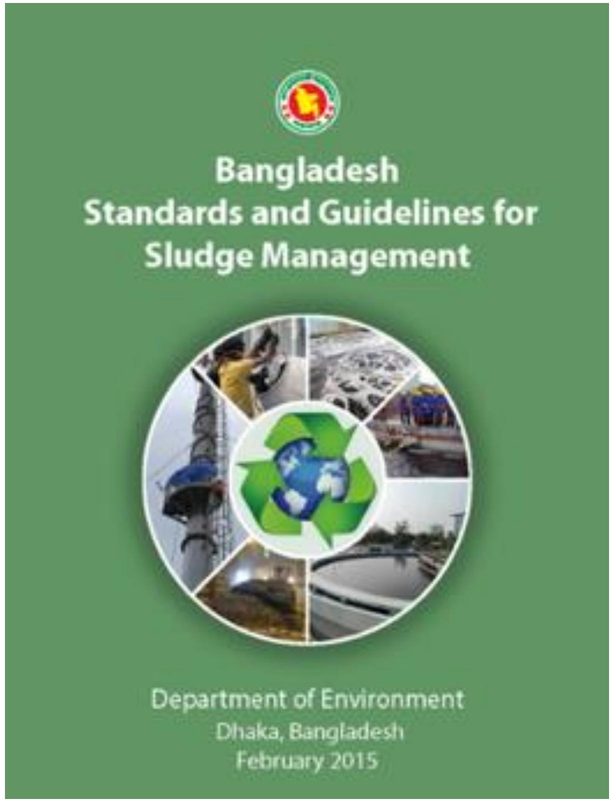
**Disposal logistics and costs**

- In Bangladesh, **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 in Bangladesh

- Sludge from textile ETP considered hazardous requiring special disposal.
- **Sludge guidelines** adopted by DoE of Bangladesh:
  - Three groups of sludge categories (A, B, C)
  - Category A only for municipal sludge; remaining sludge either B or C based on concentration of heavy metals.
  - **Sludge from textile ETPs mostly category B** but also **some in category C**.



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# Sludge disposal requirements in Bangladesh

Disposal requirements for category C 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 category B & C for making construction materials,
  - in Bangladesh only one co-processing company (Geocycle).

Sludge incinerator



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# Sludge disposal requirements in Bangladesh

- To simplify classification approach, acceptable limits for major sludge quality parameters defined in the **Guideline for Sludge Management in Bangladesh Textile Sector**
- Threshold differentiates by categories A, B and C

| Parameter | Unit | Category A | Category B | Category C |
|---|---|---|---|---|
| Cadmium, Cd | mg/kg | 10 or less | 11 – 85 | > 85 |
| Chromium, Cr | mg/kg | < 600*** | < 600 | > 600 |
| Copper, Cu | mg/kg | 800 or less | 801 – 4300 | > 4300 |
| Lead, Pb | mg/kg | < 840** | < 840 | > 840 |
| Nickel, Ni | mg/kg | 200 or less | 201 - 420 | > 420 |
| Zinc, Zn | mg/kg | 2500 or less | 2501 – 7500 | > 7500 |
| Mercury, Hg | mg/kg | 8 or less | 9 - 57 | > 57 |


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