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

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

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GIZ FABRIC – Waste Management Course

Presentation 4: Hazardous materials in the effluent and its treatment

Contents

- Sources of hazardous materials the general effluent, hazardous pollutants in garment washing effluent.
- Overview of textile waste water treatment techniques.
- Concentration of different pollutants including heavy metals, content Vs discharge standards.
- Treatment techniques for heavy metals.
- Chemical precipitation technique and chemicals used.
- Need to generate & removal of excess sludge from biological treatment.
- Sludge characteristics from different type of ETPs.

Sources of hazardous materials the general effluent, hazardous pollutants in garment washing effluent

The use of harmful chemicals in the textile sector has consequences for the environment

- Water pollution
- Pollution of soil and farmland
- Hazardous waste generation
- Pesticides used for cotton

Pollution of soil and farmland

- Hazardous chemicals in wastewater can pollute soil and farmland along rivers
- Sewage sluge containing hazardous chemicals is being applied to land as a soil supplement
- Contaminated soil can lead to contaminated food that is grown on these fields; therefore chemicals can enter the food chain

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Water pollution

- Effluents from textile production pollute freshwater resources
- Used hazardous chemicals can even build up in the food chain

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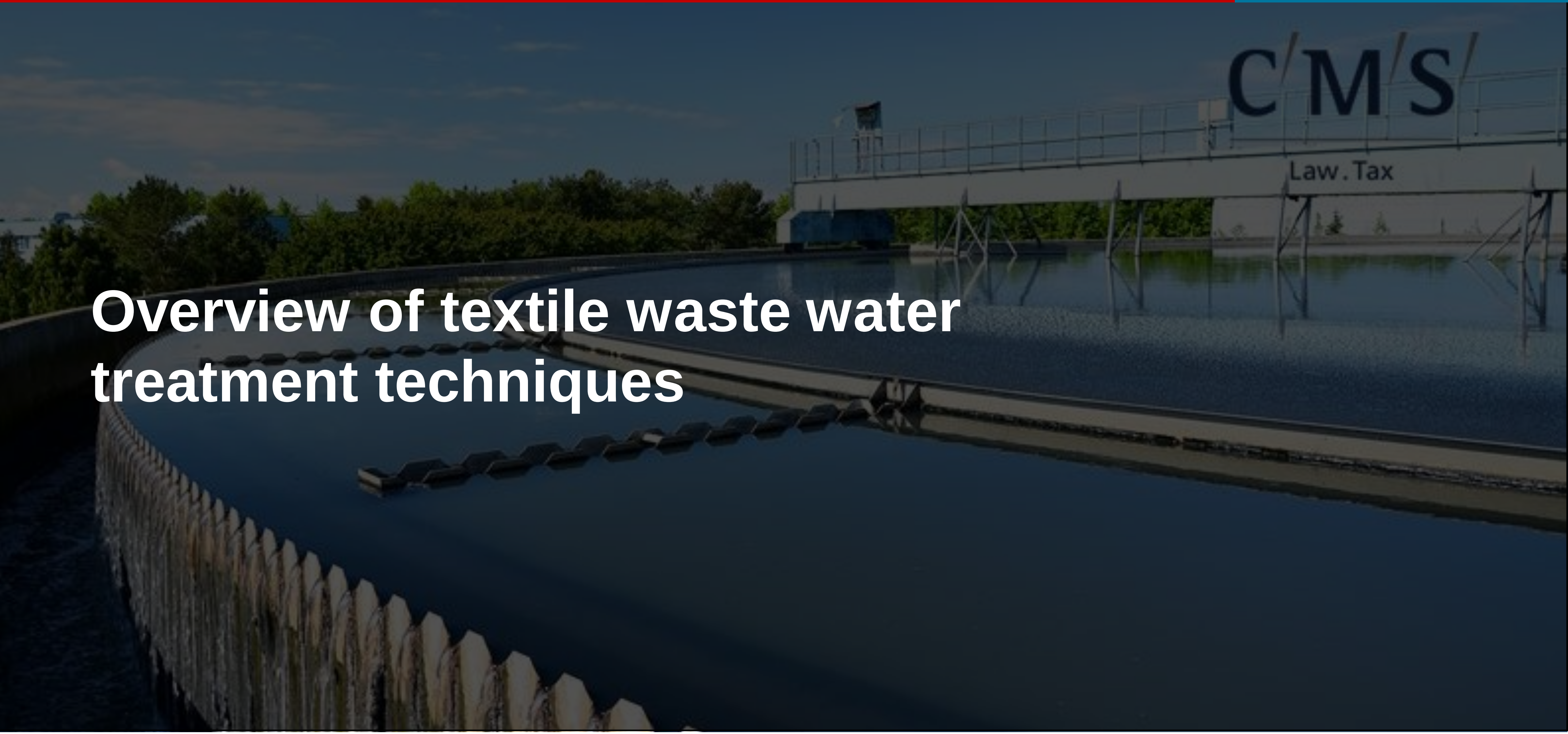
Overview of textile waste water treatment techniques



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Classical Waste Water Treatment Techniques

IT WILL BE ELIMINATED

- Coarse materiel, sand
- Crease and oil
- Settable substances
- Biodegradable substances
- Biol. activated sludge

BY

- Grids Sand traps
- Floating materiel separators
- Pretreatment, sedimentation
- Biological treatment
- Clarification
- Water-body

Sludge Treatment

Scheme of the common treatment of waste water from textile industries

Waste water From textile industry

Reverse osmosis for removal of colorfulness or reduction of salt

Discoloration by biological process

Discoloration by chemical process

Activated sludge treatment

(aerobic multiple stage process, high detention time tTs, low sludge load BTS, last process unit as fixed bed reactor)

Adsorption

Sand filtration

Active carbon filtration

Precipitation/flocculation or flotation

Treated waste water

Mixed waste water from textile industries are generally characterized by organic carbon-containing substances, which concentrations are slightly higher concentrated than in municipal waste water, but are more difficultly to degrade. The concentrations of nitrogen and phosphorous containing substances are lower than in municipal waste water.

Advanced Textile waste water treatment

Process	Main objective Typical	fluxes (L/m2/h)
Microfiltration (MF)	Suspended solids removal including microorganisms and colloids. Reduction in turbidity 90+%.	>50
Ultrafiltration (UF)	Elimination of long chain dissolved substances including colloidal, oil and fatty substances. Turbidity reduction 99%. Good for removal of metal hydroxides to 1 mg/L or less. In textile applications, COD removal is 21 – 77%, colour 31 – 76% and surfactants 32 - 94%. Requires NF or RO to polish the permeate further for dyeing lighter colours.	50 - 100
Nanofiltration (NF)	Selectively removing of charged ions including calcium and polar substances. Water softening applications and decolourisation. Prone to fouling from colloidal materials and polymers. COD removal 79 – 81%	1.4 - 12
Reverse osmosis (RO)	Inorganic ions removal to very low concentrations used in desalination. Very sensitive to fouling. Pre-treatment required. COD removal 89 – 91%	0.05 -1.4

Concentration of different pollutants including heavy metals, content Vs discharge standards

Typical characteristics of untreated textile effluent

pH	6 – 10
Temperature 0C	35 – 45
Total dissolved solids mg/L	1,000 – 12,000
Biological Oxygen Demand (BOD) mg/L	80 – 6,000
Chemical Oxygen Demand (COD) mg/L	150 – 12,000
Total suspended solids (TSS), mg/L	15 – 8,000
Chloride, mg/L	1,000 – 6,000
Free chlorine, mg/L	<10
Oil & Grease, mg/L	10 – 30
Total Kjeldahl Nitrogen (TKN) mg/L	70 – 80
Nitrate (NO3) mg/L	<15
Free ammonia, mg/L	<10
Sulphate, (SO4) mg/L	600 – 1,000
Heavy metals, mg/L	<10

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Typical characteristics of untreated textile effluent

Parameters	Units	Typical Values	DOE Standards For Waste from Industrial Water Discharge
pH		8-10	6-9
Heavy Metals	mg/l	10 – 15	Varies depending on type of metal
Suspended Solids (SS)	mg/l	200 – 300	150
Total Disolved Solids (TDS)	mg/l	5000 – 6000	2100
Chemical Oxygen Demand (COD)	mg/l	1500 – 175	200
Bio-chemical Oxygen Demand (BOD)	mg/l	500 – 600	50
Oil & Grease	mg/l	40 – 60	10
Surfactants	mg/l	10 – 40	
Sulfide as S	mg/l	50 – 60	1

Typical characteristics of untreated textile effluent

Parameter	Effluent Discharged Water Standards/Limit (mg/l) [1]	Standard for Wet Processing ((mg/l)) [2]	Avg. Discharge quality of Bangladeshi ETP's (Biological Based) (mg/l) [3]
Total Suspended Solid (TSS)	100	1	15-50
BOD5 20°C	150*	50	30-50
COD	200	200	100-150
DO	4.5-8	Not Permitted	4-5
Oil & Grease	10	1	1-3
Total Dissolved Solid	**2100**	200	**1500-2100**
pH	6.5-9	7-8	7-8

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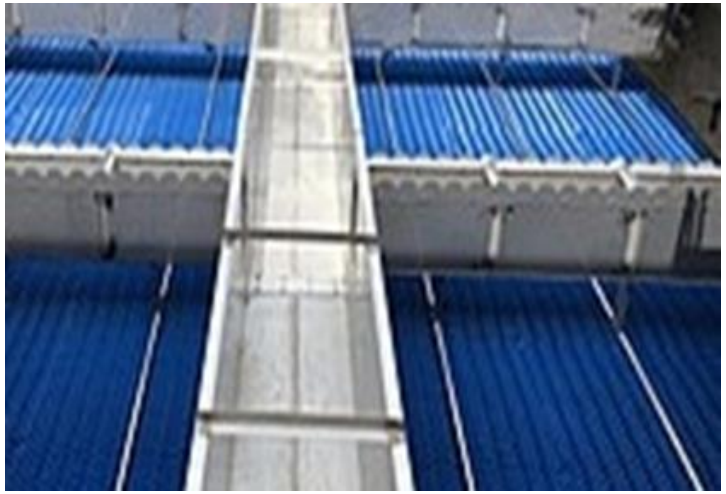
Treatment techniques for heavy metals

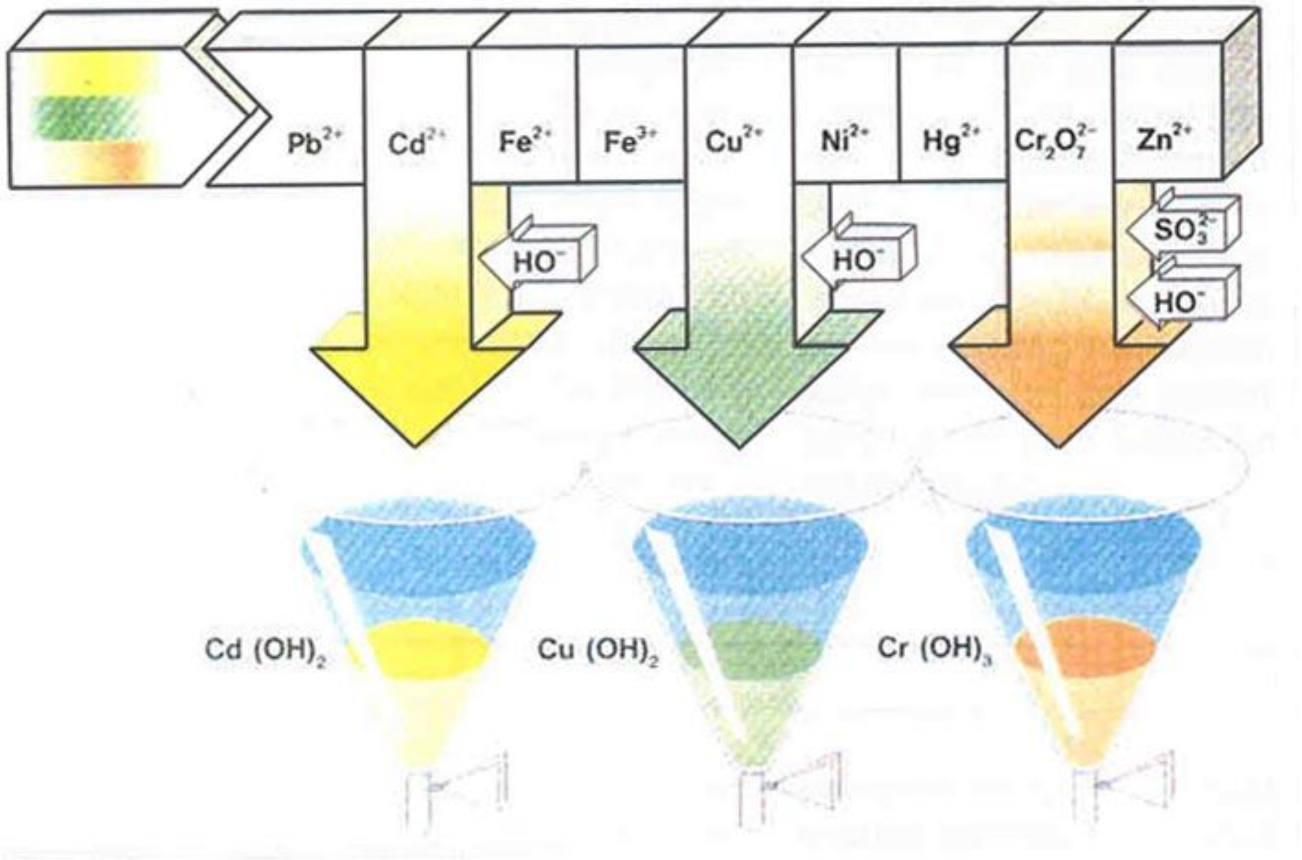
Effluent treatment



- **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

Elimination of Heavy Metals

Industrial waste water



Antimony removal

- In fabrics, made of 100% polyester, Sb concentrations as much as 208 mg/kg were found.
- During dyeing at high temperature, Sb leaches into the wastewater. Concentrations can reach as high as 175mg/L.
- ZDHC recommendations for concentrations of Sb are 0.1, 0.05 to 0.01 mg/L (100, 50 and 10µg/L) as the supplier progresses from foundational and progressive to aspirational. Due to its toxicity, Sb needs to be removed from wastewater.

Antimony removal

- Sb exists in many valent forms from the trivalent (Sb^{3+}) to the pentavalent form (Sb^{5+}) which makes its removal more challenging.
- The trivalent form is ten times more toxic than other forms. Methods recommended for its removal range from precipitation, ferric chloride coagulation/flocculation, ozone oxidation, membrane separation and adsorption.
- Ferric chloride at dosages of 40 – 50mg/L at a low pH followed by microfiltration is a low-cost measure.

Need to generate & removal of excess sludge from biological treatment

Activated sludge process

- In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter.
- Part of organic matter is synthesized into new cells and part is oxidized to CO_2 and water to derive energy.
- In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks.
- A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Activated sludge process

Activated sludge plant involves:

1. wastewater aeration in the presence of a microbial suspension,
2. solid-liquid separation following aeration,
3. discharge of clarified effluent,
4. wasting of excess biomass, and
5. return of remaining biomass to the aeration tank.

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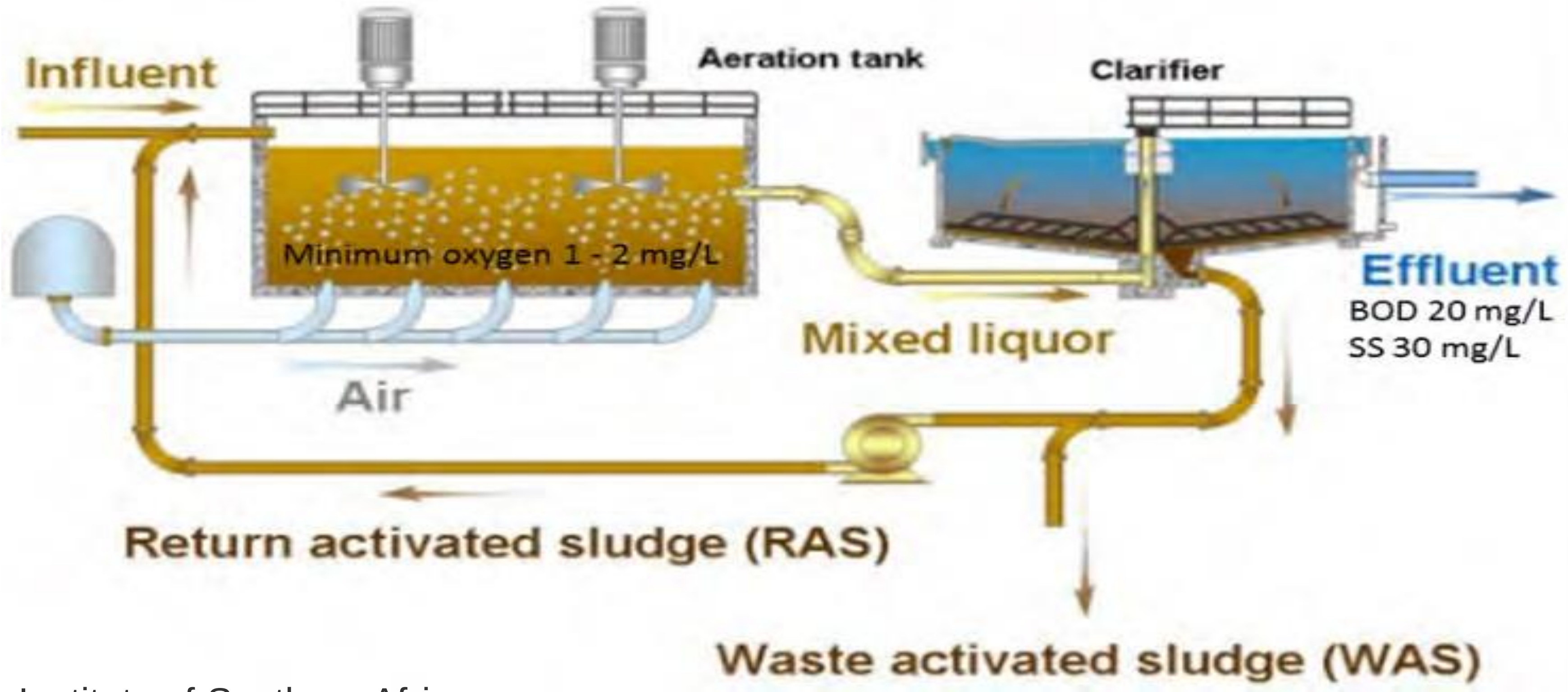
Schematic of activated sludge process

treatmSource: Water Institute of Southern Africa (2002): “Handbook for the operation of waste water treatment plants”ent plants”



Source: Water Institute of Southern Africa (2002): “*Handbook for the operation of waste water treatment plants*”

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Secondary treatment

For removal of organic pollutants, the most efficient process is biological treatment known as *Secondary treatment*. It primarily employs microbes naturally present in wastewater to break down organic contaminants. Some inorganic compounds like ammonia, cyanide, sulphide, sulphate and thiocyanate are also biologically degradable. Biological processes can be broadly classified as:

i. Aerobic – microbes that require oxygen to grow

ii. Anaerobic – microbes that grow in the absence of oxygen but uses other compounds such as sulphate, phosphate or other organics present in the wastewater other than oxygen

iii. Facultative – microbes that can grow in the presence or absence of oxygen.

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Treatment of azo dye wastewater

- Reactive azo dyes are not degraded by aerobic treatment, whilst anaerobic treatment is able to degrade reactive azo dyes to aromatic amines which are still toxic, and aerobic systems located downstream of an anaerobic plant are able to degrade them further.
- Therefore, the two together, where an anaerobic system is used followed by an aerobic system, produces the best results.
- In anaerobic systems if there is sufficient COD, then sufficient biogas can be produced to power a generator.

Food to microorganism (F/M) ratio

Food to microorganism (F/M) ratio: A term for expressing the organic loading of an activated sludge process F/M is a critical factor in process design and operation, especially in determining the aeration basin volume. F/M range is about 0.5 – 1.5. For conventional plants, F/M of 0.2 – 0.5 is aimed for. In biological treatment plants operating at high F/M loads (0.8 – 1.5), the rate of treatment increases but at the cost of poor settleability of the sludge.

Processes operating at low F/M loads (0.05 – 0.2) are associated with slow BOD removal rates but with good sludge settling. However, the system can be easily upset by a spike load of organics.

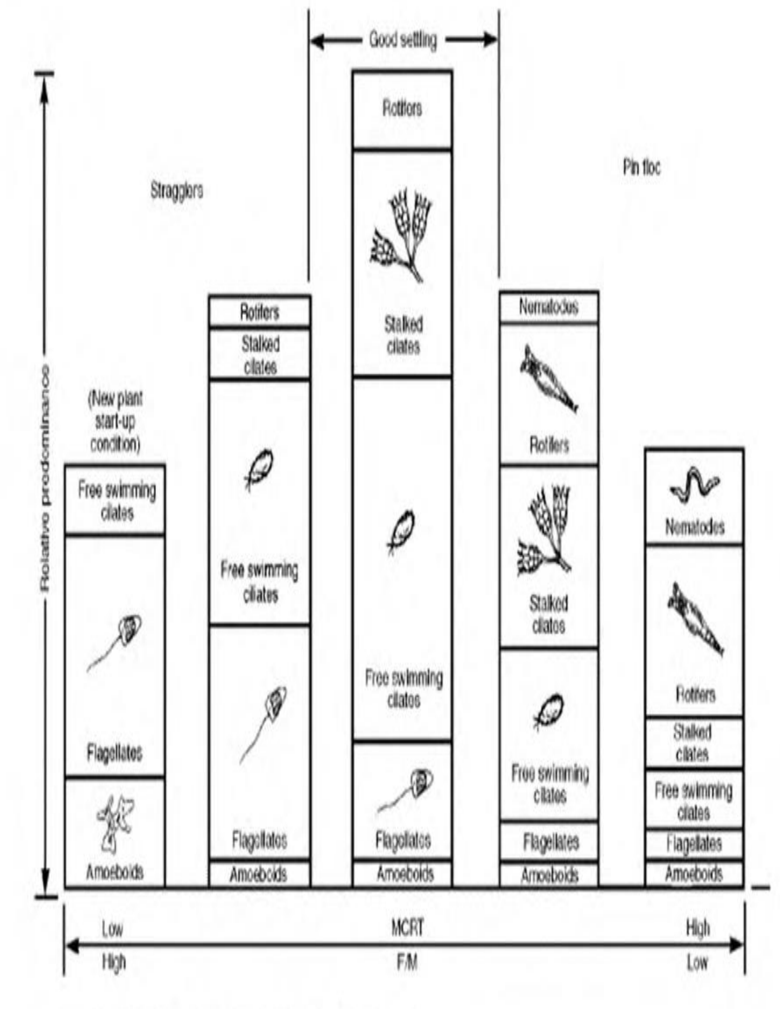
Sludge age

Sludge age is also known as **Mean Cell Residence Time (MCRT)** and **Solids**

Retention Time (SRT): is calculated as the total quantity of sludge in the aeration tank and clarifier divided by the daily sludge losses through waste activated sludge and effluent. Sludge age can vary from 0.5 to 75 days in low-growth rate systems. However, in conventional systems it is 3 – 15 days and in textile wastewater treatment plants 20 – 30 days. Sludge Age is an indication of F/M ratios. Shorter times are indicative of high F/M ratios and longer times are indicative of low F/M ratios. Sludge age is expressed as:

Sludge age = Sludge mass in (Aeration tank + Clarifier) / daily sludge losses.

Sludge Volume Index (SVI)



Source: USEPA "Activated Sludge Process," Section 4, Laboratory Control

Another useful indicator is the Sludge Volume Index (SVI). Sludge is poured to a 1L graduated cylinder and the percentage of settled sludge in 5 minute intervals is noted for 30 minutes.

SVI is expressed in mL/g. It is a reliable troubleshooting test. SVI values can vary from 30 to 400 mL/g. Values below 150 indicate good sludge settling and above this indicate sludge bulking.

Chemical precipitation technique and chemicals used

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

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, iron- and aluminum-salts
  - Polyelectrolytes
  - Newer coagulation methods include electro coagulation.

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Sludge characteristics from different type of ETPs

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Sludge

A residual semi-solid material formed as a **by-product from industrial and municipal wastewater treatment**.

A residue of effluent treatment plants (ETP) independent of applied treatment:

- Physio-chemical.
- Biological.
- Chemical.

Sludge dewatering and drying

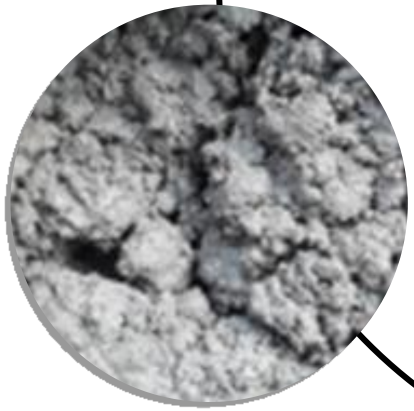
Sludge characteristics

- 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 Handling

Disposal

- Landfill.
- Incineration.
- Upcycling.



Removal of Moisture

- Thickening.
- Dewatering.

Sludge / solid waste from the effluent stream could potentially **contain high levels of chemicals**, and requires proper handling and disposal:

- Disposal must meet all local requirements.
- Safety protocol need to be followed when handling sludge.
- Sludge must be disposed of through a qualified disposal company.

Sludge disposal requirements in Bangladesh

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

- 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

Group work

15 min Group Work, please document your results

Discuss your experience with wastewater testing.

What were your challenges?

What solutions have you found to positive test results?

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Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60 - 0
F +49 228 44 60 - 17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79 - 0
F +49 61 96 79 - 11 15

E info@giz.de
I www.giz.de

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH