TRAINING PROGRAMME FOR ETP OPERATORS IN TEXTILE INDUSTRY

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

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Pollutants in textile effluents

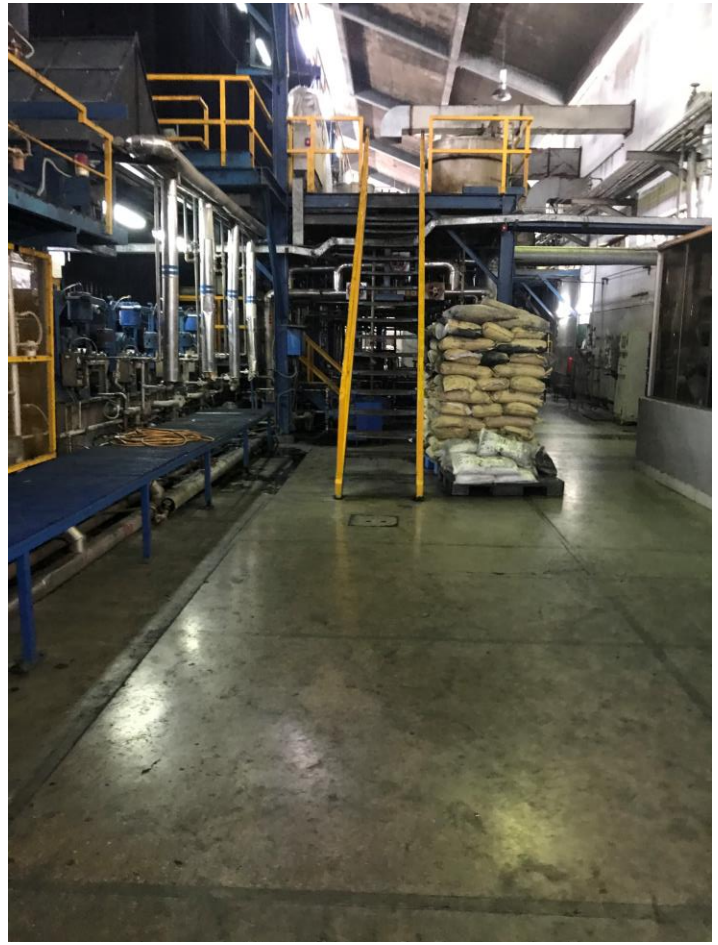
GIZ FABRIC – ETP Operator Course

Contents

- Overview of water usage in textile production
- Critical textile production areas
- Types of water pollutants in textile effluent
- Impacts on Environment

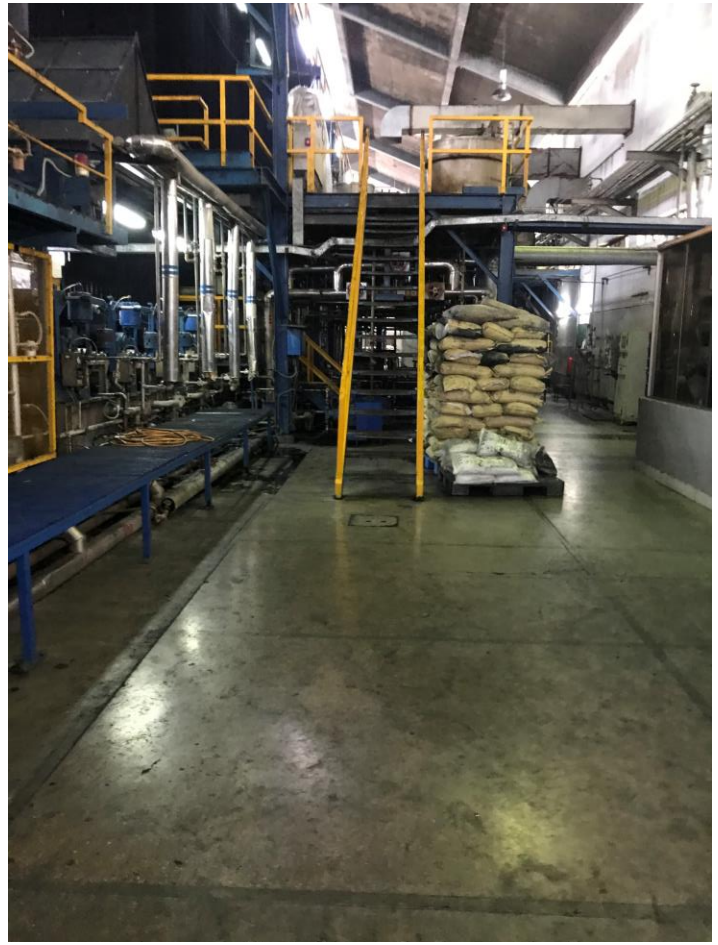
Water usage in textile production - overview

- Water consumption differing by operations in factory:
  - Operations **upto bleaching about 40%** of total water needed.
  - **Dyeing & printing another 25%,** boiler
  - **Humidification about 25%** and
  - about 8% for sanitary applications.
- Almost all water discharged as effluent at end.



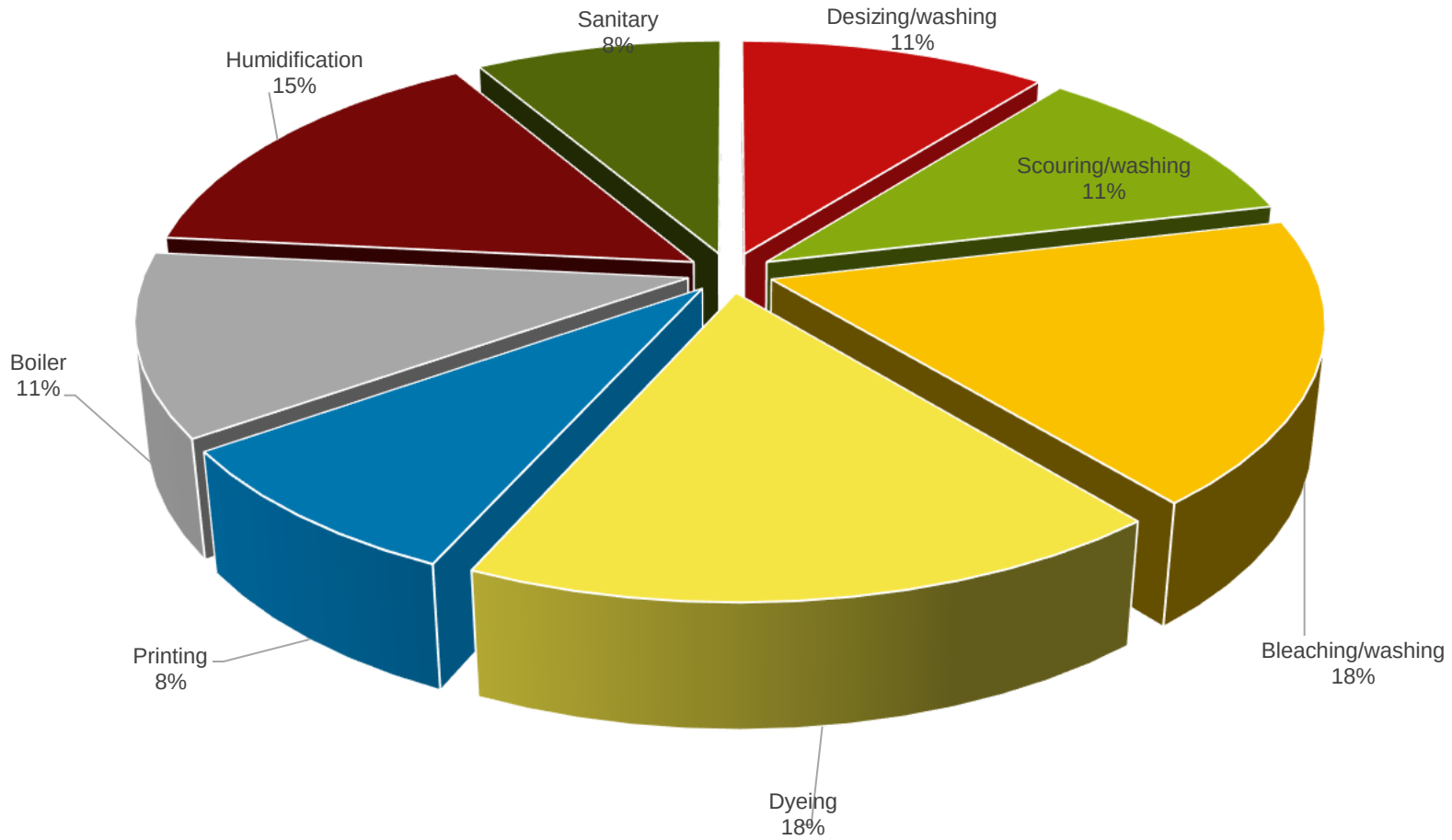
Water usage in textile production - overview

- Water consumption depending on type of material processed (cotton, wool, Nylon, Rayon etc.).
  - **More water** required for **cotton**.
- Average consumption in Bangladesh between **90 to 160 litres per kg** of material processed.



Water usage in textile production - overview

Typical distribution of water consumption by areas of use in textile processing



Critical textile production areas

- **Desizing:** Removal of sizing materials like starch either by hydrolysis (by enzyme or acid) or by oxidation (by sodium bromide, sodium chlorite, etc.)
- **Scouring:** Chemical washing to remove natural wax and non-fibrous impurities. The fabric is boiled in an alkali, which forms a soap with free fatty acids. Water is used to make the alkali bath and thereafter for rinsing.
- **Bleaching:** Removal of natural color (creamy appearance) to the fabric is bleaching. Hypochlorite & hydrogen peroxide are ususal bleaching agents.
  - Of late hypochlorite replaced by other bleaching agents
  - Lot of water used for rinsing after bleaching.

Critical textile production areas

Mercerization

- Mercerization impart luster, increase strength, and improve dye uptake for cotton material
  - Cotton material treated with a strong solution of sodium hydroxide (about 18–24%);
  - Thereafter caustic washed-off after 1 to 3 min, while holding material under tension

Critical textile production areas

Dyeing

- Treatment of fiber or fabric with chemical pigments to impart color is dyeing.
  - Water used to transfer dyes and in form of steam to heat the treatment baths;
  - excess dyes washed off through rinsing.

Critical textile production areas

Printing

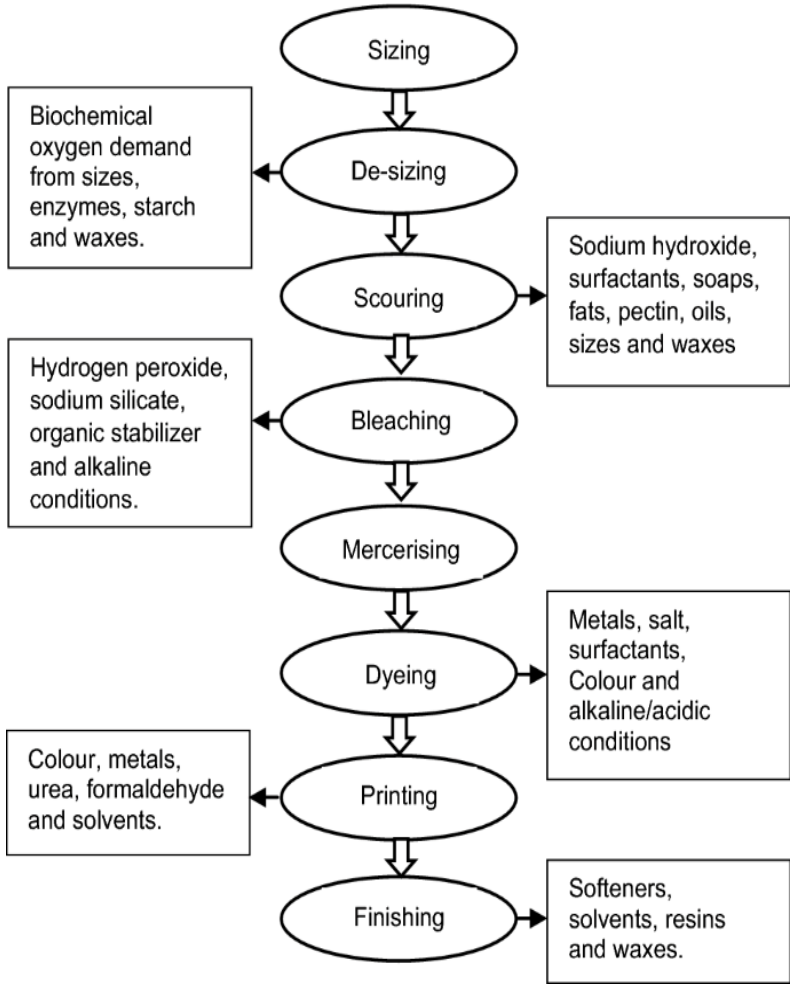
- A form of dyeing to a certain portion of fabric as per a design.
  - Application of color in form of thick paste of dyes;
  - After-treatment of the printed material for fixation of colour

duction areas

Finishing

- Improve specific properties in fabric for both natural and synthetic textiles
  - Finishing involves use of large number of finishing agents for softening, cross-linking, and water proofing.
  - Water used in these processes too.

Sources and types of pollutants in textile effluent



Sources and types of pollutants in textile effluent

Pollutant	Examples
Organic pollutants	residues of organic material used both as raw material and process ingredients.
Salt	
Suspended particles	mostly fine fibers and residues of chemicals.
Heavy metals	Normally present in dyeing & printing chemicals and discharged in these effluents.
Colour	caused by the remnants of the dyes & printing agents.

Sources and types of pollutants in textile effluent

Inorganic

- Only small portion of chemicals used in manufacturing process actually consumed in the process → most of it comes out in effluent.
- Common compounds
  - **Alkalis, mineral acids, neutral salts**
    - residuals of these chemicals mostly emerging as salts; source being either as direct salts or salts formed due to inter-reaction of alkali and acids,
  - **Heavy metals** used in process chemicals

Sources and types of pollutants in textile effluent

Alkalis, mineral acids and neutral salts

- Chlorides
- Sulphates,
- Phosphates
- Oxidizing agents
  - Peroxides
  - Chlorine
  - Chlorine dioxide

Heavy metals (selection)

- **C**opper
- Chromium
- Nickel
- Zinc
- Cadmium
- Mercury
- Antimony

Sources and types of pollutants in textile effluent

Organic

Common differentiation by

1. Moderate to high organic load but readily degradable
2. High organic load, but difficult to degrade
3. Medium organic load, but difficult to biodegrade
4. Low organic load but very difficult to degrade

Sources and types of pollutants in textile effluent

Organic (Examples)

Load	Degradibility	Example
Moderate to high	**Readily degradable**	• Starch sizes • Vegetable oils • Fats and waxes, • Biodegradable surfactants • Organic acids and reducing agents

Sources and types of pollutants in textile effluent

Organic (Examples)

Load	Degradibility	**Example**
High	**Difficult to degrade**	• Dyes and fluorescent brighteners • Fibres and polymeric impurities, • Polyacrylate sizes • Synthetic polymer finishes • Silicones

s of pollutants in textile effluent

Organic (Examples)

Load	Degradibility	Example
Medium	**Difficult to degrade**	• Wool grease • PVA sizes • Starch ethers and esters • Mineral oil (spin finish) • Surfactants • Anionic and non-ionic softeners.

Sources and types of pollutants in textile effluent

Organic (Examples)

Load	Degradibility	**Example**
Low	**Difficult to degrade**	• Formaldehyde • N-methylol reactants • Chlorinated solvents and carriers, • Cationic retarding and softening agents • Biocides • Sequestering agents.

Sources and types of pollutants in textile effluent

Colour

- Not included in Environment Conservation Rules (ECR)
- Posing issue for aesthetic and psychological reasons.
- Removal generally difficult
- Often producing unwanted issues such as sludge to dispose.

Sources and types of pollutants in textile effluent

Odour

- Effluent giving of foul smell, particularly if kept for some time
- Smell caused by chemicals and degradation of organics as well as sulphur containing compounds.
  - Sulphur comes from sodium sulphate used in dying and some other sulphur containing chemicals degrading into sulphides if kept without oxygen.
  - Sulphur degradation generating foul smelling (rotten egg smell) and **poisonous(!) hydrogen sulphide**.

Sources and types of pollutants in textile effluent

Acidity and alkalinity (pH)

- indicating how acidic or alkaline, measuring hydrogen atoms present in water:
  - pH value 7 (neutral, e.g. pure water).
  - pH value below 7 acidic and above 7 is alkaline.
- Different effluent streams from textile processing either acidic or alkaline.
  - Composite **effluent from cotton processing** generally **alkaline** due to large quantity of caustic soda
- For satisfactory ETP operation, **pH value preferably** in range of **7.5 - 8.5** → allow micro-organisms in ETP to strive.

Sources and types of pollutants in textile effluent

Suspended solids (SS)

- Visible as solid particles in effluent settling at bottom over time
- Generated from minute fiber particles and remnants of chemicals used
- **To be removed** before aeration tank (especially non-readily degradable ones) because
  - **retarding growth of micro-organisms** and clog diffusers
  - **blocking tanks and pipes**

Sources and types of pollutants in textile effluent

Organics: Biochemical Oxygen Demand (BOD)

- measure of bio-degradable organics in effluent.
- equal to oxygen consumed when organics degraded by micro-organisms
  - generally calculated by measuring oxygen consumed after 5 days at 200 C or 3 days in ambient temperature).
- BOD rich effluent discharge drastically **reducing dissolved oxygen** essential for fish and aquatic life in water body.
  - ➢ Very high BOD causing death of fishes and aquatic life.
- anaerobic degradation causing **foul odour.**
- **Desizing largest source** in textile effluent is

Sources and types of pollutants in textile effluent

Chemical Oxygen Demand (COD)

- indicating oxygen consumed by organic and some inorganic compounds in effluent.
  - including bio-degradable organics → always higher than BOD value.
  - determined by oxidizing set quantity of effluent, then measuring the oxygen consumed through chemical analysis.
  - COD tests done in 2 hours and more accurate → operators to use **COD as control parameter for ETP operations** (!)
- **Harmful** because of **reducing dissolved oxygen** in the receiving water body.
- Almost **all textile effluent streams** contributing to COD, primarily from desizing, scouring and dyeing.

Sources and types of pollutants in textile effluent

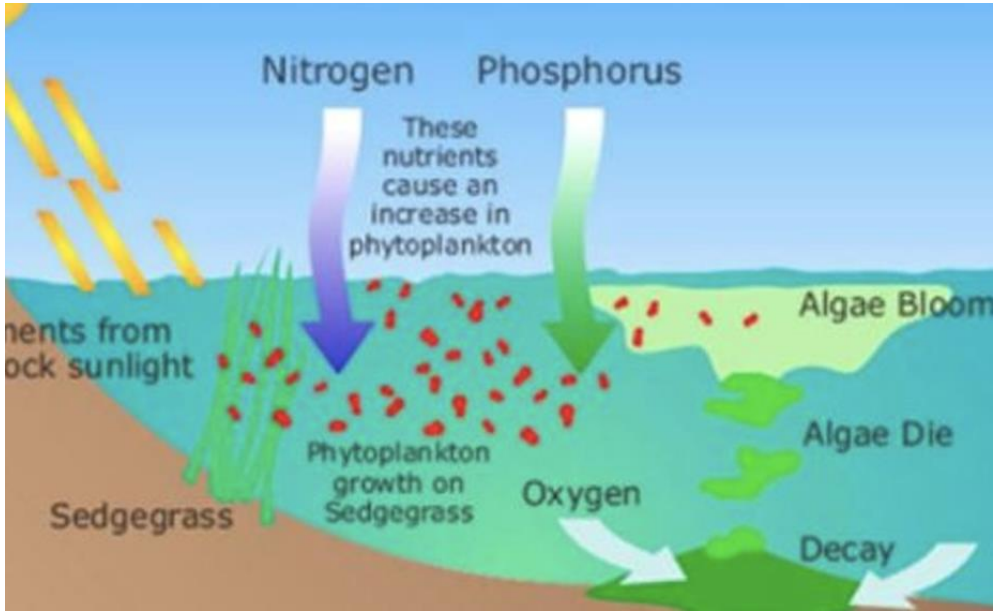
Nutrients

- present as Phosphorous & Nitrogen;
- also **added in ETP** to facilitate biological treatment.
- discharge of excess nutrients into water bodies causing **eutrophication**
- Special care required by ETP operator when adding any nutrients

Sources and types of pollutants in textile effluent

Eutrophication concept

- Nutrients producing excessive algae growth
- Excessive algae growth reducing light penetration
- Photosynthesis stopped
- Algae dying in large quantity
- Decaying algae consuming dissolved oxygen in water
- Fishes and other aquatic life dying due to shortage of oxygen.

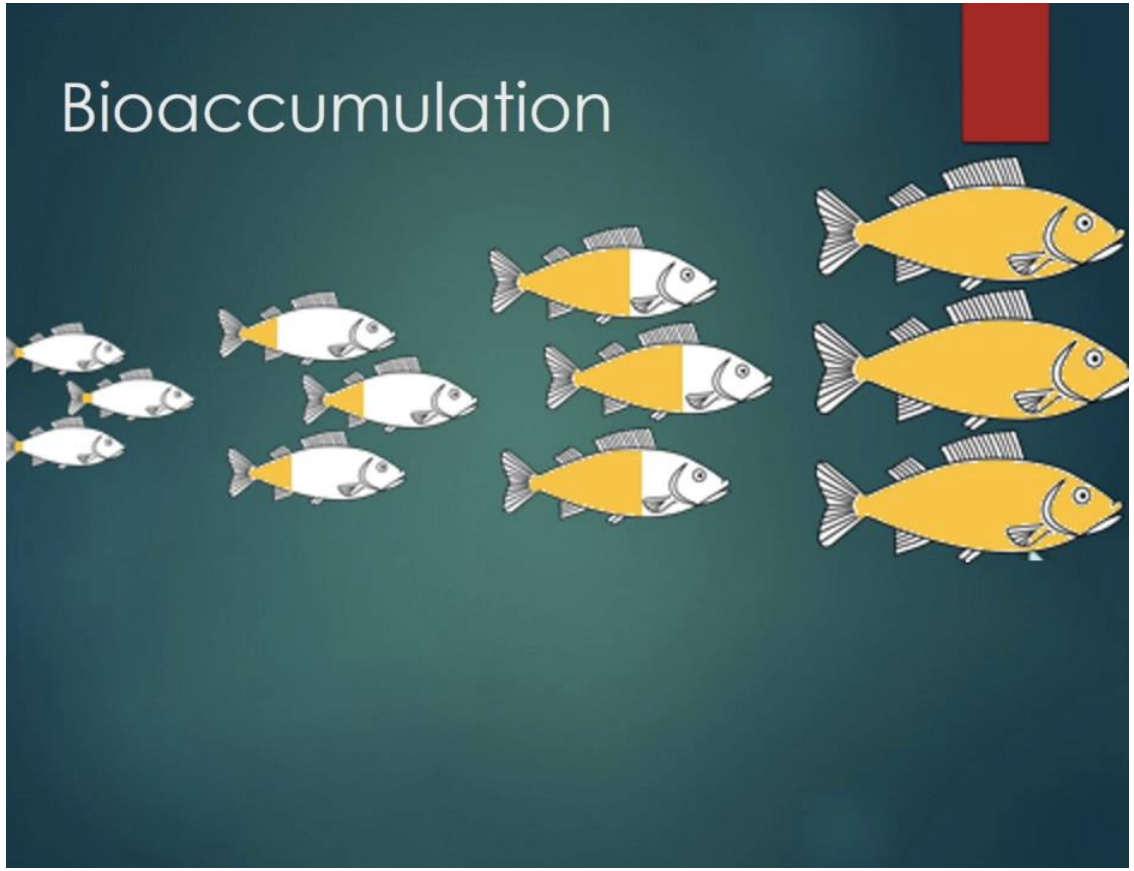


Sources and types of pollutants in textile effluent

Heavy metals & hazardous compounds

- Source:
  - Chemicals used **dyeing and printing processes** ccontaining heavy metals to impart the required colour;
  - Almost all metals discharged along with effluent
- Effects
  - Potentially **toxic** to humans, plants, fish and other aquatic life,
  - Capable of **bio-accumulating in fishes** and entering humans through food chain

Bioaccumulation of heavy metals & hazardous compounds



General pollutants in textile effluent

Heavy metals & hazardous compounds

- Treatment and challenges
  - Part of metals removed by **chemical precipitation in primary ETP**
  - Ending up in **treatment sludge**
  - Sludge considered hazardous by most environmental protection agencies.
- **Biological treatment not moving** heavy metals
- In case no chemical precipitation applied, heavy metals discharged with treated effluent

General pollutants in textile effluent

Heavy metals & hazardous compounds

Commonly listed in national environmental quality standards for industrial wastewater and sludge

- Cadmium
- Chromium
- Manganese
- Copper
- Iron
- Lead
- Mercury
- Boron
- Nickel
- Selenium
- Zinc.

General pollutants in textile effluent

High Temperature

- Many of production steps in **cotton processing** (e.g. scouring, bleaching & dyeing) done at high temperatures contributing to higher efficiency of processes
- Composite raw effluent with a high temperature (often >60 degree C) creating **thermal pollution.**
  - Dissolution of oxygen in water dependent on temperature of water: Higher the temperature → lower the solubility of oxygen.
  - Discharge of hot effluent reducing dissolved oxygen → damaging to lives of fishes and other aquatic life
- **Reduced temperature** (i.e, say <40 degree C) also needed to ensure **healthy microbial population** and hence efficiency of aeration tanks → Cooling towers used in ETP after equalization, particularly in all-biological ETPs.

General pollutants in textile effluent

Total dissolved solids (TDS)

- Mainly due to **salts used in production** (mainly dyeing); also generated through inter-reactions of chemicals used (acid and alkali)
- including both organic & inorganic compounds; TDS generally referred to inorganic (fixed) salts only.
  - Sodium chloride and sodium sulphates (sued in dyeing) main contributors to TDS;
  - Some chemicals like caustic soda and acid reacting and producing salts.
- Be aware of **severe and long lasting effects** from salt in effluent; inorganic salts not getting degraded over time.

General pollutants in textile effluent

Total dissolved solids (TDS) – contnd.

- Common limits for different discharge as set by international environmental standards
  - Upper limit of TDS as 2100 mg/l in treated effluent,
  - 1000 mg/l for chloride (600 mg/l if discharged into land)
  - 1000 mg/l for sulphate commonly set
  - No limits usually set for marine discharge

General pollutants in textile effluent

Total dissolved solids (TDS) – contnd.

- Effects of TDS:
  - High TDS making **water unfit for drinking**; desirable limit of TDS in domestic water less than 500 mg/l.
  - High concentration of sodium salts **dangerous to body** increasing **blood pressure** and other health issues including kidney damages.
  - Salt rich water **unsuitable for construction** contributing to corrosion of cement and steel.
  - Detrimental to **vegetation stunting growth** and resulting in lower yield with many crops and plants

Pollutants in textile effluent -

Non-heavy metal hazardous compounds

- Many organic chemicals used in cotton processing hazardous.
- Several compounds also suspected and confirmed being carcinogenic or having other adverse systemic effects
- Remnants discharged along with effluent from processes and entering ETP.
- Less biodegradable,
  - compounds not showing as BOD, but as COD or Total organic carbon readings.
  - not easily removed in biological treatment.

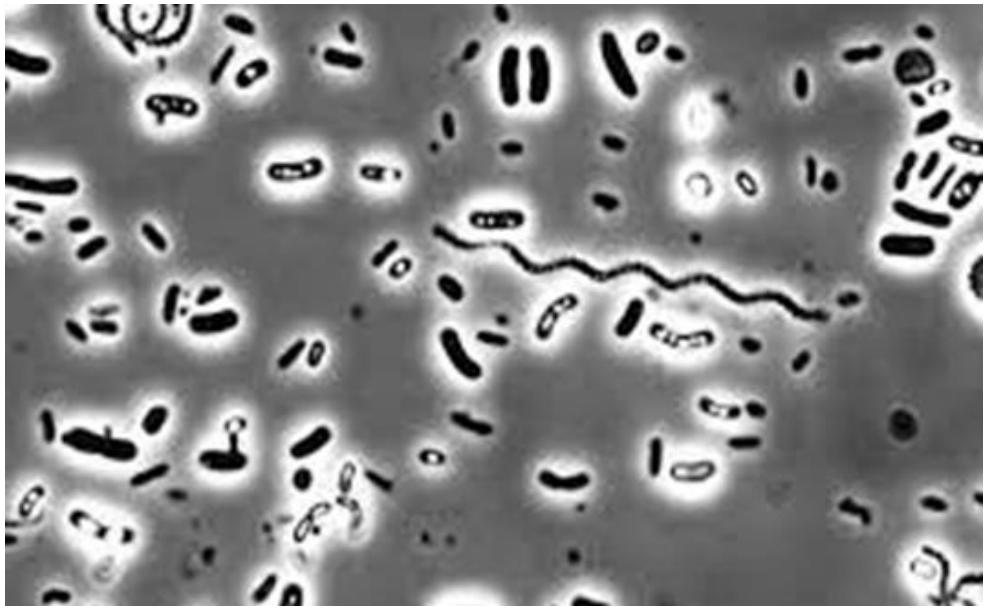
Toxic

General pollutants in textile effluent -

Non-heavy metal hazardous compounds

For successful treatment:

- maintaining steady level of these compounds in effluent
- keeping high MLSS in aeration important
  - bacteria able to degrade these forming naturally and removing these
  - ‘acclimatization’ process of bacteria necessary to, “persuade bacteria to ‘eat’ these since not their favourite food



To remember

- Comprehensive approach needed for controlling of pollutants involving production personnel and ETP operators
  - Effluent quantity and composition influenced by usage of water and process chemicals
  - Pollutants not only negatively affecting environment but also influencing effluent treatment processes.
- As ETP operator,
  - stay informed about changes in selection and changes of chemicals and process practices
  - look beyond removal of colour and treatment of organics pollutants.
  - pay special attention to heavy metals, hazardous compounds and salts.

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