





Wastewater treatment in textile industry by focusing on the application and impact of chemicals involved during the textile production and effluent treatments

ttz Bremerhaven

Workshop, Knowledge Sharing Activity
UMFCCI Building, Yangon
September 25th, 2017

Prof. Dr.-Ing. Gerhard Schories
Head of Institute, TTZ Bremerhaven

Mirko Hänel
Head of R&D, TTZ Bremerhaven

With financial support of the
German Federal Ministry for Economic Cooperation and Development (BMZ)

TABLE OF CONTENT

1. **Textile chemistry and process overview**
2. **Textile fibers and their environmental impacts**
3. **Water, chemicals and dyes used in textile processing and their environmental impacts**
4. **Textile effluent and its characteristics**
5. **Treatment approach from wet processing**

5. Case study Bangladesh

6. Conclusion

7. Questions

8. Refrences

ttz Bremerhaven

1. Textile chemistry

- Ever wonder how certain fabrics protect against the bitter cold, keep athletes cool, or stretch with you as you bend? It's all textile chemistry.
- Textile chemistry is a highly specialized field that applies the principles of chemistry to the production of textiles, such as those used in clothing, furniture, tire yarn, air bags, and much more.
- From cotton corp to manufacturing of garment, the textile chemistry is involved in every step [1]
- During manufacturing, it takes from 10% to 100% of the weight of the fabric *in chemicals* to produce that fabric.
- And the final fabric, if made of 100% natural fibers (such as cotton or linen), contains about 27% , by weight, chemicals. [2]

Preparation of textile chemicals [33]

2. Textile fibers and their environmental impacts

Cotton Production.

- Cotton is the most pesticide intensive crop in the world. While only 2.4 percent of the world's cropland is planted with cotton, it consumes 10 percent of all agricultural chemicals and 25 percent of insecticides. [3]
- Pesticide use for cotton production has serious effects on wildlife. It has been estimated that pesticides sprayed in cotton fields kill at least 67 million birds in the U.S. each year.
- These chemicals typically remain in the fabric after finishing, and are released during the lifetime of the garments. [4]
- It can take more than 20,000 liters of water to produce 1kg of cotton; equivalent to a single T-shirt and pair of jeans. 73% of global cotton harvest comes from irrigated land.[5]

Cotton Farming [34]

ttz Bremerhaven

2. Textile fibers and their environmental impacts

Wool Production.

- More than 9,000 pounds of insecticides were applied to sheep in the U.S. alone in 2010.
- From raising the sheep to cleaning the fiber; it takes approximately 500,000 liters of water to manufacture a metric ton of wool.[6]

Wool production [35]

Nylon & Polyester production.

- Made from petrochemicals, these synthetics are also non-biodegradable, and so they are inherently unsustainable on two counts.
- Nylon manufacture creates nitrous oxide, a greenhouse gas 310 times more potent than carbon dioxide.[7]

Nylon production [36]

Rayon production.

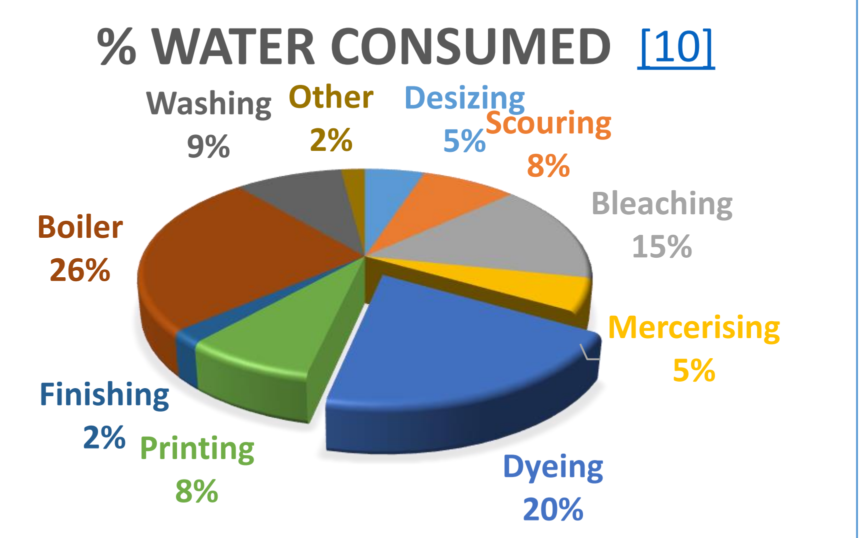
- **Rayon** (viscose), another artificial fiber, is made from wood pulp, which on the face of it seems more sustainable.
- To make rayon, the wood pulp is treated with hazardous chemicals such as caustic soda and sulphuric acid.[8]

RayonFibers [37]

3. Water, chemicals and dyes used in textile processing and their environmental impacts

3.a. Water consumption in textile processes

Water requirements for cotton textile wet finishing processes [9]	
Process	Requirements in L/1000 kg of product
Sizing	500 – 8200
Desizing	2500 – 21000
Scouring	20000 – 45000
Bleaching	2500 – 25000
Mercerizing	17000 – 32000
Dyeing	10000 – 300000
Printing	8000 - 16000



3. Water, chemicals and dyes used in textile processing and their environmental impacts

3.b. Chemicals expelled in waste water

- The textile industry is the #1 industrial polluter of water in the world. [11]
- Vast quantities of water are returned to our ecosystem, untreated, filled with process chemicals – chemicals which circulate in the groundwater of our planet
- Because these chemicals are released into the environment, they become available to living organisms (like us). That's why PBDE's (a fire retardant chemical widely used in the textile and electronics industries) are found in the blood of every animal in the world, from the artic to the amazon – in the most remote parts of the world, far from any industry. And the rate of increase for PBDE's is rising exponentially.
- Disease rates correlated with chemical exposure are on the rise – You can send your children to private schools and provide the best medical care in the world, but you can't protect them from chemical pollution.[12]

Dyes & Chemicals discharged without treatment into fresh water river in china [26]

Wildlife in Danger [38]

3. Water, chemicals and dyes used in textile processing and their environmental impacts

3.c. Process wise chemicals [13]

From pre-treatment of textiles to their finishing, there are various categories and subcategories of textile chemicals.

These chemicals are separate from the use of dyes (used for coloring the fabric) & printing colors (used for printing the fabric).

Process	Chemicals
Pre-treatment chemicals	➢ Scouring agents & low foam scouring agents ➢ Wetting agents & low foam wetting agents ➢ Sequestering agents ➢ Mercerising agents ➢ Peroxide stabilisers ➢ Peroxide killers ➢ Neutralizers
Dyeing chemicals	➢ Solubalisers & dispersents ➢ Levelling agents ➢ Soaping agents ➢ Dyeing agents
Printing chemicals	➢ Vat levelling agents ➢ Thickeners ➢ Binders ➢ Stain removers ➢ Anti back staining agents
Finishing chemicals	➢ Cationic softners flakes/ paste ➢ Nonionic softners flakes/ paste ➢ Anionic softners flakes/ paste ➢ Reactive softners ➢ Cold water soluble softner flakes

ttz Bremerhaven

3. Water, chemicals and dyes used in textile processing and their environmental impacts

3.d. Dyes used in various textile processes [14]

Various dye material are being used in textile industry depending on the variety of fiber.

Textile	Dyes
Cellulose Fiber	Direct dyes, reactive dyes, Vat dyes, Azo dyes, Sulfide dyes
Wool	Acid dyes
Silk	Direct dyes, Acid dyes
Polyester	Azo dyes, disperse dyes
Polyester cotton	Disperse/vat dyes, Disperse/insoluble dyes
Polyacrylonitrile fiber wool	Cationic dyes, acid dyes
Vinylon	Direct dyes, vat dyes, Sulfur dyes, acid dyes

4. Textile effluent and its characteristics

- Among all the textile processes, the wet processes produce most harmful wastewater.
- It is estimated that about 1,000 – 3,000 m^3 of wastewater is reproduced after processing about 12 – 20 tons of textiles per day.
- This water discharge after the production of textiles contains a large amount of dyes and other chemicals that are harmful to the environment.[15]
- Surveys show that nearly five percent of all landfill space is consumed by textile waste. Besides, 20 percent of all fresh water pollution is made by textile treatment and dyeing.[16]

Textile wastes Directly dischrage into Environment in Bihar India [27]

Inorganic substances

- Oxidizing and reducing agents
- Salts
- Acids
- Alkalis
- Dyes

Organic substances

- Dyes
- Organic acids
- Thickeners
- Finishing agents
- Detergents
- Textile auxiliaries

ttz Bremerhaven

4. Nature of effluents released from each step of wet processes [17]

Process	Effluent composition	Pollutant capture	pH	COD (mg/L)	BOD (mg/L)
Desizing	Starch, glucose, Polyvinyl Alcohol (PVA), resins, fats & waxes	Very small volume, high BOD (30 – 50 %) of total, PVA	5.8 – 6.5	10,000 – 15,000	1700 – 5200
Kiering	Caustic soda, waxes, soda ash, sodium silicate& fragments of cloth	Very small, strongly alkaline, dark colour, high BOD values (30 % of total)	10 – 13	1200 – 3300	260 – 400
Bleaching	Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids	Small volume, strongly alkaline, low BOD (5 % of total)	8.5 – 9.6	150 – 500	50 – 100
Mercerizing	Caustic soda	Small volume, strongly alkaline, low BOD (less than 1 %)	8 – 10	100 – 200	20 – 50
Dyeing	Dye stuff, mordant and reducing agents like sulphides, acetic acids and soap	Large volume, strongly coloured, fairy high BOD (6 % of total)	7 – 10	1000 – 3000	400 – 1200
Printing	Dye, starch, gum oil, china clay, mordents, acids & metallic salts	Very small volume, oily appearances, fairly high BOD	8 – 9	250 – 450	115 – 150
Finishing	Traces of starch, tallow, salts, special finishes etc	Very small volume, less alkaline, low BOD.	7.5 – 8.5	300 – 500	100 - 200

ttz Bremerhaven

4. Textile effluent and its characteristics

4.a. Dyes in effluent

- Due to inefficiency of the dyeing processes, up to 200,000 tons of dyes are lost to effluents every year during the dyeing & finishing operations.
- Unfortunately, most of the dyes escape conventional wastewater treatment processes and persist in the environment as a result of their high stabiltiy to light, temperature, water, detergents, chemicals, soap and other parameters such as bleach and perspiration. [18]

4.b. Amounts of un-fixed dyes in the effluent of different fabrics[19]

Fibre	Dye type	Unfixed dye %
Wool & Nylon	Acid dyes	7 – 20
	Pre metallised dyes	2 – 7
Cotton & Viscose	Azoic dyes	5 – 10
	Reactive dyes	20 – 50
	Direct dyes	5 – 20
	Pigment	1
	Vat dyes	5 – 20
	Sulphur dyes	30 – 40
Polyester	Disperse	8 – 20
Acrylic	Modified basic	2 - 3

River in China, polluted by Textile Dyes [28]

4. Textile effluent and its characteristics

Untreated Dye waste water discharged [29]

4.c. Toxicity of dyes

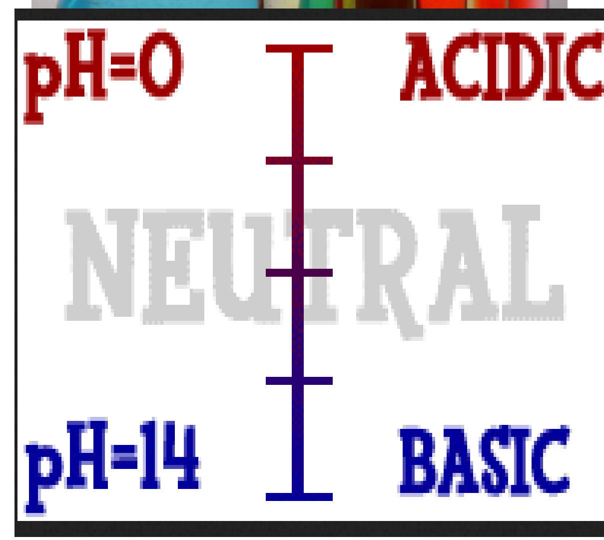
- The measurement of BOD and COD offers a good indication of the organic pollution of water. But these procedures alone are not sufficient to get information about the potential harmful effects of chemicals.
- The toxic effects of other unknown and undetermined substances in complex wastewaters can be estimated only through toxicity studies.
- Toxicity study refers to bioanalytical techniques applied to organisms at various levels to ascertain the harmful effects of chemicals on them. [20]

4.d. Salinity in the effluent

- The salt acts like a glue to hold the dye molecules in place, and with the addition of alkali, a certain percentage of the dyestuff (called the "fixation rate") will permanently grab hold of the fiber and become a part of the fiber molecule rather than remaining as an independent chemical entity. [21]
- For conventional reactive dyes, the fixation rate is often less than 80%, resulting in waste of dyestuff, and also the need to remove that 20% (which is not fixed) from the fabric.

4.e. Chemicals involved in ETP [23]

Chemical	Function
H_2SO_4	Neutralize the waste water controlling the PH. It is auto dispensed in the neutralization tank.
Polyelectrolyte	Used for sedimentation / sludge coagulation and also killing bacteria.
Antifoaming agent	Used for reduction / controlling foam. It is used auto / manually in the distribution tank.
De-colorant	Used for removing color. It is used auto / manually in the sedimentation feeding tank.
Sodium Hypochlorite	It is used to kill the harmful bacteria. It is used in the biological oxidation tank
Sodium Hydroxide	Neutralize the acidic waste water (low pH) controlling the pH
Calcium Hydroxide	Neutralize the acidic waste water (low pH) controlling the pH.
Hydrochloric acid	Neutralize the alkali waste water (high pH) controlling the pH.



4. Textile effluent and its characteristics

4.f. Textile industry standards for water pollutants by the China National Environmental Protection Department		
Parameters	The limits of discharged concentration	The limits of discharged concentration for new factory
COD	100 mg/L	80 mg/L
BOD	25 mg/L	20 mg/L
pH	6 – 9	6 – 9
SS	70 mg/L	60 mg/L
Chrominance	80	60
TN	20 mg/L	15 mg/L
NH3-N	15 mg/L	12 mg/L
TP	1 mg/L	0.5 mg/L
S	1 mg/L	Cannot be detected
ClO_2	0.5 mg/L	0.5 mg/L
Cr^{6+}	0.5 mg/L	Cannot be detected
Aniline	1 mg/L	Cannot be detected

4. Textile effluent and its characteristics

4.g.Germans discharge standards for different indicators of water pollutants

Parameters	The Limits of discharged Concentration
COD	160 mg/L
BOD	25 mg/L
TP	2 mg/L
TN	20 mg/L
NH_3-N	10 mg/L
Nitrite	1 mg/L

4.g.Bagladesh discharge standards for different indicators of water pollutants

Parameter	Unit	Inland Surface Water	Public Sewer secondary treatment plant	Irrigated Land
Ammonical Nitrogen (N molecule)	mg/L	50	75	75
Ammonia (free ammonia)	mg/L	5	5	15
Arsenic	mg/L	0.2	0.5	0.2
BOD_5, 20℃	mg/L	50	250	100
Boron (B)	mg/L	2	2	2
Cadmium (Cd)	mg/l	0.05	0.5	0.5
Chloride (Cl^-)	mg/L	600	600	600
Chromium (total Cr)	mg/L	0.5	1	1
COD	mg/L	200	400	400
Chromium (hexavalent Cr)	mg/L	0.1	1	1
Copper (Cu)	mg/L	0.5	3	3
Dissolved Oxygen (DO)	mg/L	4.5-8	4.5-8	4.5-8
Electrical Conductivity	micro mho/cm	1200	1200	1200
Total Dissolved Solids (TDS)	mg/L	2100	2100	2100
Fluoride (F)	mg/L	7	15	10
Sulfide (S)	mg/L	1	2	2
Iron (Fe)	mg/L	2	2	2
Total Kjeldahl Nitrogen (N)	mg/L	100	100	100
Lead (Pb)	mg/L	0.1	0.1	0.1
Manganese (Mn)	mg/L	5	5	5
Mercury (Hg)	mg/L	0.01	0.01	0.01
Nickel (Ni)	mg/L	1	1	1
Nitrate (N molecule)	mg/L	10	Undetermined	10
Oil & Grease	mg/L	10	20	10
Phenol Compounds (C6H5OH)	mg/L	1	5	1
Dissolved Phosphorus (P)	mg/L	8	8	10

ttz Bremerhaven

5. Treatment approach of textile produce water from wet processing

5.a. General treatment approach

Physiochemical treatment consist of three steps [39]

a. Primary treatment

- *Remove organic colour, suspended solids*
- *Helps in primary reduction of COD and BOD*

a. Secondary treatment

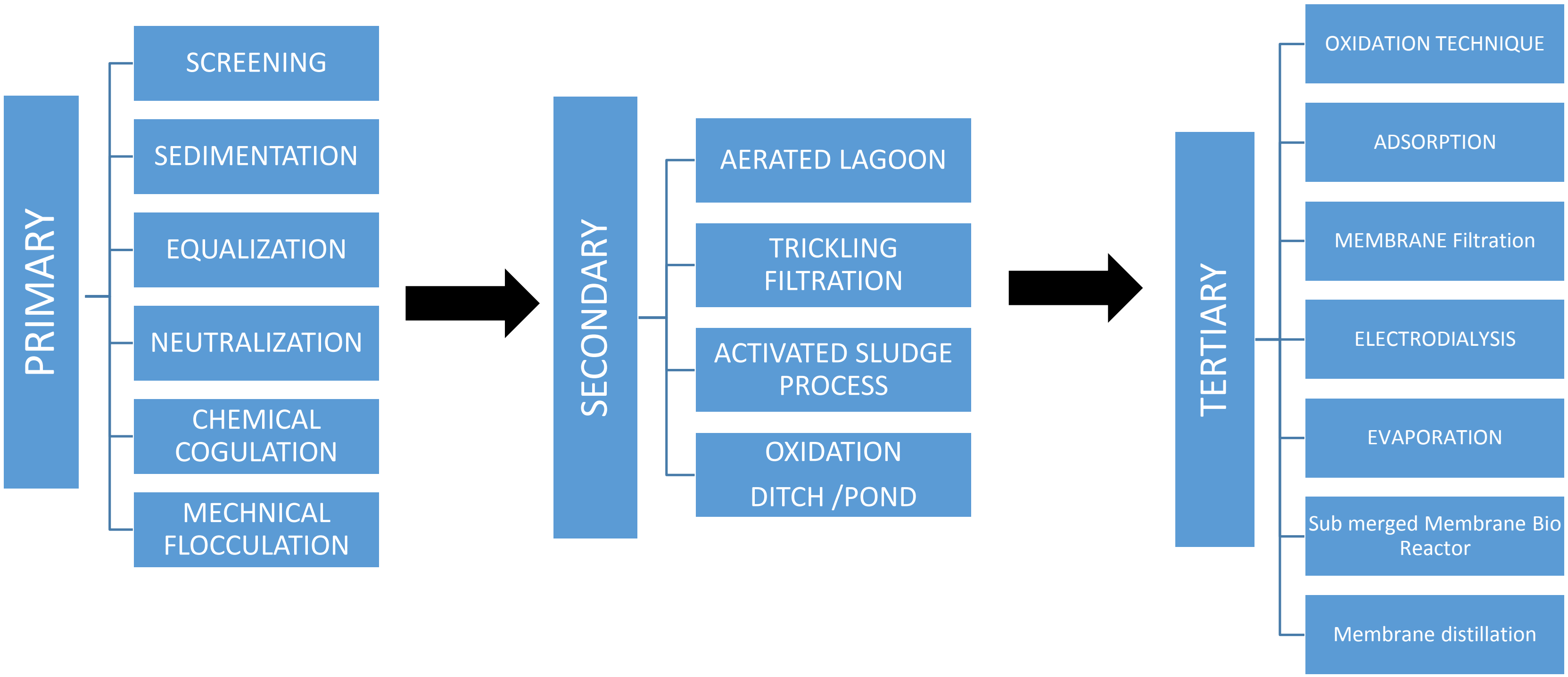
- Remove dissolved and residual organic matter aerobic mode (with air CO_2 & CH_4) or with anaerobic mode)
- Achieved by digestive action of bacteria under suitable conditions
- Reduce COD, BOD and toxicity

a. Tertiary treatment

- Remove dissolved solids (mineral salts) and residual colour and odour
- Water can be easily discharged or reused after treatment
- To reduce further TDS tertiary treatment is implemented
- Several technologies can used to treat water such as membrane filtration, oxidation. Ion exchange, evaporation etc

5. Treatment approach of textile produce water from wet processing

5.a. General treatment approach



<u>Physiochemical treatment [39]</u>

5. Treatment approach of textile produce water from wet processing

5.b.Problem & solution

Problems:

Mixing of all streams of wastewater results into:

- High BOD & COD
- Huge volume
- Extra cost for treatment
- Requires huge area for treatment
- More energy required
- More man power requried
- Inefficient treatments
- High chemical demand

Solutions:

Segregation of effluent depends on the combination of different wet process streams such as

- Bleaching, mercerizing & finishing have low volume of effluent with low COD & BOD.
- Dyeing & printing their washing have huge volume with high BOD , COD, colour appearance etc.
- Desizing & kiering have high BOD, COD with low volume.

5. Treatment approach of textile produce water from wet processing

ttz Bremerhaven

5.c.TTZ cascading approach of textile wet processing

1. DESIZING
W/w Amount: 28m3/d
COD: 16000 mg/l
Possible pollutants in waste water: Starch, glucose, Polyvinyl Alcohol (PVA), resins, fats & waxes
Nature of waste water: Very small volume, high BOD (30 – 50 %) of total, PVA

→

2. SCOURING
W/w Amount: 33m3/d
COD: 8000mg/l
Possible pollutants in waste water: Caustic Soda, waxes, soda ash, sodium silicate& fragments of cloth
Nature of waste water: Very small, strongly alkaline, dark colour, high BOD values (30 % of total)

→

3. BLEACHING
W/w Amount: 40m3/d
COD: 9000mg/l
Possible pollutants in waste water: Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids
Nature of waste water: Small volume, strongly alkaline, low BOD (5 % of total)

→

4. MERCERIZING
W/w Amount: 50m3/d
COD: 1600mg/l
Possible pollutants in waste water: Caustic soda,
Nature of waste water: Small volume, strongly alkaline, low BOD (less than 1 %)

↓

5. WASHING
W/w Amount: 200m3/d
COD: 2290 mg/l
Possible pollutants in waste water: Washing agent
Nature of waste water: BOD, COD, pH, TDS, TSS, O&G, fluff

←

6. DYEING
W/w Amount: 800m3/d
COD: 3000mg/l
Possible pollutants in waste water: Dye stuff, mordant and reducing agents like sulphides, acetic acids and soap
Nature of waste water: Large volume, strongly coloured, fairy high BOD (6 % of total)

←

7. PRINTING
W/w Amount: 600m3/d
COD: 2500 mg/l
Possible pollutants in waste water: Dye, starch, gum oil, china clay, mordents, acids & metallic salts
Nature of waste water: Very small volume, oily appearances, fairly high BOD

←

8. FINISHING
W/w Amount: 1500m3/d
COD:2000 mg/l
Possible pollutants in waste water: Traces of starch, tallow, salts, special finishes etc, small volume
Nature of waste water: Very small volume, less alkaline, low BOD.

Example: 15000 M/day Fabric is Processing

ttz Bremerhaven

5.c.TTZ Cascading approach of textile wet processing

Segregation

- Stream 5 — WASHING
  - Washing agents , fluffs, acids
  - Strongly alkaline, BOD 50 – 100, COD 1000 – 2500 mg/L

↓

- Stream 1 — DESIZING
  - Starch, glucose, Polyvinyl Alcohol (PVA), resins, fats, waxes
  - Small volume, BOD 1700 –5200 mg / L, COD 10,000 – 18,000 mg/L

↓

- Stream 2 — SCOURING
  - Caustic Soda, Soda ash, Sodium Silicate, waxes, fragments of cloths
  - BOD 250 – 400 mg/L, COD 1200 – 9000 mg/L

↓

50 - 60 % of BOD from 1700 – 5200 mg/l
COD 10,000 – 18,000 mg /l
pH 8 – 10
30 % of total volume of Effluent

Stand alone treatments
-
possible treatment technologies:
Biological treatment, membrane Separation process.

Membrane filtration & techniques:

Membrane separation process is the method that uses the membrane's micropores to filter and makes use of membrane's selective permeability to separate certain substances in wastewater. Currently, the membrane separation process is often used for treatment of dyeing wastewater mainly based on membrane pressure, such as reverse osmosis, ultra filtration, nano filtration and microfiltration.

Membrane separation and phases‘ composition

	Feed	Permeate
Microfiltration	liquid, suspension, emulsion	liquid
Ultrafiltration	liquid, suspension, emulsion	liquid
Nanofiltration	liquid, suspension, emulsion	liquid
Reverse osmosis	liquid	liquid
Electrodialysis	liquid	liquid (ions)
Pervaporation	liquid	gas
Gas permeation	gas	gas

MBR

- MBR systems are compact, state-of-the art sewage treatment systems that use membrane technology to decontaminate and clean sewage water to recyclable standards.
- MBR systems has the following advantages against conventional systems:

  - Small footprint required
  - Fully automated
  - High removal efficiency
  - Free pathogen effluent
  - Low sludge generation
  - Low visual impact
  - Remote monitoring and control
  - Easily adaptable to existing systems
  - Easy maintenance and reparation

FILTRATION SYSTEMS

- FILTRATION systems are compact, state-of-the art treatment systems that use and combine different technologies of filtration (membranes, disc filter, sand filter) and treatment to decontaminate and clean industrial water to recyclable standards.
  - Small footprint required
  - Fully automated
  - High removal efficiency
  - Free pathogen effluent
  - Optimised energy consumption

ttz Bremerhaven

DOSING SYSTEMS

- **DOSING systems are complete dosing pump systems for large or small volumes within flocculation, disinfection, and pH adjustment. There are “plug and pump” solutions with optimised hydraulic design.**

  - Plug and pump systems
  - Wide flow range
  - Solenoid pumps
  - Peristaltic pumps
  - Motor driven pumps

Practical applications

SBR and MBR combination system: urban and textile wastewater (Pune), India

- Type of application: Urban and textile wastewater (approx. 350 PE)
- Footprint: 8x8 m
- Membrane type: Flat sheet Ultrafiltration
- Filtration surface: 70 m^2
- Cut-off: 0.04 µm
- Flow: 45 m^3/day
- Trans-membrane pressure: 80 mbar
- Energy consumption: 1.2 kWh/m^3

Practical applications

Reverse Osmosis unit (285 m^3/d)

- Type of application: Water Reuse in industrial textile facility
- Footprint (WxLxH): 5 x 2.5 x 2.5 m
- Type of membrane: RO membrane Toray
- Number of units: 10
- Pretreatment: Microfiltration cartridges
- Working pressure: 16 bar
- System recovery: 70 %
- Flow: 285 m^3/d
- Power installed: 3.56 kW

ttz Bremerhaven

Practical applications

Reverse Osmosis unit ($25 m^3/d$)

- Type of application: Production of low conductivity water for a cooling tower
- Footprint (WxLxH): 1 x 2.5 x 1.8 m
- Type of membrane: RO membrane Toray
- Number of units: 7
- Pretreatment: 2 filters of 5 & 1 µm
- Working pressure: 5.0 bar
- System recovery: 65 %
- Flow: 25 m^3/d
- Effluent conductivity: 24 µS/cm
- Power installed: 0.4 kW

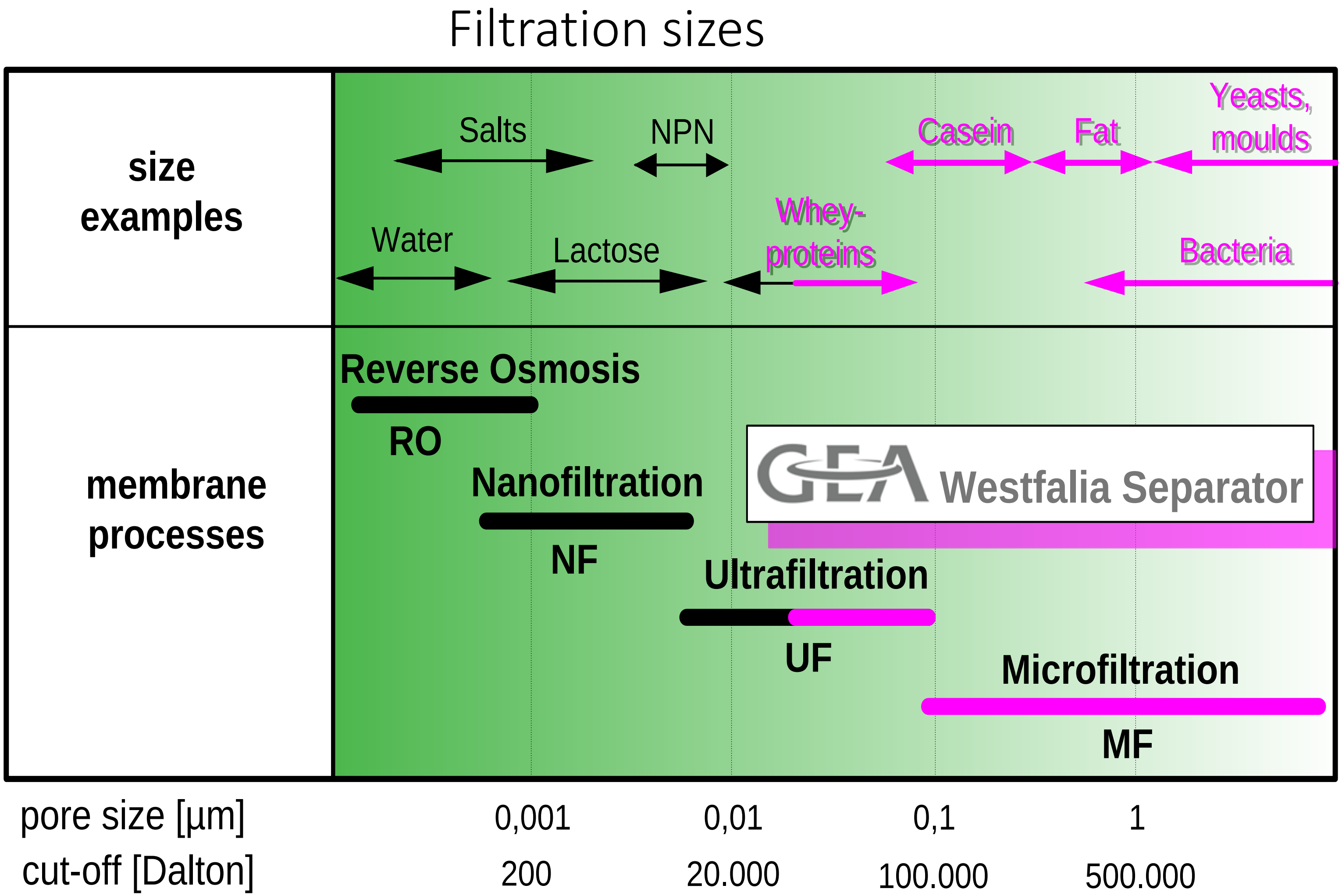
ttz Bremerhaven

Practical applications

Reverse Osmosis unit ($5 m^3/d$)

- Type of application: Production of low conductivity water for a chemical industry
- Footprint: 0.5 x 0.5 x 1.8 m
- Type of membrane: RO membrane Toray
- Number of units: 1
- Pretreatment: 2 filters of 5 & 1 µm
- Working pressure: 4.5 bar
- System recovery: 75 %
- Flow: $5 m^3/d$
- Effluent conductivity: 10 µS/cm
- Power installed: 0.6 kW

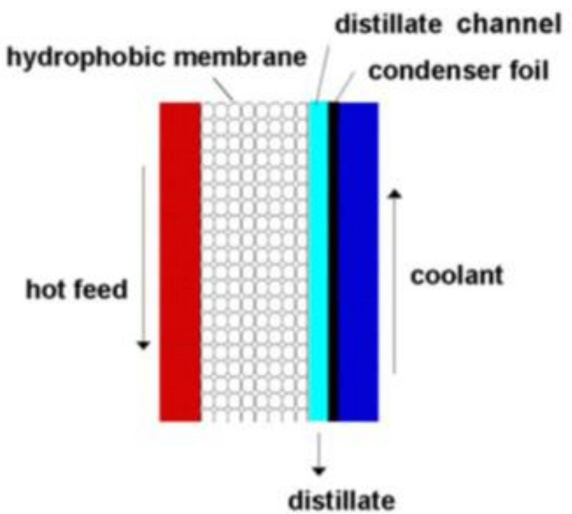
Membrane filtration & rejected substances [40]:



Membrane distillation

Membrane distillation is a thermally driven separational process in which separation is enabled due to phase change

- Driving force is the vapor pressure gradient.
- 30°C to 80°C feed temperature
- Waste heat or solar pannel [44]



General process MD [43]

Principle of membrane distillation:

- Mostly use a static pressure difference as the driving force between the two bounding surface.
- Selectivity of a membrane is produced by either its pore size in relation to the size of the substance.
- Membranes are made of hydrophobic synthetic material (e.g. PTFE, PVDF or PP) and offer pores with a standard diameter between 0.1 to 0.5 µm. [44]

TTZ Pilot scale MD unit

ttz Bremerhaven

5.c.TTZ Cascading approach of textile wet processing

Segregation

Stream 3 — BLEACHING

Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids

Small volume, strongly alkaline, BOD 50 – 100, COD 1500 – 10,000 mg/L

↓

Stream 4 — MERCERISE

Caustic soda, small volume, strongly alkaline, low BOD (less than 1 %)

BOD 20 – 50 mg / L, COD 500 – 2000 mg/L

↓

Stream 8 — FINISHING

Traces of starch, tallow, salts, special finishes etc, small volume

BOD 100 – 200 mg/L, COD 500 – 2000 mg/L

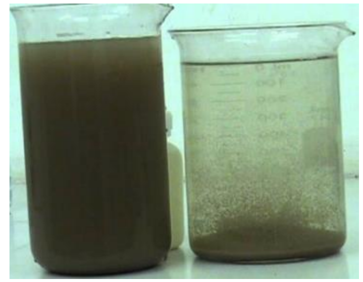
↓

5 % of BOD from 100 – 200 mg/L
COD 500 – 10000 mg / L
pH 8 – 10
30 % of total volume of effluent.

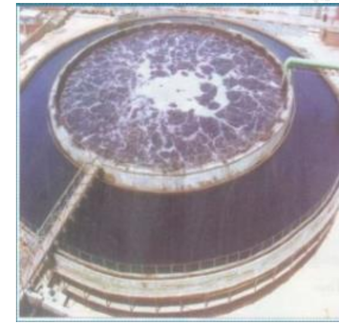
Stand alone treatments
-
Possible treatment technologies:
Neutralization, chemical coagulation & electrodialysis.

Possible Treatment Technologies[40]

Screening

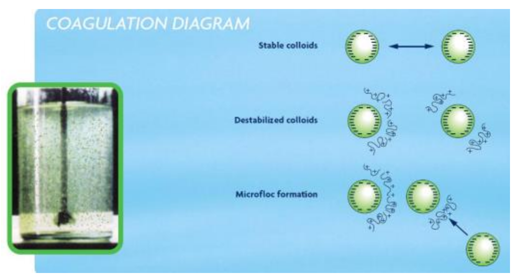


Sedimentation

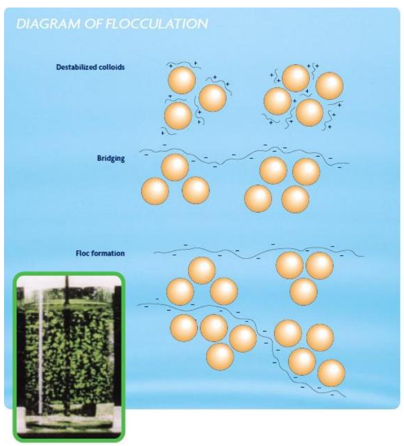


Equalization

Neutralization



Chemical coagulation



Floculation

5.c.TTZ Cascading approach of textile wet processing

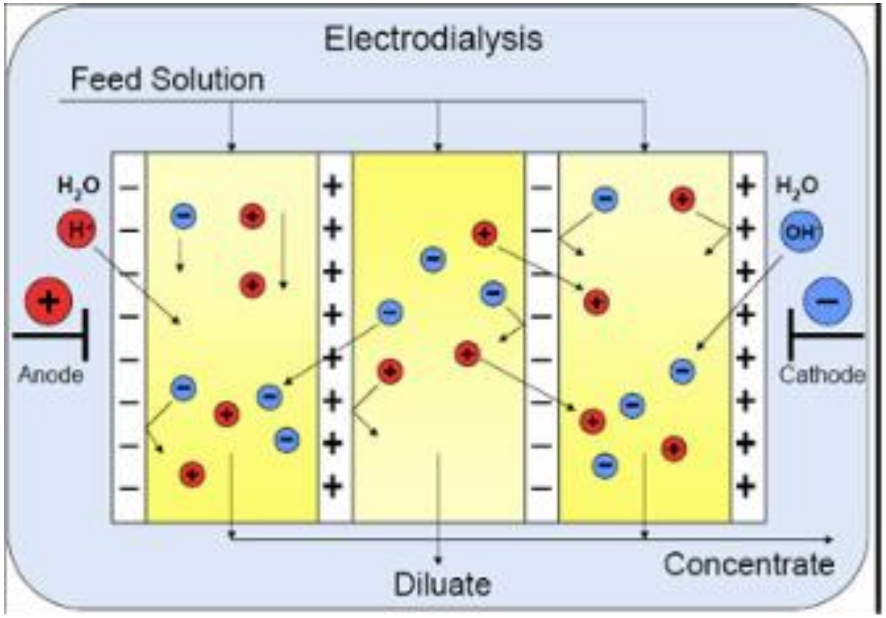
Electrodialysis :

- Passing water between two plates with opposite electrical charges.

- The cations attracted to negative charge
- Anions are attracted to positive charge.
- Both types of ions can be removed
- Electrodialysis is used on very hard water, more than 500 mg/L as Calcium Carbonate [41]

.

TTZ laboratory scale electrodialysis



Electrodialysis process [41]

5.c.TTZ Cascading approach of textile wet processing

Segregation

- Stream 6 — DYEING

Dye stuff, mordant , reducing agents, Sulphides, Acetic acid, soap, strongly colored,

BOD 400 – 1200, COD 1000 – 3000 mg/L

↓

- Stream 7 — PRINTING

Dye, starch, gum oil, mordants, metallic salts, low BOD (less than 1 %)

BOD 115 – 150 mg / L, COD 250 – 2500 mg/L

↓

- Stream 9 — WASHING

Unfixed dyes, printing colors, BOD 100 – 300 mg/L, COD 500 – 1000 mg/L

↓

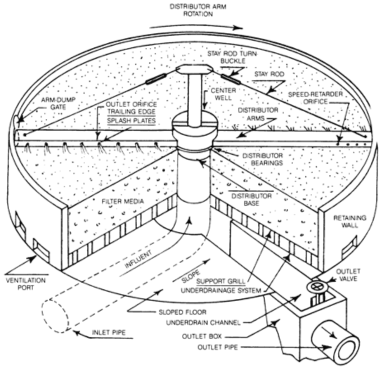
40 - 45 % of BOD from
300 – 1200 mg/L
COD 1,000 – 3,000 mg / L
pH 8 – 10
40 % of total volume of effluent.

Stand alone Treaments
-
Possible Treatment Technologies ,
Biological & Physiochemical Combined Treatment Processes
Activated Sludge Process, Chemical Oxidation, Zero Liquid Discharge

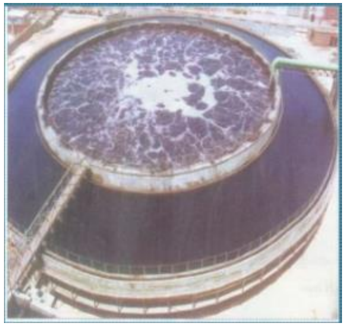
Possible Treatment Technologies[41]

Screening

Aerated Lagoon

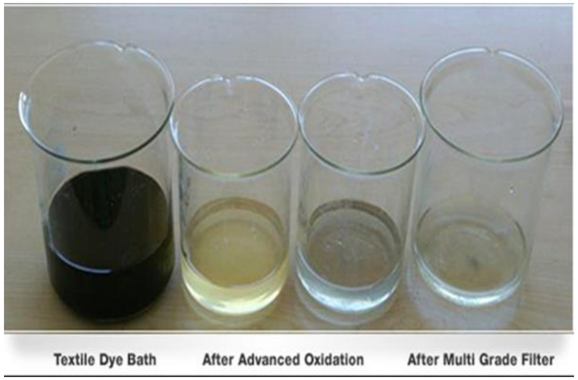


Trickling Filtration



Activated Sludge

Oxidation



Ozone Oxidation

Reuse

Advanced Oxidation Process/Ozonation [41]

- ***Conventional oxidation treatment*** have found difficulty to oxidize dyestuffs and complex structure of organic compounds:
  - At ***low concentration*** or
  - If they are especially ***refractory to the oxidants.***
- The goal of any AOPs design is to ***generate and use hydroxyl free radical (HO·)*** **as strong oxidant** to destroy compound that can not be oxidized by conventional oxidant.
- AOP processes are combination of :
  - Ozone (O_3),
  - Hydrogen peroxide (H_2O_2) and
  - UV radiation, which showed the greatest promise
- These oxidants effectively decolorized dyes, however did not remove COD completely.

Textile Dye Bath After Advanced Oxidation After Multi Grade Filter

Ozone]:

- Ozone is powerful oxidising agent for water and wastewater.
- Once dissolved in water, ozone reacts with great number of organic compounds in two different ways:
  - By indirect oxidation as molecular Ozone or
  - By indirect reaction through formation of secondary oxidants like hydroxyl radicals
- The conventional fine bubble contactor is the most widely ozone generator used becuase of high ozone mass transfer efficiency (90%) and high performance.
- Results presented by a few researchers revealed that ozone decolorize all dyes, except non-soluble disperse and vat dyes which react slowly and take longer time.
- Colour removal using ozone from textile wastewater is dependent on the dye concentration.

Evaporation:

Evaporation is a sustainable approach, which consists of a series of wastewater treatment techniques which lead to a solid (or near solid) waste stream and purified water stream which can be treated further or (re-)used for industrial applications.

Example-Ethiopia

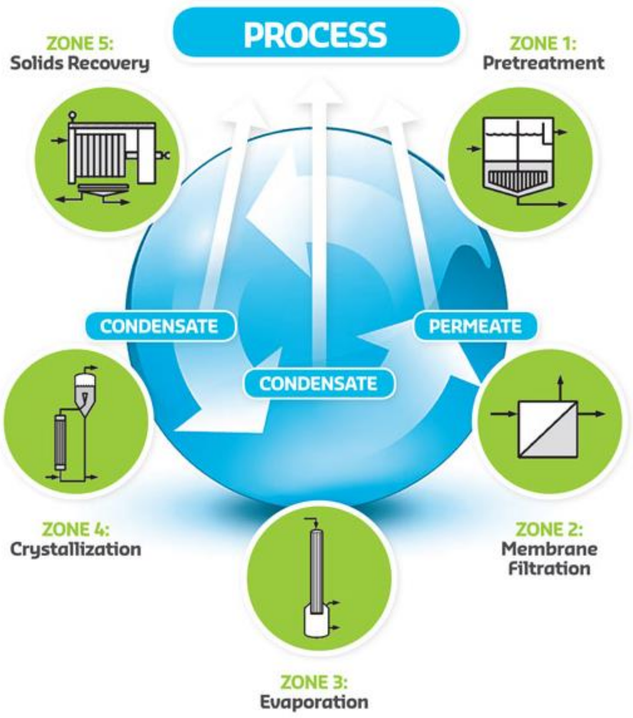
TTZ experts visited textile factories in Ethiopia, the outcome of these visits are:

Kanoria Africa Textile PLC

- 90% water reuse (ZLD orientation) with evaporation system.
- 30 litres of water is needed for 1 meter of denim material.

Bahir Dar Textile SC

- Effluent quality after treatment is at BOD 20 mg/l and COD 30 mg/l.
- Own laboratory for 10 different parameters for water quality (pH, conductivity, COD and BOD measures, etc.)



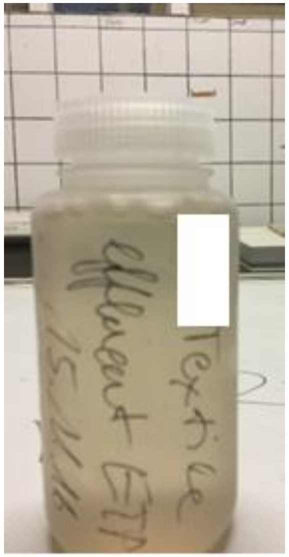
Zero Liquid discharge through Evaporation [42]

6. Bangladesh, a case study

Example for Ozone treatment

Sample	COD/CSB	Conductivity	Salinity	pH	PO4	NO3	Hardness	Arsenic(As)	Ca2+	Mg2+
	mg/l	mS/cm	g/l		mg/l	mg/l	°dH	mg/l	mg/l	mg/l
1. Effluent	42.5	1.791	0.8	7.86	3.97	12.7	3.97	0	18.4	6.04
2. Influent	177	6.73	4.1	11.88	5.55	3.8	1.8	0.005	5.93	4.18

Influent

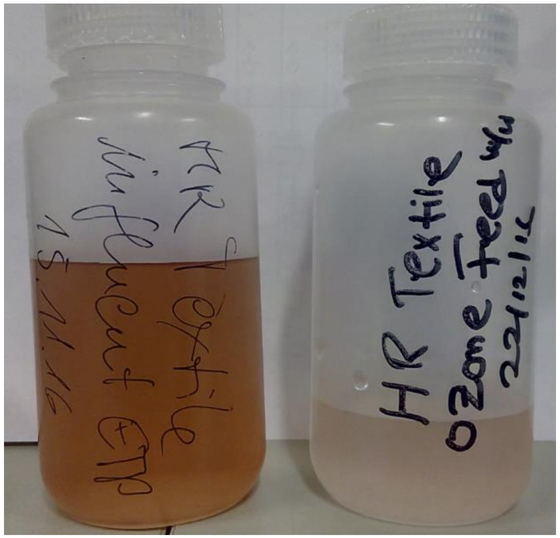


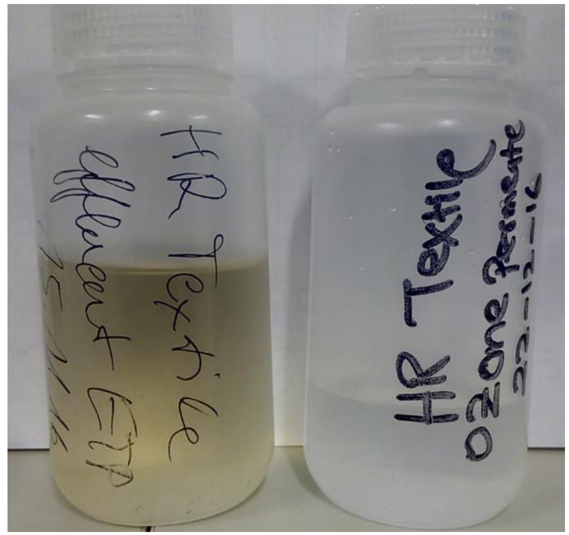
Effluent

ttz Bremerhaven

6. Bangladesh, a case study

Treatment with Ozone 2g/l

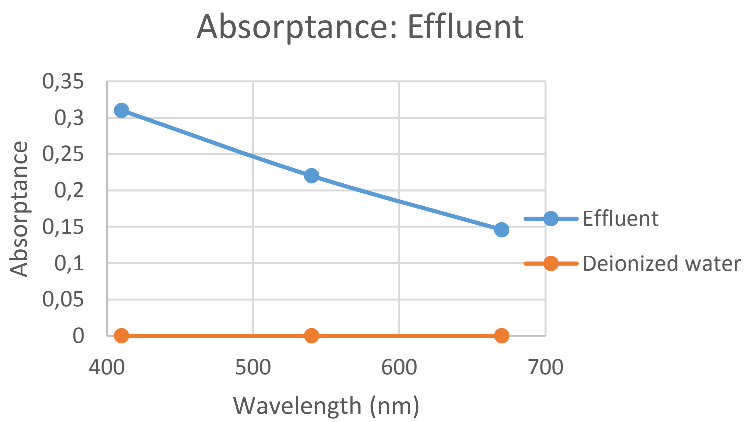


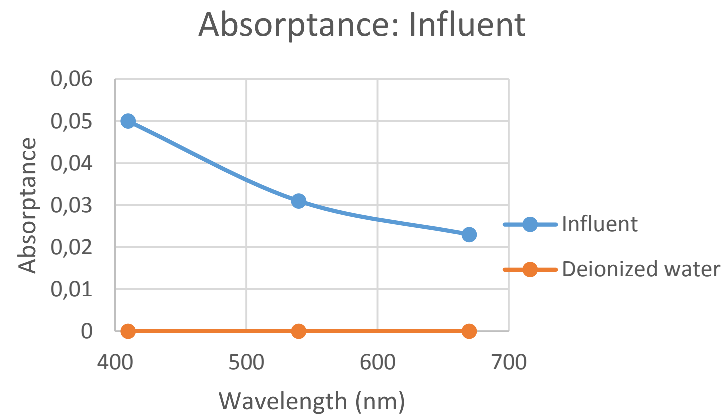


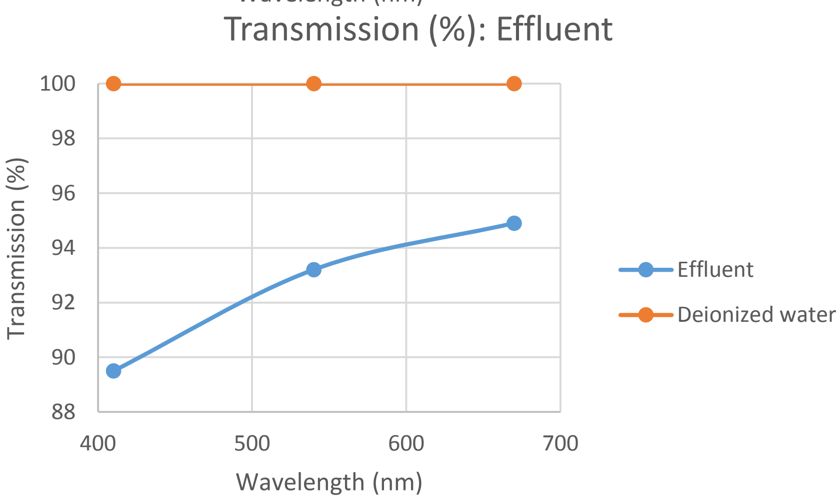
Influent before Ozone treatment | **Influent after Ozone treatment** | **Effluent before Ozone treatment** | **Effluent after Ozone treatment** | **TTZ lab scale Ozone Generator unit**

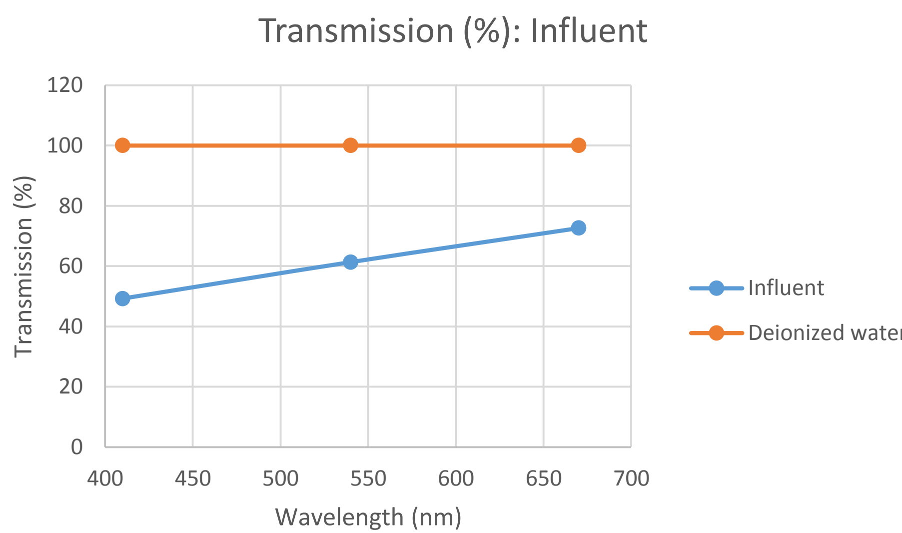
Bangladesh, a case study

Results after Ozone treatment









The Bangladesh samples showed some signs of general improvements after they were subjected to Ozone treatment. The post-ozone treated samples were consistently found to have higher transmittance. It was noticed that the improvement is more pronounced at lower frequencies. At 410 nm, for example, there is an increase in transmittance of about 23% but at a wavelength of 670 nm, the transmittance increases only 1.6%. However, the absorbance of the samples, contrary to what one would have expected, increased in the post-ozone treated samples and the departure from the deionized water values were significant.

ttz Bremerhaven

7. Conclusion

- The global textile and garment industry (including textile, clothing, footwear and luxury fashion) is currently worth nearly $3000 trillion [47].
- Wastewater production and disposal is one main problem currently textile industry is facing.
- The textile industry has been condemned as being one of the world's worst offenders in terms of pollution because it requires a great amount of two components:

  -Chemicals: as many as 2000 different chemicals are used in the textile industry, from dyes to transfer agents; and

  -Water: a finite resource that is quickly becoming scarce, and is used at every step of the process both to convey the chemicals used during that step and to wash them out before beginning the next step [48].
- A suitable combination of standard and tailor made solution for the treatment is needed for each customer.
- Segregation of different waste stream and treatment is one of the possible solution.
- Learning Lesson from other countries

ttz Bremerhaven

7. Discussion

- What is the current status? Development
- Which lessons can be learnt from other countries?
- What would be the next steps to be taken?
- ????

Thanks for your attention!

Prof. Dr. Gerhard Schories
Head of Institute (TTZ Bremerhaven)

Mirko Hänel
Head R&D, TTZ Bremerhaven

Am Lunedeich 12
D-27572 Bremerhaven

Phone: +49 (0)471 80934-191
Fax: +49 (0)471 80934-199
Email: Mhaenel@ttz-bremerhaven.de

www.ttz-bremerhaven.de

ttz Bremerhaven

ttz Bremerhaven

References

1. https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/textile-chemistry.html
2. https://oecotextiles.wordpress.com/2013/01/10/chemicals-used-in-textile-processing/
3. http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/thirsty_crops/cotton/
4. http://www.fibre2fashion.com/industry-article/1709/impact-of-textiles-and-clothing-industry-on-environment?page=2
5. http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/thirsty_crops/cotton/
6. https://www.sbcmag.info/news/2017/jun/smart-wall-benefits-organic-wool-insulation
7. http://www.fibre2fashion.com/industry-article/1709/impact-of-textiles-and-clothing-industry-on-environment?page=2
8. http://www.fibre2fashion.com/industry-article/1709/impact-of-textiles-and-clothing-industry-on-environment?page=2

ttz Bremerhaven

References

9. https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.php?aid=22482
10. https://texnoteblog.wordpress.com/page/20/
11. https://oecotextiles.wordpress.com/tag/1-industrial-polluter-of-water/
12. https://oecotextiles.wordpress.com/2011/03/09/what-effects-do-fabric-choices-have-on-you/
13. http://www.teonline.com/knowledge-centre/textile-chemicals.html
14. https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.php?aid=22482
15. https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.php?aid=22482 http://www.fibre2fashion.com/industry-article/6262/undefined
16. https://www.intechopen.com/books/eco-friendly-textile-dyeing-and-finishing/textile-dyes-dyeing-process-and-environmental-impact

References

17. https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.pdf
18. https://www.intechopen.com/books/eco-friendly-textile-dyeing-and-finishing/textile-dyes-dyeing-process-and-environmental-impact
19. https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.pdf
20. http://www.ipublishing.co.in/ijesarticles/twelve/articles/volthree/EIJES31094.pdf
21. https://oecotextiles.wordpress.com/category/chemicals/salt-chemicals/
22. https://oecotextiles.wordpress.com/2013/01/16/textile-chemicals-beginning-with-the-one-used-the-most/
23. http://textilelearner.blogspot.de/2013/03/required-chemicals-and-their-functions.html

ttz Bremerhaven

References

24) .
25) https://www.omicsonline.org/open-access/production-characterization-and-treatment-of-textile-effluents-a-critical-review-2157-7048.1000182.php?aid=22482
26) https://lanaplantae.com/2015/02/16/mordant-madness/
27) http://www.eco-business.com/news/bihars-toxic-textile-industry/
28) https://www.changemakers.com/discussions/entries/fungi-based-waste-water-treatment
29) http://www.jbbardot.com/toxic-fashion-wrapping-your-body-in-an-dangerous-environmental-and-health-nightmare
30) https://blogs.scientificamerican.com/plugged-in/duke-study-finds-radium-and-elevated-salinity-in-treated-oil-and-gas-wastewater-highlights-need-for-revised-water-quality-regulations/#
31) http://extwprlegs1.fao.org/docs/pdf/eth44004.pdf
32) http://www.ais.unwater.org/ais/pluginfile.php/231/mod_page/content/188/Session3b_CountryReport_Teklu_Ethiopia.pdf

ttz Bremerhaven

References

33. http://www.myklassroom.com/Engineering-branches/43/Textile-Chemistry
34. http://blog.agrivi.com/post/growing-cotton-within-a-cooperative
35. http://nice.klapp.no/en/professional-guide/production/wool.html
36. http://www.explainthatstuff.com/nylon.html
37. https://www.pinterest.com/pin/341921796690280093/
38. https://www.worldwildlife.org/industries/cotton
39. https://www.slideshare.net/textilevandana/waste-water-and-its-treatment-in-textile-industry
40. https://en.wikipedia.org/wiki/Membrane_technology
41. https://www.slideshare.net/GranchBerheTseghai/textile-effluent-treatment

References

42. http://chinawaterrisk.org/resources/analysis-reviews/zero-liquid-discharge-a-real-solution/

43. solarspring.de

44. S. Bandini, C. Gostoli, and G. C. Sarti, —Role of heat and mass transfer in membrane distillation process,‖ Desalination, vol. 81, pp. 91-106, July 1991

45. (S. Judd)

46. (Mallevialle et al., 1996).

47. http://www.cochawaii.org/30-shocking-figures-and-facts-in-global-textile-and-apparel-industry

48. http://www.oecotextiles.com/PDF/textile_industry_hazards.pdf

ttz Bremerhaven

8. Programme Refrences

- Sustainable Action & Vision for Better Environment
- SAVE project. SAVE is Public Private Partnership (PPP) project co-financed by DEG (KFW), a German developmental organization, and PUMA, one of the world's leading Sports Brands.
- The project was overseen by PUMA and H&M and implemented at 35 suppliers in cooperation with ASSIST, a leading NGO based in Asia

➢ Manufacturing Restricted Substance list , A ZDHC Programme (Zero Discharge of Hazardous Chemicals Programme)

▪ Chemical Management System guidance Manual, A ZDHC Programme (Zero Discharge of Hazardous Chemicals Programme)

❖ WasteWater Guidelines, A ZDHC Programme (Zero Discharge of Hazardous Chemicals Programme)

8. Refrences

Reviewed Literature

- http://textileguide.chemsec.org/find/get-familiar-with-your-textile-production-processes/
- https://www.slideshare.net/nishohel/wet-processing-23961418
- http://www.dupont.com/products-and-services/industrial-biotechnology/industrial-enzymes-bioactives/articles/what-is-desizing.html
- http://textilefashionstudy.com/scouring-definition-objectives-effects-and-methods-of-scouring/
- http://textilelearner.blogspot.de/2011/03/textile-bleaching-process_5937.html
- http://dyeingworld1.blogspot.de/2010/02/fabric-mercerising-process.html
- https://www.britannica.com/technology/textile/Dyeing-and-printing
- http://textilefashionstudy.com/reactive-dyes-definition-classification-properties-and-influencing-factors/
- http://textilelearner.blogspot.de/2011/02/defination-classification-application_2111.html

8. Refrences

- https://textileapex.blogspot.de/2013/12/disperse-dye_1.html
- http://www.food-info.net/uk/colour/azo.htm
- http://textilelearner.blogspot.de/2012/03/why-so-called-vat-dye-classification-of.html
- http://www.dharmatrading.com/home/did-you-know-how-acid-dye-works.html
- http://textilelearner.blogspot.de/2011/07/printing-method-method-of-printing_5617.html
- http://sswm.info/sites/default/files/reference_attachments/SHAKIH%202009%20Water%20conservation%20in%20the%20textile%20industry.pdf
- https://www.researchgate.net/publication/258365448_Chemical_Properties_of_Treated_Textile_Dyeing_Wastewater
- http://article.sapub.org/10.5923.j.re.20150501.03.html
- http://www.oecotextiles.com/PDF/textile_industry_hazards.pdf

ttz Bremerhaven

8. Refrences

http://przyrbwn.icm.edu.pl/APP/PDF/128/a128z2bp122.pdf

http://cdn.intechopen.com/pdfs/22395.pdf

http://www.iwapublishing.com/news/physico-chemical-water-treatment-processes

https://emis.vito.be/en/techniekfiche/chemical-oxidation-techniques

http://www.pjoes.com/pdf/14.1/11-16.pdf

http://cdn.intechopen.com/pdfs/22395.pdf

http://www.ipcbee.com/vol87/rp005_ICAER2015-A0005.pdf

https://www.intechopen.com/books/advances-in-treating-textile-effluent/textile-dyeing-wastewater-treatment

https://www.cotton.org/journal/2007-11/3/upload/jcs11-141.pdf

8. Refrences

- https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwiE1baJ-IDUAhVC1ywKHbX1CvcQFghSMAM&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9789811021879-c2.pdf%3FSGWID%3D0-0-45-1584722-p180182080&usg=AFQjCNFDLXyobLe7Rs2HnkZdZf9Z0l5wCw&sig2=U-1f6v23ljC9U5gNe8mcFA
- https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwiE1baJ-IDUAhVC1ywKHbX1CvcQFghSMAM&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9789811021879-c2.pdf%3FSGWID%3D0-0-45-1584722-p180182080&usg=AFQjCNFDLXyobLe7Rs2HnkZdZf9Z0l5wCw&sig2=U-1f6v23ljC9U5gNe8mcFA
- https://www.cotton.org/journal/2007-11/3/upload/jcs11-141.pdf

ttz Bremerhaven

8. Refrences

- https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwiE1baJ-IDUAhVC1ywKHbX1CvcQFghSMAM&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9789811021879-c2.pdf%3FSGWID%3D0-0-45-1584722-p180182080&usg=AFQjCNFDLXyobLe7Rs2HnkZdZf9Z0l5wCw&sig2=U-1f6v23ljC9U5gNe8mcFA.

- http://cpcb.nic.in/newitems/27.pdf

- http://cpcb.nic.in/newitems/27.pdf

- https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwiE1baJ-IDUAhVC1ywKHbX1CvcQFghSMAM&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9789811021879-c2.pdf%3FSGWID%3D0-0-45-1584722-p180182080&usg=AFQjCNFDLXyobLe7Rs2HnkZdZf9Z0l5wCw&sig2=U-1f6v23ljC9U5gNe8mcFA

- http://www.iosrjournals.org/iosr-jmce/papers/vol8-issue5/I0856268.pdf?id=7187