Unit 6.1. Sustainable substances and wastewater treatments

Content

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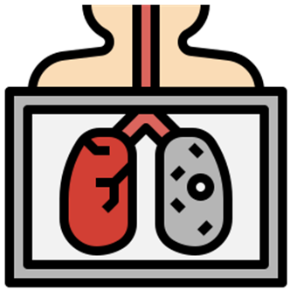
6.1.1 Legislation and regulation on the use of substances in textile and campaigns

- Chemicals are used at every step in the textile manufacturing: from the farm, where pesticides may be used for growing raw materials, to the production of textile itself, such as for dyeing and finishing processes

- Many of them are potentially hazardous to human health and the natural world. Up to 3.500 chemical substances are used to turn raw materials into textiles, approximately 10 percent of these are hazardous to human health or the environment[1]
- Adverse reported effects are:
  - allergic reactions
  - respiratory diseases
  - increased instances of cancer in humans
  - loss of aquatic life
  - soil contamination
  - global warming/ GHG emission



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Elimination of substances of concern from textiles production is required to enable healthy flows of materials in a circular system, along with methods to remove those that remain in circulation from existing textiles.

There has already been a significant industry shift, driven by increasing demands for transparency on the environmental costs of dyes and other chemicals used in the textiles industry from NGOs, governments, and customers pressurising players along the value chain to act[2]

Figure 1. Example of dyeing process in textile industry[3]

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REACH Regulation (EU) No 1907/2006

Source[4]

- In 2006 European Union adopted its REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) regulation, supported by several global clothing brands, conscious of a heightened level of consumer awareness in Europe on the issue of hazardous chemicals in products[5].

- The aim is the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

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- It covers the registration, evaluation, authorization and restriction of chemicals produced or imported in the EU over 1 tonne per annum. Companies have become largely responsible for the safety assessment of substances and the classification and labelling of substances. They are obligated to provide the European Chemicals Agency (ECHA) with all the required information on these substances[6]

- On 1 November 2020, Regulation (EU) 2018/1513 amending Annex XVII to REACH Regulation (REACH) entered into force.

- Annex XVII to REACH contains restrictions on the manufacture, placing on the market and use of certain substances. In this case, this new regulation includes restrictions for certain substances considered to be CMRs (carcinogenic, mutagenic and toxic to reproduction) of category 1A or 1B, thus adding entry 72 to the Annex.

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- with the aim of protecting the health of consumers, this restriction applies to:
  - clothing or related accessories
  - textiles other than clothing which, under normal or reasonably foreseeable conditions of use, come into contact with human skin to an extent similar to clothing
  - footwear[7]

Table 1. Example of substances restricted for use in textiles (REACH Annex XVII)[6]

Substance	Restriction
Mercury compounds	In the impregnation of heavy-duty industrial textiles and yarn intended for their manufacture
Tris(2,3 dibromopropyl) phosphate	Shall not be used in textile articles, such as garments, undergarments and linen, intended to come into contact with the skin.

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Biocides Regulation (EU) 528/2012

- The Biocidal Products Regulation (BPR, Regulation (EU) 528/2012) concerns the placing on the market and use of biocidal products, which are used to protect humans, animals, materials or articles against harmful organisms like pests or bacteria, by the action of the active substances contained in the biocidal product. This regulation aims to improve the functioning of the biocidal products market in the EU, while ensuring a high level of protection for humans and the environment.
- The text was adopted on 22 May 2012 and will be applicable from 1 September 2013, with a transitional period for certain provisions. It will repeal the Biocidal Products Directive (Directive 98/8/EC).
- Biocides can be applied to textiles with a specific intention, such as to serve an antibacterial function[8].

Source[9]

POP Regulation (EC) 850/2004

- Persistent organic pollutants (POPs) are substances that persist in the environment, i.e. bioaccumulate, are transported across international boundaries far from their sources and pose a risk to the environment as well as to human health. POPs are characterized by low water solubility, high lipophilicity, semivolatile, high molecular weight and stability.
- The objective of the regulation (EC) 850/2004 is to protect human health and the environment by prohibiting, phasing out as soon as possible, or restricting the production, introduction to the market and use of these substances. Some of them are also used for the production of textiles[10].

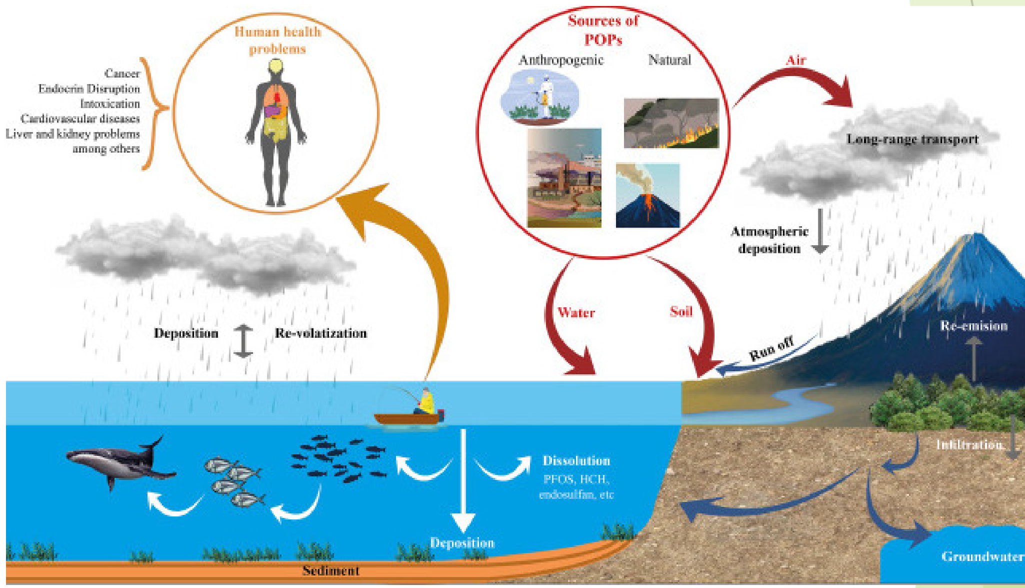

Figure 2. Effects of POPs of environment and human health[11]

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Extra European regulation

- In the US, the TSCA (Toxic Substances Control Act) regulates both the introduction of new chemicals and the use of existing chemicals. This law was introduced in 1976 and updated in 2016 by the Frank R. Lautenberg Chemical Safety for the 21st Century Act.
- China's MEP Order 7 (also known as China REACH) was released by the Chinese Ministry of Environmental Protection (MEP) and came into force on October 2010: chemical manufacturers and importers were required to submit notifications and obtain approvals before producing or importing chemicals. From January 2021 it was replaced by MEE Order 12 that shall apply if companies plan to manufacture or import chemicals not listed in the Inventory of Existing Chemical Substance in China (IECSC)
- Companies often develop Restricted Substances Lists (RSLs) to provide global suppliers with guidelines limiting the amount of chemicals that can be present in finished products. Manufacturers can also implement their own RSLs to restrict hazardous chemicals used during the manufacturing process.

Source[12]

Source[13]

Source[14]

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The Greenpeace Detox Campaign

Detox My Fashion is a campaign launched by GreenPeace in 2011 with the goal of making the fashion industry more sustainable, inviting fashion brands to a more environmentally friendly production. Brands signing the Greenpeace Detox Commitment implement preventive and precautionary action on chemicals, by setting goals to eliminate hazardous chemicals in manufacturing.

The key elements of the Detox Commitment are:

- Chemical management
- Transparency
- Substitution and elimination

Source[15]

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- **Chemical management:** creation of a Manufacturing Restricted Substances List (M-RSL), initially focussed on 11 priority hazardous chemical groups and testing for them in wastewater discharges and sludge. MRSL informs on bans and timelines for phase-out towards the 2020 goal of elimination of all hazardous chemicals[16]

Table 2. Some of the 11 priority hazardous chemical groups and examples of uses and hazards[16]

Chemical villains	Examples of use/functions	Examples of hazards to environment and human health and relevant regulation
Azo dyes with cleavable carcinogenic	Dyes and colourants	Release chemicals known as aromatic amines, which are carcinogenic for these azo dyes. Banned by the EU in textiles that come into contact with human skin.
Per- and polyfluorinated chemicals (PFCs)	Water-, oil-, stain-resistant coatings	Many PFCs are persistent and bioaccumulative. Some can affect the liver or act as endocrine disruptors, altering levels of growth and reproductive hormones.

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- **Transparency:** publication of wastewater testing data by suppliers to reveal the discharge of hazardous chemicals and track progress over time, and the inclusion of wet processing suppliers in suppliers lists
- **Substitution and elimination:** with a particular focus on alkylphenol ethoxylates (APEs), per- and polyfluorinated chemicals (PFCs) and phthalate

Greenpeace decided to pause its Detox campaign in response to the significant improvements of the industry. The NGO's decision is due to the progress made in the sector, particularly through the industry's response to its campaign, the Zero Discharge of Hazardous Chemicals (ZDHC).

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The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

Source[17]

- Collaboration of leading brands, value chain affiliates, and associate contributors committed to advancing towards zero discharge of hazardous chemicals in the textile, leather, and footwear value chain, thereby reducing harm to the environment and human well-being.
- ZDHC was founded in 2011 by Six brands, they individually signed public commitments with Greenpeace to commit to zero discharge of hazardous chemicals by 2020 and today consists of 85 contributors, divided into three categories - 23 Signatory Brands, 47 Value Chain Affiliates and 15 Associates.

The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

Objectives:

- To eliminate or replace hazardous chemicals from the entire production chain
- To promote safer chemistry
- To improve chemical management through tools, best practices and training
- To develop collaboration with stakeholders in order to promote transparency about chemical used/discharged

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The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

ZDHC MRSL

The Manufacturing Restricted Substances List (ZDHC MRSL) is a list of chemical substances banned from intentional use during manufacturing and related processes in supply chains of the textile, apparel, and footwear (including leather and rubber) industries

This tool is designed to support brands, retailers, suppliers, and manufacturers with a unified approach to managing chemicals during the processing of chemical formulations, within the apparel and footwear supply chain[18].

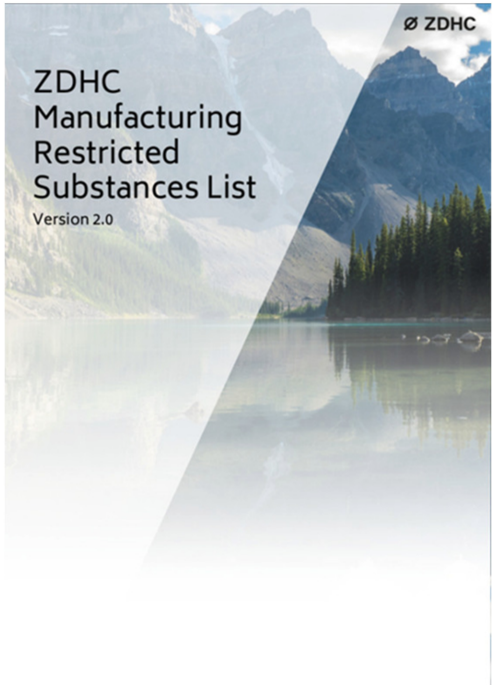

Figure 3. ZDHC MRSL[19]

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The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

ZDHC toolkit

ZDHC Gateway – Chemical Module**:** his online platform containing the world's first database of safer and more sustainable and innovative chemistry for the entire value chain. It currently includes nearly 10,000 chemical products at different levels of ZDHC MRSL conformance.

ZDHC Wastewater Guidelines: it defines a single, unified standard for wastewater testing that goes beyond regulatory compliance and conventional wastewater testing parameters

ZDHC Gateway– Wastewater Module: it discloses verified wastewater test results publicly, the global online platform to register and share verified data on wastewater tests conducted against the ZDHC Wastewater Guidelines

ZDHC's Academy: it offers certified training

ZDHC Implementation HUB: it helps organizations to find accredited experts for support on implementation challenges[16]

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The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

ZDHC MRSL conformance Levels

The ZDHC MRSL conformance Levels means that the chemical formulation does not contain any of the chemical substances on the ZDHC MRSL above the ZDHC MRSL threshold. Levels are 0,1,2,3.

Higher conformance levels are expected to reflect a higher confidence that a chemical product meets the ZDHC MRSL conformance levels, and therefore a lower probability of any ZDHC MRSL substances being present in the certified chemical product.

The ZDHC decided to leverage existing certification as indicators of ZDHC MRSL conformance.

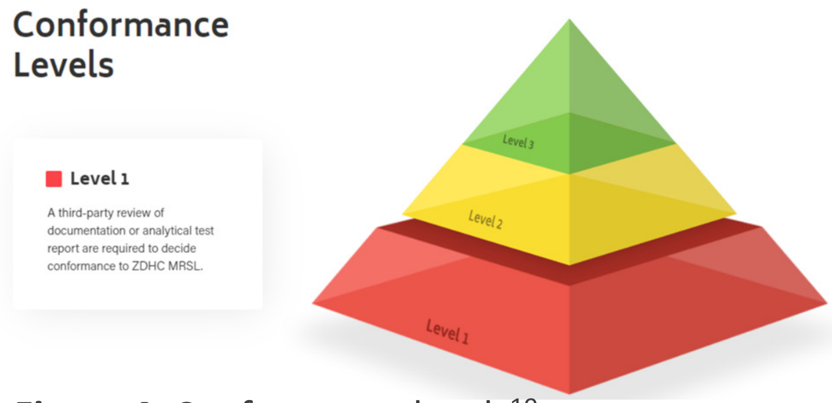

Figure 4. Conformance levels[19]

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The Zero Discharge of Hazardous Chemicals (ZDHC) Programme

ECO PASSPORT by OEKO-TEX®

Independent certification system for chemicals, colourants and auxiliaries used in the textile and leather industry, by which chemical manufacturers and suppliers can demonstrate that their products meet specific standards.

OEKO-TEX®
CONFIDENCE IN TEXTILES
ECO PASSPORT

Source[21]

ZDHC accepted OEKO-TEX's ECO PASSPORT as an indicator of compliance with their MRSL in 2017[20]

Bluesign®

Holistic system that provides solutions in sustainable processing and manufacturing to industries and brands based on five principles of sustainability:

- ✓ Resource productivity
- ✓ Consumer safety
- ✓ Water emission
- ✓ Air emission
- ✓ Occupational health & safety[22]

bluesign®
PRODUCT

Source[23]

It is the newest ZDHC Accepted Certification Standard to indicate ZDHC MRSL conformance at the highest level 3.

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6.1.2 Reduction and substitution of hazardous substances with safer alternatives

The substitution of hazardous substances is an important measure to protect the environment, as well as the health and safety of workers and consumers.

Stricter chemicals legislation gives an incentive for the textile industry to substitute hazardous chemicals with safer alternatives. Many of the world's largest textile manufacturers have already formed a joint initiative to reduce the number of hazardous chemicals in their products. Several tools and techniques are available to help substitution in the textile industry.

Source: Pixabay[23]

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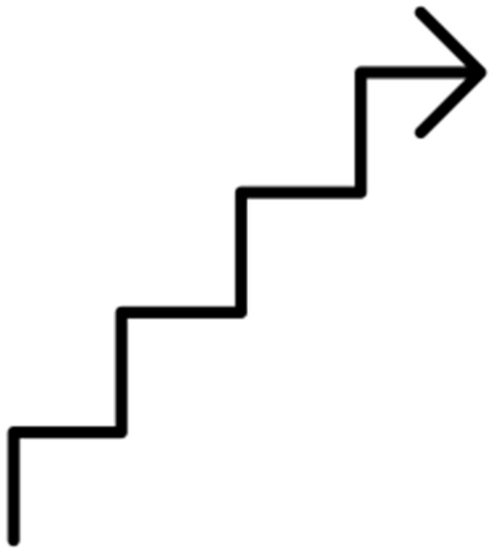
Steps of the substitution process

- Define the function, use and need of the substance you want to replace
- Define criteria for the alternative
- Search for available alternative solutions
- Evaluate and compare alternatives
- Test on a pilot scale
- Implement substitution



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Steps of the substitution process

Define the function, use and need of the substance you want to replace
It is very useful to consider about substitution using these different levels – function, use and need

Define criteria for alternatives
Before moving on to assessing and comparing alternatives it is important to think through what you want for alternative

Search for available alternative solutions
The following channels are recommended:

- In-house knowledge
- Trade associations
- Networks of stakeholders (e.g. the ZDHC group)
- Reports from authorities (e.g. ECHA, US EPA, KEMI and others)
- Web-based resources (e.g. SUBSPORT, OECD, MARTEKPLACE and others)
- Suppliers
- Chemical producers and formulators

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Source[25]

Marketplace

- global platform where business-to-business companies can find safer alternatives to hazardous chemicals, enabling buyers and suppliers to start substituting chemicals of concern.
- Possibility to filter for chemical functions, relevant industry or a specific hazardous chemical that you are looking for safer alternatives
- It represents a new way to market safer alternatives and green chemistry solutions online[26].

Source[27]

Subsport (Substitution Support Portal)

Platform for information exchange on alternative substances and technologies, as well as tools and guidance for substance evaluation and substitution management[28].

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OECD Substitution and alternatives toolbox (SAAT)

OECD BETTER POLICIES FOR BETTER LIVES

Source[28]

A compilation of resources relevant to chemical substitution and alternatives assessments:

- Alternatives Assessment Tool Selector : it provides information about the main tools (databases, guides, methodologies and models) that can be used to make substitutions or evaluations of alternatives.
- Alternatives Assessment Frameworks: A summary of the current frameworks that can be used to assess alternatives.
- Case Studies and Other Resources: links to case studies with examples substitution approaches, to other substitution support portals and websites (e.g. Subsport, Substitution-CMR, etc.) and product safety assessment systems (e.g., Cradle to Cradle, Product Innovation Institute, CleanGredients, etc.).
- Regulations and Restrictions: it provides a table of restricted substances lists and related laws and regulations organized by geographic scope[29]

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Steps of the substitution process

Possible safer alternatives in textile processes

Table 3. Alternative substances in textile processes manufacturing[30]

Process	Substances used	Possible alternative for substitution
Scouring	Acid alkylphenol ethoxylates TSP, NaOH Alkyl benzene sulphonates NTA, EDTA	Hydrogen peroxide and enzymes Fatty alcohol ethoxylates, Sodium carbonate Fatty alkyl sulphates, Polyglycolether Zeolites (sodium aluminium Silicate)
Bleaching	Reductive sulphur Chlorine compounds	Peroxide bleaches, Peroxide bleaches
Dyeing (1)	Benzidine based dyestuffs and other amine releasing dyes Dichromate used for oxidation in vat and sulphur dyes Acetic acid in the dyeing bath Dispersants for dyes and chemicals Copper sulphate used to treat direct dyes	Mineral/pigment dyes Peroxide, air oxygen, metal free agents Formic acid Water based system Polymeric compound

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Process	Substances used	Possible alternative for substitution
Dyeing (2)	Dye Powder in automatic injection Sodium hydrosulphite Stabilised Aldehyde and toxic metallic salts used as auxiliaries Sodium sulphide	Liquid dyes Sodium hydrosulphite High molecular weight polymeric auxiliaries Glucose based reducing agents
Printing	Kerosene or white spirit	Water based systems
Finishing	Formaldehyde Alkylphenol dimethylol dihydroxyethylene urea MAC complexing agents like DTDMAC, DSDMAC, DHTDMAC	Polycarboxylic acids Fatty alcohol ethyoxylates Polycarboxylic acids Cellulase enzymes
Flame retarding	Asbestos, Halogenated compounds and heavy metals compounds	Inorganic salts and non-halogenated phosphonates
Preservation	Biocides such as chlorinated phenols (PCP), metallic salts (As, Zn, Cu or Hg), DDE, DDT, Benzothiazole	UV treatment, mechanical or enzymatic finishing

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Steps of the substitution process

Evaluate and compare alternatives

The following aspects can be considered when assessing alternatives:

- ✓ Hazard assessment
- ✓ Functionality of alternatives
- ✓ Availability of alternatives
- ✓ Costs
- ✓ Changes to processes
- ✓ Life-cycle considerations: energy, waste/discharge, carbon dioxide emissions, etc.

✓

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Steps of the substitution process

Test on a pilot scale

- ✓ Carry out a practical pilot test before implementing full-scale substitution to evaluate the feasibility of the alternative
- ✓ Assess substitution as regards to functional performance, impact on workers, environment or consumers.
- ✓ Pay attention to possible shift of risks and the necessary control measures

Implement substitution

Update the supply chain and inform the downstream users and collect extended feedback from workers and clients.

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6.1.3 Minimization and reuse of textile wastewater: innovative treatments and technologies

- Each textile process utilizes a large amount of water (up to 100L/kg textile product) which will finally become wastewater
- The characterization of wastewater of individual process suggested that wastewaters are highly polluted including high concentration of organics, color, and metals
- the World Bank estimates that 20% of industrial wastewater pollution worldwide originates from the textiles industry.
- The most significant sources of pollution among various process stages are pretreatment, dyeing, printing, and finishing of textile materials.

Source: Pixabay[24]

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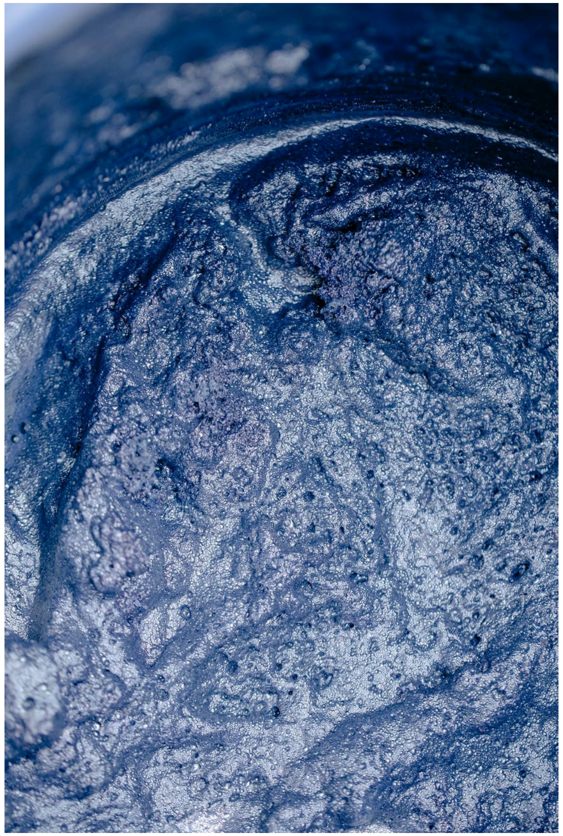
Composition of effluents

The textile effluents are typically highly coloured, usually alkaline, Biochemical oxygen demand (BOD)* chemical oxygen demand (COD)** at high concentrations and a variety of toxic contaminants such as suspended solids(SS), dissolved solids (DS) dyes, acids, bases, salts, surfactants, chlorinated compounds, oxidizing and reducing agents



Source: Pexels[31]

*the concentration of oxygen consumed during the degradation of organic compounds contained in a wastewater sample

** the overall oxygen concentration required for to chemical oxidation of all the organic compounds contained in a wastewater sample

Table 4. Effluent production from different process of textile industries[32]

Process	Effluent composition	Nature of wastewater
Sizing	Starch, waxes ,carboxymethyl cellulose (CMC) Polyvinyl alcohol (PVA) wetting agents	High in BOD, COD
Desizing	Starch, CMC, PVA, fats, waxes, pectins	High in BOD, COD, SS, DS
Bleaching	Sodium hypochlorite, Cl2, NaOH, H2O2, acids, surfactants, NaSiO3, sodium phosphate	High salinity, high SS
Mercerizing	Sodium hydroxide	High pH, low BOD, high DS
Dyeing	Dyestuffs urea, reducing agents, oxiding agents ,acetic acid, detergents, wetting agents	Strongly colored, high BOD, DS, low SS
Printing	Pastes, urea, starches, gums, oils, binders, acids reducing agents, alkali	Highly colored, high BOD, oily appearance, SS slightly alkaline, low BOD

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Wastewater treatment

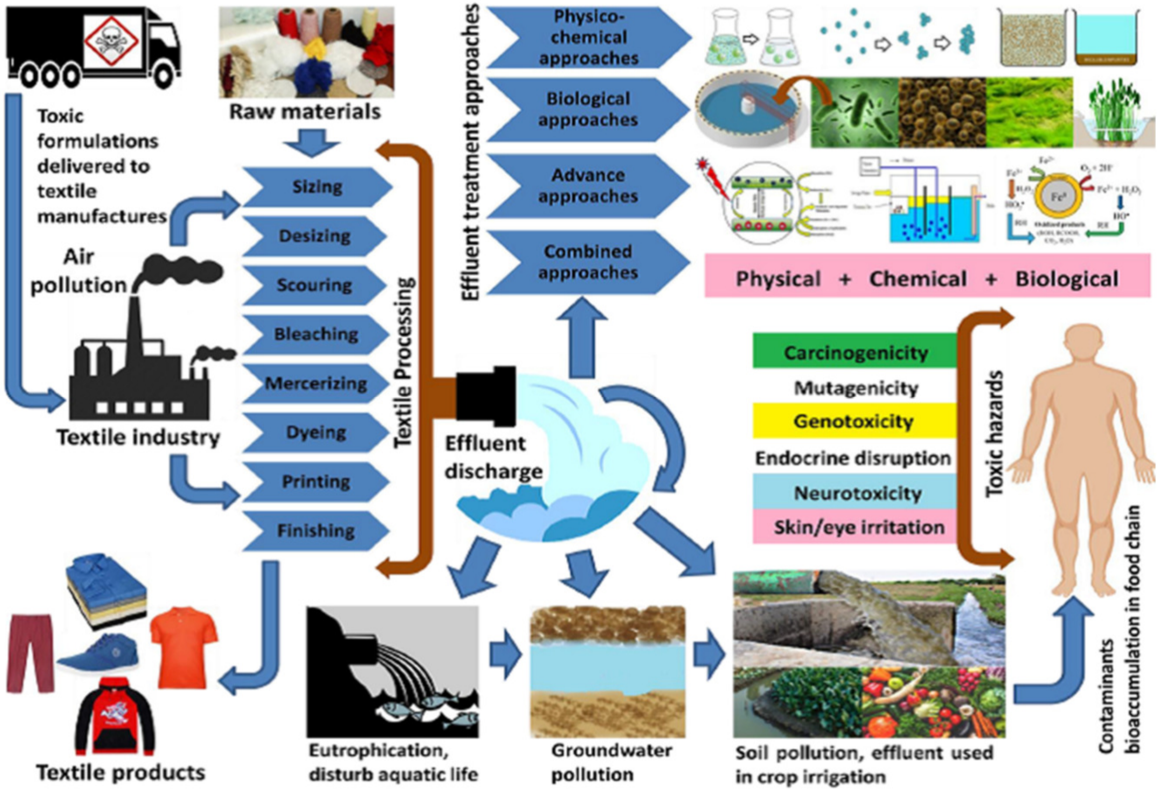
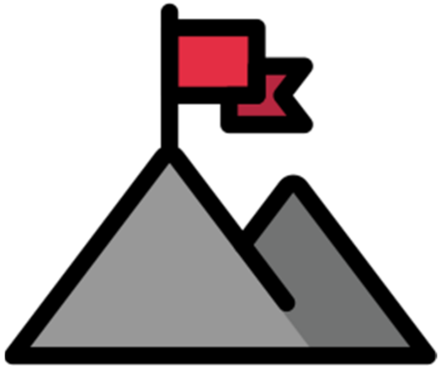


Figure 5. Processing in textile industry, wastewater generation, its toxicity and various treatment approaches [33]

Objectives of wastewater treatment

- To ensure discharge of good water quality to the natural environment
- To remove pollutants most efficiently and at the lowest cost
- To avoid and/or minimise other environmental impacts – odour creation, gas emission, noise production and solid disposal
- To produce treated water for reuse and recycling
- To recover salts if economically viable[34]



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Classification of wastewater treatment

Primary treatment: remotion of floating and settleable materials, i.e., suspended solids, organic matter, excessive quantities of oil and grease and gritty materials (physical and chemical). In primary treatment, textile effluent undergoes screening for coarse suspended particles such as yarn, lint, pieces of fabric, fibres and rags, using bars and fine screens. The screening process is carried out by sedimentation, which uses gravity to settle suspended particles. In most cases coagulation-flocculation processes is applied to improve solids separation[32].

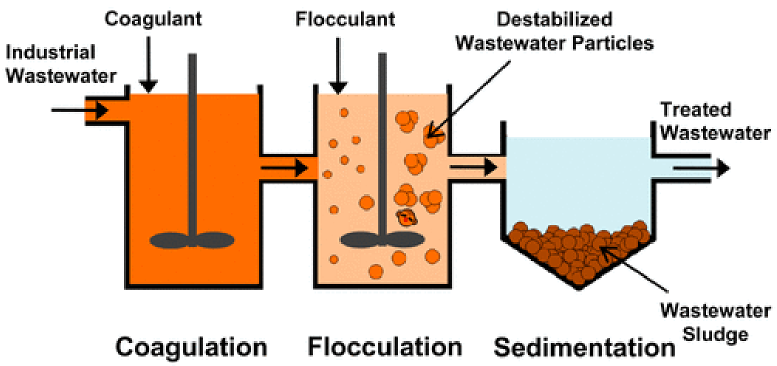

Figure 6. Block of Flocculation Process Diagram[35]

Figure 7. Sedimentation tank[36]

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Classification of wastewater treatment

Secondary treatment: The biological mechanism has a significant role for the removal of organic pollutants. 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. The most common processes are aerobic (presence of oxygen) as Activated sludge process (ASP) and anaerobic (absence of oxygen).

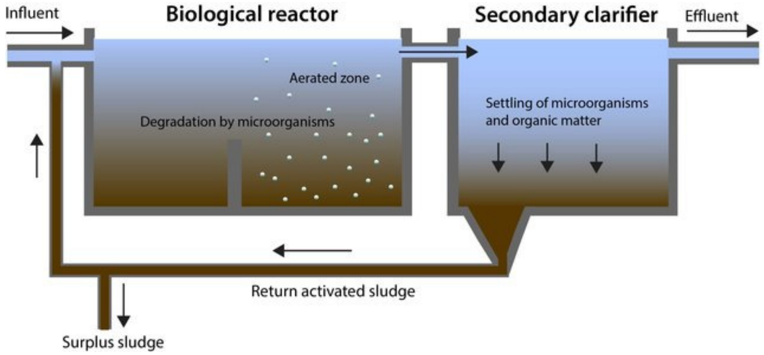

Figure 8. Schematic description of an activated sludge system[37]

Tertiary treatment: Processes to complete solids and organic matter removal, for color reduction or recalcitrant compounds degradation, nutrient (ammonia and phosphorous more common in domestic sewage) reduction and disinfection. Most common tertiary application includes filtration, disinfection, and removal of microbes or salts using membranes[34].

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Classification of Wastewater treatment

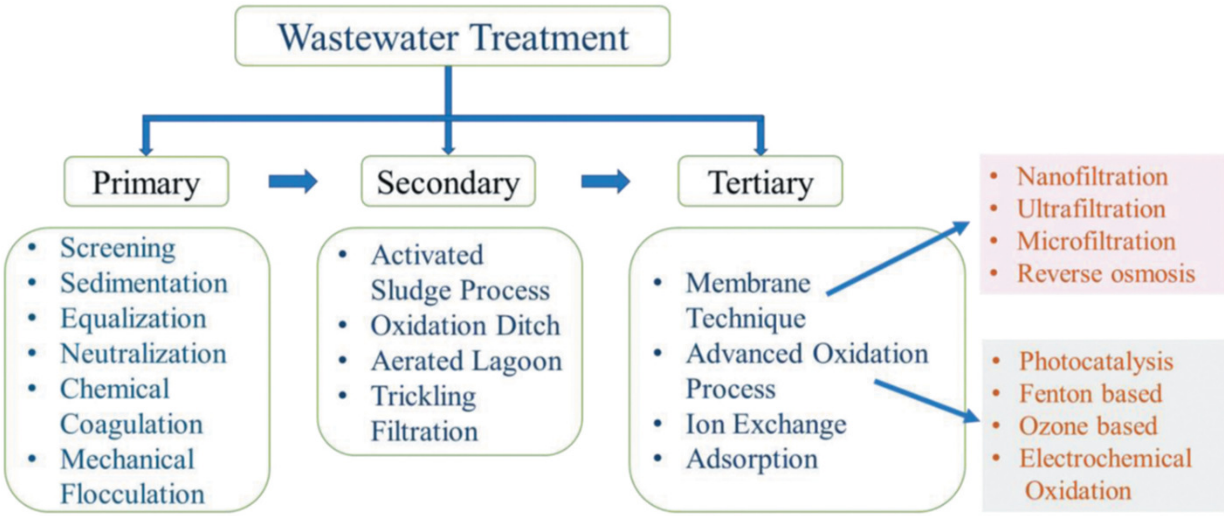

Figure 9 Classification of wastewater treatment[38]

The conventional methods used to treat the wastewater are physico-chemical and biological methods The physico-chemical methods include coagulation, flocculation and ozonation etc. whereas biological methods are used for the removal of nitrogen, phosphorous, organics and metal traces. In the last few decades, many techniques or methods have been developed which offers economic and competent means to treat the textile wastewater

Development of sustainable and eco-friendly textile waste treatments of dyes and pollutants

Advanced oxidation processes (AOP)

Suitable technique for degradation of organic dyes by radiation of visible light due to its eco-friendly nature, complete degradation, low cost, increase reusability of water and decrease in the pollutant load. Titanium Dioxide (TiO2) is used in photocatalytic degradation due to its nontoxic nature, chemical stability and environmental compatibility.

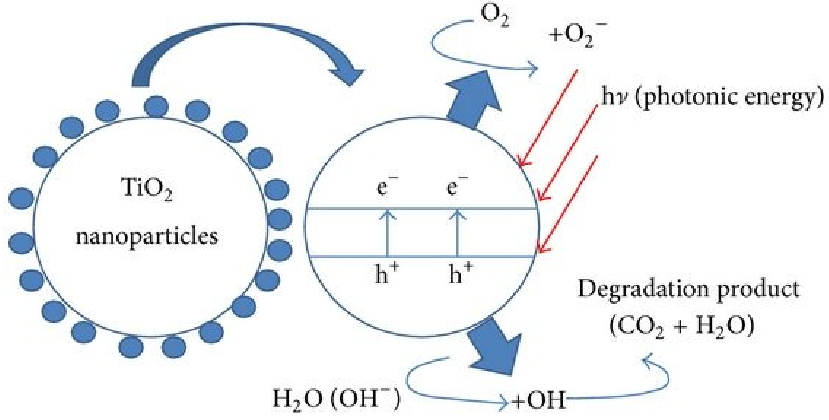

Figure 10 Overall mechanism of the photocatalytic degradation of organic dye compounds using TiO2-based nanomaterial[39]

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Development of sustainable and eco-friendly textile waste treatments of dyes and pollutants

Bio-electrochemical system (BES)

BES is a developing technology to improve energy and environment relevant problems by making wastewater treatment procedures more sustainable and more economical. The bio-electrocatalytic reaction combined with extracellular electron transfer can drive several procedures such as synthesizing chemicals, producing electricity from wastewater, removing pollutants and desalinating seawater.

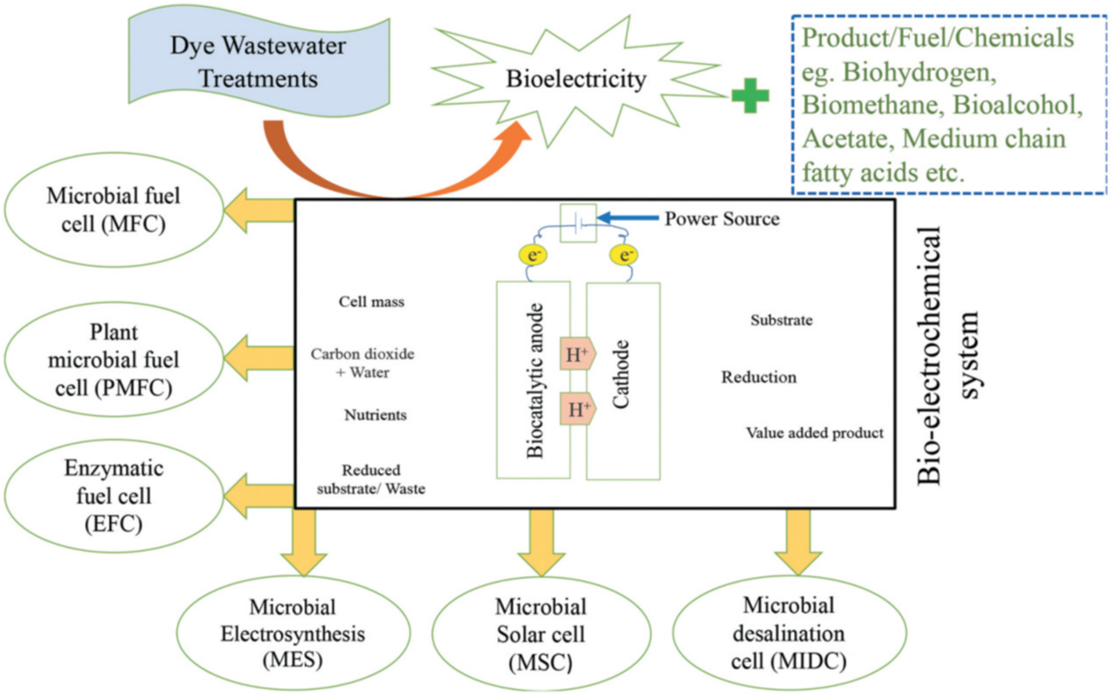

Figure 10 Schematic presentation of different types of bio-electrochemical systems (BES) and their application[38]

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Development of sustainable and eco-friendly textile waste treatments of dyes and pollutants

Biological treatment approaches

Different taxonomic category of microorganisms (bacteria, fungi, algae, yeats) and plants have the potential to degrade and mineralize remove waste wastewater pollutants. These treatments are green and low expensive[40].

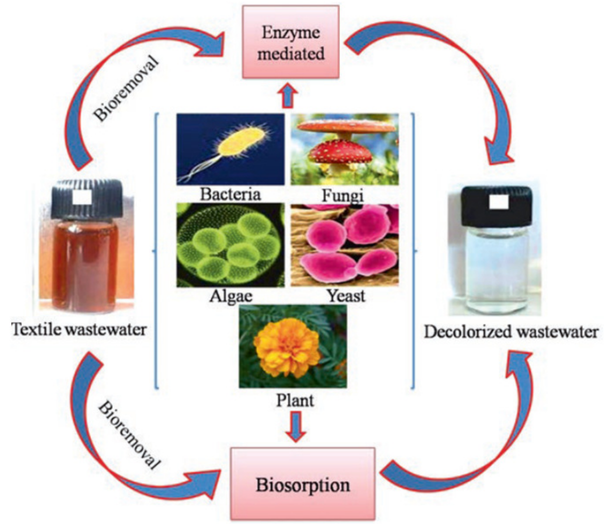

Figure 11 Biological treatment of wastewater[40]

Agricultural waste

Agricultural wastes show a high potential as low-cost adsorbents for the removal of dyes from wastewater. Particularly, agricultural by-products such as rice husk, corn cob, peanut, coconut, coffee, banana peel and flower wastes for the adsorption of different dyes are explored [41,42]

Figure 12 Agricultural waste

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Innovative wastewater treatments and systems

ZLD

Zero Liquid Discharge (ZLD) is a wastewater treatment process developed that allow the elimination of the water stream and enables water re-use.

The ZLD System removes dissolved solids (mainly salt) from the wastewater and returns pure water to the process. Reverse osmosis (membrane filtration) is used to concentrate pre treated waste stream and return the clean permeate to the process, funnel the reject to an evaporator, and send the evaporator concentrate to a crystallizer or spray dryer. The condensate from evaporator also returned to the process[43]

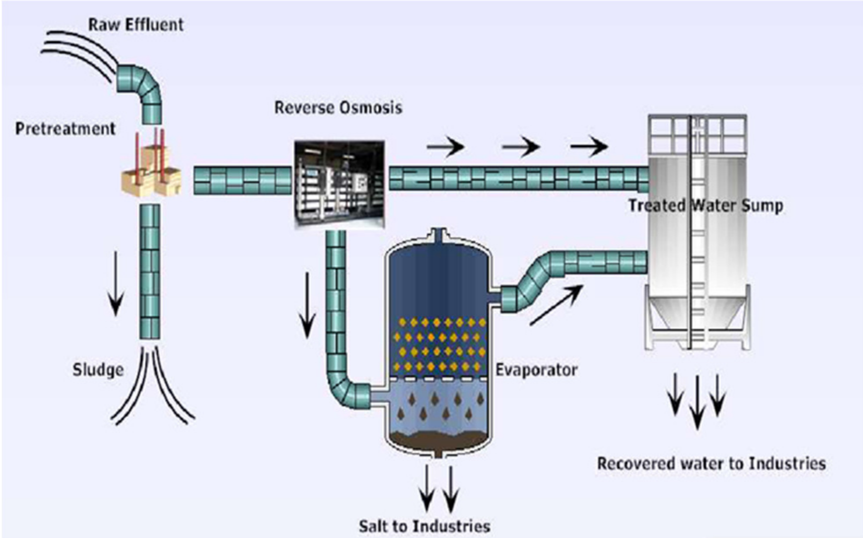

Figure 13 ZLD Flow Diagram

Innovative wastewater treatments and systems

The EColoRO concept

Source[44]

The ECWRTI project (Electro Coagulation for Water Recycling in Textile Industry) brought a new technological concept to the market that closes the waterloop by separating the water, organometallics and salty brine and creating a produced clean water that can be fully re-used: the EColoRO concept uses electro-coagulation (EC) combined with flotation to remove pollutants, colorants and chemicals from waste water very effectively. This unique feature enables using ultrafiltration and reverse osmosis membrane processes downstream in an optimized way[45].

The key advantages are:

- Total reuse of waste-water in textile industry reducing fresh-water intake by at least 75%
- Low-cost and economically highly attractive
- Very flexible, containerized and modular, easy scalable, low footprint, suitable for retro-fit, brownfield or greenfield application
- Low energy use, no use of chemicals or flocculants, producing concentrated waste streams with very high re-use potential
- Enabler for optimizing use of water, allowing for advanced energy and resource efficiency in the textile manufacturing processes

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Innovative wastewater treatments and systems

ECUVal Project

Based on innovative wastewater system which combines electrochemical techniques with UV irradiation for the treatment of dyeing textile wastewaters and the reuse of the treated effluents and salts. Currently, the ECUVal industrial prototype is operating in a textile mill where it has been optimized to treat and reuse exhausted reactive dyebaths[46].

ECUVal
Source[46]

The key advantages are:

- 100% colour removal
- Reuse of 70% treated effluent
- Reuse between 20-75% of salt
- Reduction of effluent salinity and wastewater discharge rates

Figure 14 ECUVal system

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Innovative wastewater treatments and systems

PURIFAST Project

The aim was to demonstrate the technical and economic feasibility of an advanced wastewater treatment system based on Ultra Filtration (UF) and an innovative Advanced Oxidation Process (AOP). This would reduce the toxicity of purified effluents compared with other AOP technologies and enable the reuse of the water in the textile production processes, with a consequent reduction in freshwater consumption.

Source[47]

Source[48]

Results from tests on textile wastewater revealed that:

- the removal of colour can be more than 90%;
- COD abatement is around 80%;
- Total Suspended Solid (TSS) reduction is about 80% at pre-industrial scale
- As much as 60% of textile effluent was proven to be reusable (and possess a low toxicity) following the PURIFAST process[49]

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Innovative wastewater treatments and systems

WASTE2FRESH Project

This EUH2020 funded project will develop a closed-loop process for textile manufacturing factories in which wastewater is collected, recycled and used again.

- Novel and innovative catalytic degradation approaches with highly selective separation and extraction techniques will be integrated;
- The aim is near-zero discharge and a reduction of current use of freshwater resources;
- The project expects this system to result in significant environmental gains.

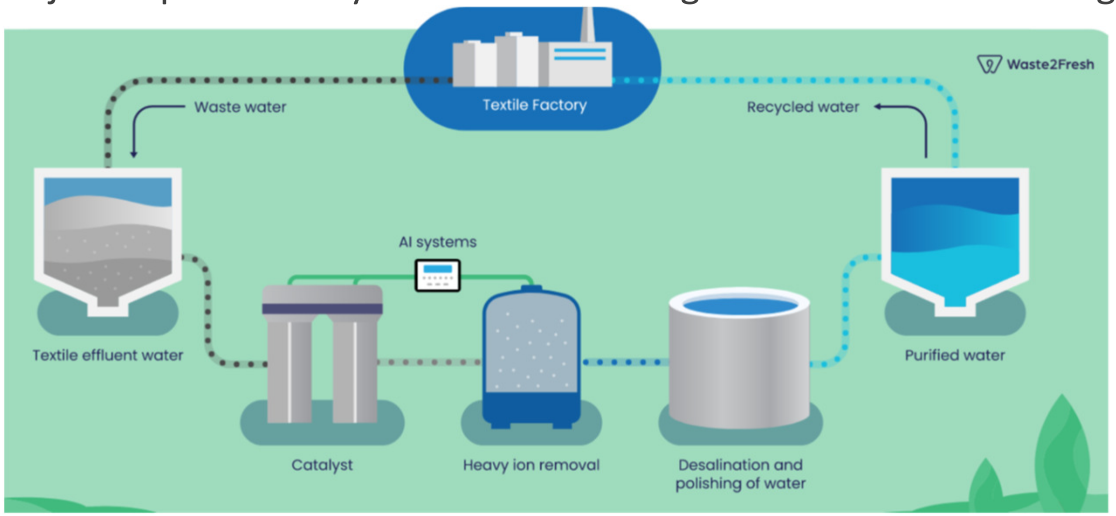

Figure 14 Waste2fresh wastewater treatment[51]

Waste2Fresh
Source[50]

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