

Unit 4.2 Textile and clothing waste

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4.2.1 Classification, identification and description of waste from textile industry

Definition of waste

The European Union's Waste Framework Directive³ (WFD) - the umbrella Directive that provides definitions for many legislative documents concerning packaging waste, end-of-life vehicles (ELV), or waste from electronic and electrical appliances, to name a few - defines 'waste' as:

Art. 3(1): 'Waste' means any substance or object which the holder discards or intends or is required to discard¹



Source²

Waste consists of substance that reaches at the end of its life span for a person or business, which is normally disposed of, in addition to other wastes, at a landfill, and that, in turn, creates difficulties for the environment and different sectors of society

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What is textile waste?

- ▶ Textile waste is the textile by-product of the manufacturing of garments, fabrics, yarns or fibres that are deemed unusable for its original purpose by the owner.
- ▶ Textile waste can include fashion and textile industry waste, created during fibre, textile and clothing production, and consumer waste, created during consumer use and disposal³



Source⁴

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Textile waste generation

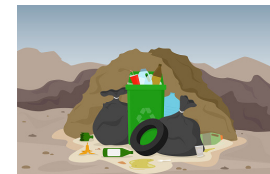
- ▶ Europe's landfills are bursting at the seams with discarded clothing and other textiles. In 2019 the EU produced approximately 5.8 mln tons of textiles and imported ≈ 6.5 mln tons. With ≈ 1.6 mln tons exported, the apparent consumption can be estimated at approximately 10.7 mln tons
- ▶ Only around 2.8 mln tons were collected in Europe
- ▶ More than 4 mln tons have largely disappeared in incinerators or landfill alongside with residual waste⁵



Textile production is resource intensive and polluting



Clothing is massively underutilized



Textile are mostly incinerated or landfilled at end-of-use

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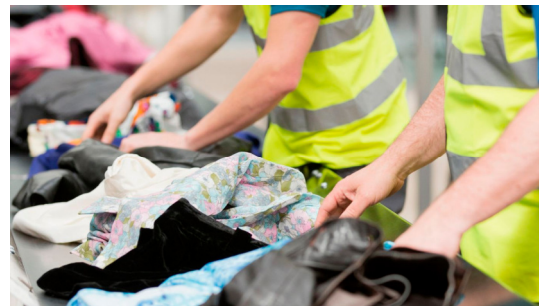
Different types of textile waste

Textile and fashion waste can be classified into different types based on their source of generation, toxicity, disposal and discarding:

- ▶ Preconsumer and postconsumer wastes
- ▶ Solid and soft waste
- ▶ Industrial textile waste
- ▶ Toxic waste



Source⁶



Source⁷

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Pre consumer waste

It's the waste generated during production—by processing fibers, and the production of finished yarns and textiles, technical textiles, nonwoven, garments and footwear, it includes scraps, damaged or defective material samples, offcuts, selvages, shearings, rejected materials and/or B-grade garments. Preconsumer textile waste is usually what is considered as “clean waste.”⁸



Figure 1. Textile scraps generated during garment manufacturing⁹

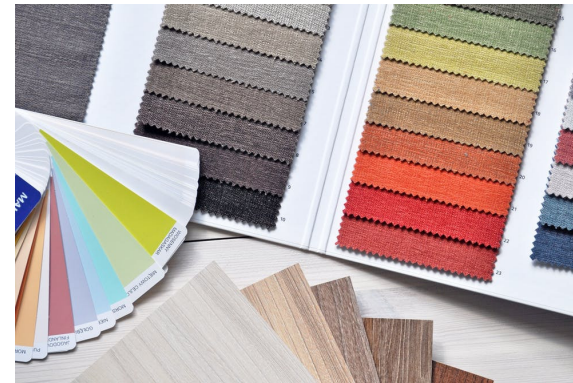


Figure 2. Leftover textile watches²

Pre-consumer textile waste is made up of manufacturing waste that has not reached the consumer.

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Post consumer waste

It refers to textile products that the consumer disposes for any reason—they might be run-down or not liked by the consumer anymore. Generally, postconsumer textile wastes tend to be of good quality, which can be recovered or reused as second-hand clothing, and are generally sold to poorer regions of the world. Even the textile products that will most likely not be used by the consumers can potentially be shredded into fiber to be reused for manufacturing⁸



Source¹⁰

Post-consumer textile waste is waste collected after the consumer has disposed of it.

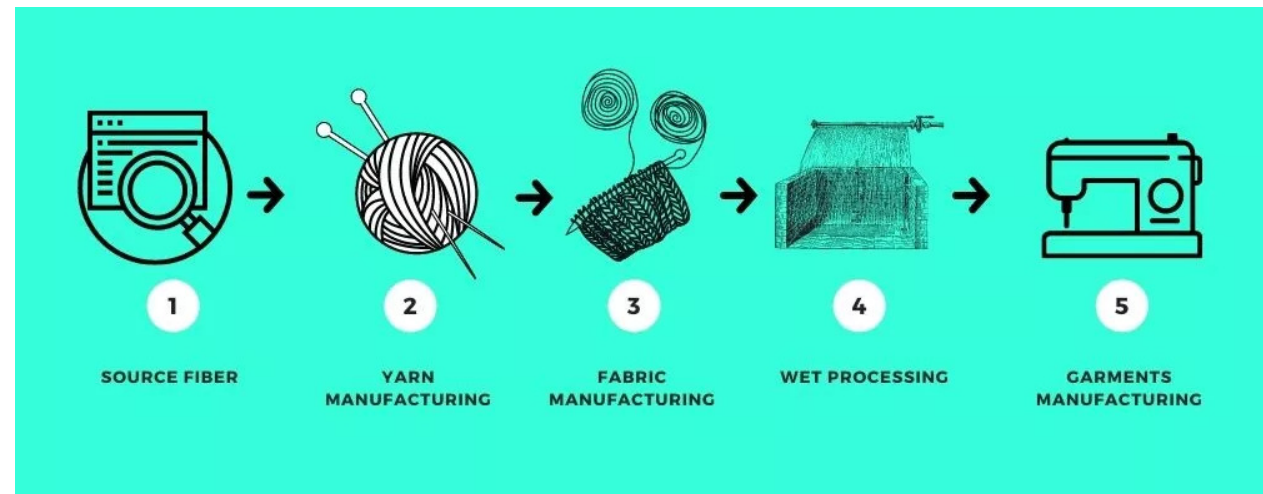
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4.2.2 Pre consumer waste in manufacturing

Waste can come from different textile manufacturing departments like:

- ▶ spinning
- ▶ weaving
- ▶ knitting
- ▶ garments manufacturing



Source¹¹

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Spinning

It's a procedure of producing/converting fiber materials in yarns.

The fibres generated by the spinning industry have various other materials like seeds, twigs, dead insects and dust. At each stage of spinning, there are different types of wastes like blow room waste, carding waste, dropping, sliver waste, draw frame waste, ring frame waste ¹²



Figure 3. Spinning wastes and their sources¹³

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Weaving

It's the second level after spinning. Here, the yarn from spinning section is sent further for doubling and twisting.

Different types of wastages are:

- ▶ Residual yarns left on the cones
- ▶ Sizing waste
- ▶ Knotting waste
- ▶ Beam residual wastage
- ▶ Auxiliary selvage wastage



Figure 4. Warp sheet wasted during sizing ¹⁴

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Knitting

It is a method by which a yarn or thread is converted into cloth or fabric or any other form. It is a complicated process and any fault in the technique of loop creation results in wastage. Wastage may occur due to any reason like yarn, fabric faults, lack of machine maintenance, sample production, problem of management, etc. There are various types of knitted fabric faults like, barriness, spirality, thick and thin place, holes, slubs, sinker marks, stains, stripes etc.¹⁵

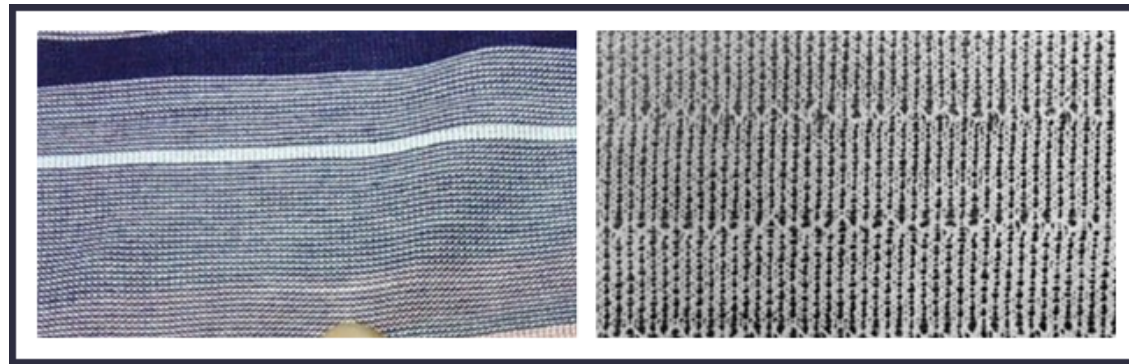


Figure 5. Barriness defect¹⁶

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Garment manufacturing process

It's the end procedure converting semi-finished cloth into finished cloth.

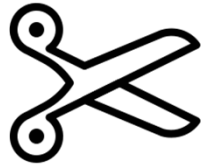


Table 1 Various stages of wastage¹⁷

Inspection
Samples from tests
Cutting room
Wrong color of shades, fabric faults, marker utilization, curved pattern edges
Sewing room
Problems in sewing machines
Final inspection
Finishing/Ironing problems, measurement faults, size mistakes etc.

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4.2.2 Pre consumer waste in manufacturing

4.2.2.1 Soft and hard waste

Table 2 Soft and hard waste ¹⁸

Soft waste	Hard waste
Generated from combing, drawing and spinning	Generated after spinning and twisting, weaving and knitting.
Fibers are relatively open structure and	Fibers are packed in a closed structure
Wastes can be reused directly in an earlier feed stage	Waste needs additional operation before reusing in soft waste

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4.2.2 Pre consumer waste in manufacturing

4.2.2.2 Solid waste

The majority of this type of waste originates from other sources during operations like transportation, bale openings, servicing process and housekeeping. The waste under this category includes:

- ▶ Tubes, pallets, cones, containers, drums
- ▶ Plastic wrap, corrugated cardboard
- ▶ Seam waste, paper waste
- ▶ Bags, shipping cartons ¹⁹



Source²⁰



Source²¹

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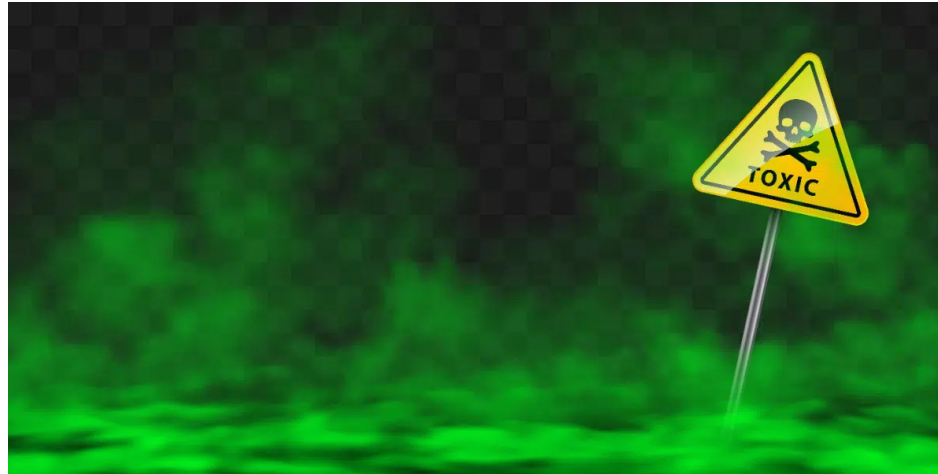
4.2.2 Pre consumer waste in manufacturing

4.2.2.3 Toxic waste

Textile waste can be classified based on their toxicity.

Such categories are:

- ▶ Hard to treat Wastes
- ▶ Hazardous or toxic wastes
- ▶ Dispersible waste
- ▶ High volume wastes²²



Source²³

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4.2.2.3 Toxic waste

Table 3a Categorization of textile waste ²⁴

Hard to treat wastes	Hazardous wastes
Waste that are persistent, resist treatment, or interfere with the operation of waste treatment facilities.	Subgroup of hard to treat wastes with a huge effect on health and environment.
<ul style="list-style-type: none"> ▶ colour and metals ▶ phosphates ▶ Non-biodegradable organic materials as surfactants and solvents 	<ul style="list-style-type: none"> ▶ Metals ▶ Chlorinated solvents ▶ Non-biodegradable and volatile organic materials
Methods of prevention are chemical substitution, waste segregation, process control and optimization, recycle and reuse	Some of these wastes can also come from non textile processes such as machine cleaning, boiler chemicals etc

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4.2.2.3 Toxic waste

Table 3b Categorization of textile waste²⁴

Dispersible wastes	High volume wastes
Founded in concentrated form as they are created	Large volume of wastes is sometimes a problem for the textile processing units.
<ul style="list-style-type: none"> ▶ Waste stream from continuous operation (e.g. preparatory, dyeing, printing and finishing) ▶ Print paste (printing screen, squeeze and drum cleaning) ▶ Lint (preparatory, dyeing and washing operations) ▶ Foam from coating operations ▶ Solvents from machine cleaning ▶ Still bottoms from solvent recovery (dry cleaning operation) ▶ Batch dumps of unused processing (finishing mixes) 	<ul style="list-style-type: none"> ▶ High volume of waste water ▶ Wash water from preparation and continuous dyeing processes ▶ alkaline wastes from preparatory processes ▶ Batch dye waste containing large amounts of salt, acid or alkali
Process modifications at the source or recycling is used to capture or reduce dispersible wastes at this stage	It can be reduced by recycle process and equipment modification.

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4.2.3 Introduction to wastewater

- ▶ The textile industry usually consumes a large amount of water and chemicals generating an enormous amount of wastewater containing pollutants.
- ▶ Textile wastewater generally contains various chemicals such as dyes and inorganic compounds (metals)
- ▶ Untreated effluents which are directly discharged into water sources contaminate water streams and cause environmental problems and health issues for humans.

Wastewater

Wastewater is the polluted form of water generated from rainwater runoff and human activities. It is also called sewage. It is typically categorized by the manner in which it is generated—specifically, as domestic sewage, industrial sewage, or storm sewage (stormwater).

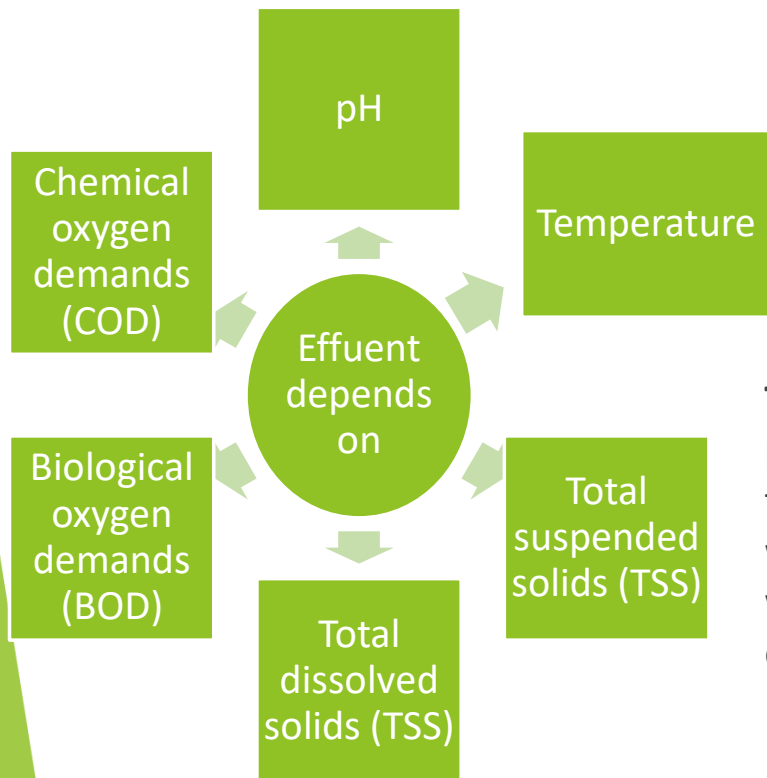


Source²⁵

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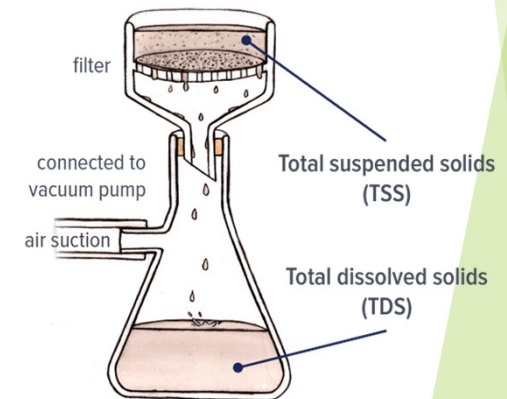
Wastewater generation



BOD is the traditional, most widely used test to establish concentration of organic matter in wastewater samples (i.e., relative strength)

COD is the most popular alternative test to BOD for establishing the concentration of organic matter in wastewater samples
COD can test wastewater that is too toxic for the BOD test²⁶

TSS and TDS measure the amount of particulate matter (tiny pieces of things) floating in water and are important water quality parameter measures for wastewater treatment operations and environmental health²⁷



Source²⁷

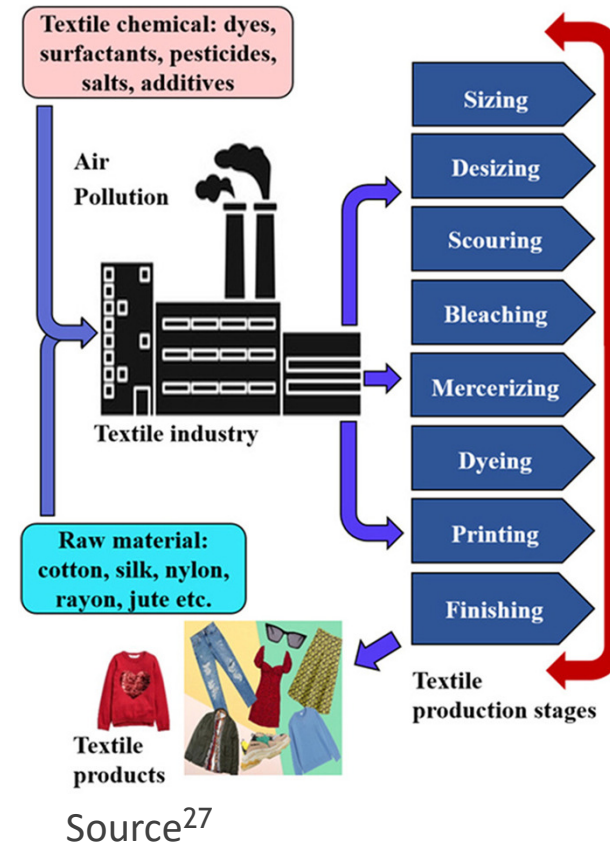
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Wastewater generation

Wastewater from the textile manufacturing processes is characterized and composed mainly of:

- ▶ Colour.
- ▶ Biodegradable and non-biodegradable or “refractory” organic compounds
- ▶ Non-biodegradable inorganic compounds (reagents and additives added during the process): heavy metals, dyes, phenols, pesticides, surfactants, etc.
- ▶ Oils and fats.
- ▶ High concentration of total suspended solids (TSS).
- ▶ Chemical oxygen demand (COD).
- ▶ Biological oxygen demand (BOD).
- ▶ High levels of total dissolved solids (TDS).
- ▶ Generally deficient in nutrients (nitrogen and phosphorus)
- ▶ High content of chlorine and salinity



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Source of wastewater

The effluent is generated under various textile wet processes as:

- ▶ **Desizing:** this process removes size ingredients such as starch, softeners, preservatives etc used in sizing. Enzymes are used to break the starch into water-soluble dextrin. Bacteria can easily attack the water-soluble dextrin and these are very degradable and have high BOD.
- ▶ **Scouring:** cleaning process used to remove impurities from fibres where alkali agents such as glycerol, ethers, sodium hydroxide, detergent, or soap are used for the removal and washing of impurities like fats, waxes, oils, and surfactants. This provokes an increasing of BOD.
- ▶ **Bleaching:** chemical process used for the removal of unwanted coloring materials from fibres. Currently, hydrogen peroxide and peracetic acid are used as bleaching agent to enhance the whiteness of fibres
- ▶ **Mercerization:** treatment with a cold concentrated caustic alkali solution and washing with liberal amount of water in a countercurrent system.

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Source of wastewater

- ▶ **Dyeing:** the nature of wastewaters coming from this process depends upon the use of different types of dyes and auxiliary chemicals. Dyes, which contain heavy metal such as chromium, cobalt, and copper, are detrimental for the environment. Major pollutants in dyeing include unfixed dye, fixing agents, reducing agents, alkali, organic acids, oxidizing agents, salts, metals, carriers etc. Dyeing section contributes 15-20% of the total wastewater flow.
- ▶ **Printing:** major pollutants in textile printing are: suspended solids, urea, solvents, colour, metals, vapours during drying and curing, screen cleaning solvents.
- ▶ **Finishing:** in this unit, the fabric is washed in an open soaping range to remove the unfixed dyes. Then, it is treated with starches to finish the fabric. The other materials may be dextrans, natural and synthetic waxes, and synthetic resins. Washing of the fabric to remove the unused color and cleaning of the color machine constitute major source of wastewater. The wastewater is strongly colored and contains fixing agent like gum, soap, and minerals ²³

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Source of wastewater

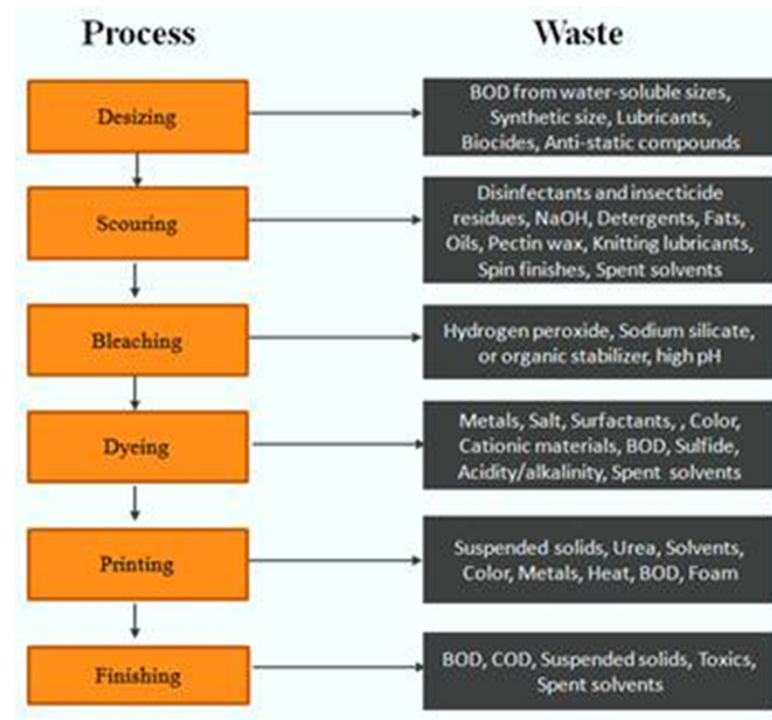


Figure 6. Characteristics of wastewater from different wet processes ²⁹

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4.2.4 Air pollution deriving from textile waste

Definition of air pollution

Air pollution is the introduction of chemicals, particulate or biological material that cause harm or discomfort to humans or other living organisms, or damages the natural environment into the atmosphere ³⁰

Air pollution in textile

All textile-manufacturing processes generate environmental pollution, the clothing industry accounts for 10% of global carbon emissions and is the second-largest industrial polluter. Workers are exposed to the risk of breathing air polluted with dust and fly and contracting respiratory ailments, byssinosis (lung disease), chronic bronchitis etc.



Source²

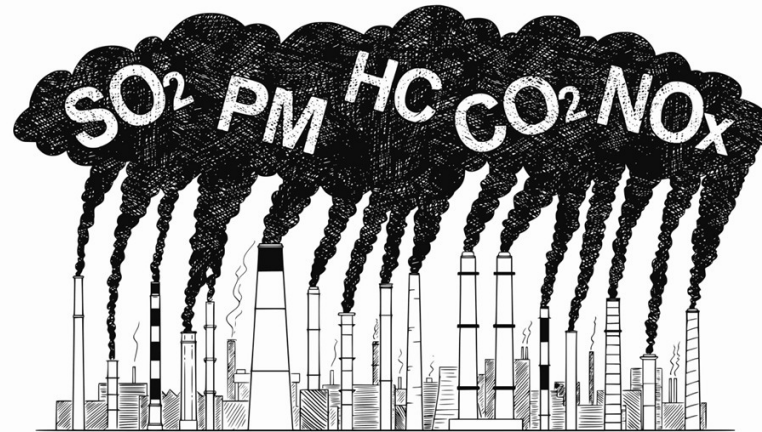
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Air pollution in textile

Air pollutants produced by the textile industry include:

- ▶ nitrous oxides and sulphur dioxide produced in the energy production stages;
- ▶ volatile organic components (VOCs) produced in coating, curing, drying, waste water treatment and chemical storage;
- ▶ aniline vapours, carrier Hydrogen sulphide, chlorine and chlorine dioxide produced in dyeing and bleaching stages³¹



Source³²

Air emissions can be classified according to the nature of their sources:

- ▶ Point sources: boilers, ovens, storage tanks
- ▶ Diffusive: Solvent-based, wastewater treatment warehouses, spills

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Air pollution in textile

Air pollution mitigation steps

Decreasing emissions of organic solvents by changing to water-based products

Using scrubbers to collect particulate matter

Optimization of boiler operations to reduce the emissions of nitrous and sulphur oxides

Pre-screening chemicals using the material safety data sheets to ensure that chemicals are not toxic

Identifying sources of air pollution and quantifying emissions³¹.



Figure 7. Venturi wet scrubber³³

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4.2.5 Post consumers waste

Collection of post consumer waste: actors

In Europe each country has different success-levels of collection of end-of-life textiles and their further treatment. Collection rates and the type of schemes to collect used textiles, vary significantly, both nationally and regionally. Collected amounts of used textiles vary greatly across countries (between 0.3 and 15.3 kg/person).

Many different kinds of actors can be involved in collection of used textiles in cities:

- ▶ charities
- ▶ municipalities
- ▶ public or privately owned waste companies
- ▶ clothing brands/retailers



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Sorting of textile waste

Sorting is the process that immediately follows the separate collection of used textiles and textile waste. In the sorting facilities, used textiles are sorted to determine their further fate:

- ▶ reuse (and for which market)
- ▶ recycling (and which type of recycling)
- ▶ or landfill/incineration

Sorting technologies
Manual
Semiautomated
Automated

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Manual sorting

- ▶ It's not a technology as such, as it is performed by humans and usually done without technological aids apart from conveyor belts and other feeding technologies
- ▶ It's the most widespread textile sorting approach used in Europe with hundreds of sorting facilities sorting hundreds of thousands of tonnes of used textiles³⁴

Advantage	Disadvantage
Able to remove non textile waste products	It's relatively expensive due to labour costs (required experienced staff)
At the momoent the only process used at large scale	It is difficult to determine detailed fibre compositions by hand – only rough sorting by fibre-type is possible



Source³⁵

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Semiautomated sorting

Manual sorting with sophisticated aiding techniques is also often referred to as semi-automated sorting: technological aids for assisting in the actual sorting of fibre types and grades for reuse and recycling, for examples held scanners that can be used by the manual sorters to assist them in determining material content.

Advantage

- ▶ The sorting for high-quality recycling can theoretically be carried out at the same time as sorting for reuse rather than requiring a new facility and processing stage
- ▶ Cost of machinery lower than the cost of labour³⁴



Figure 8. Texaid plants – Switzerland³⁶

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Automated sorting

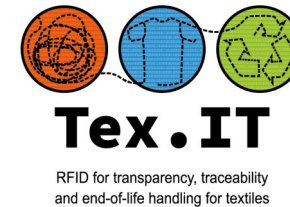
It's can efficiently and accurately sort most textile wastes by colour and fibre type ready for input into high-quality mechanical or chemical recycling.

Among the most promising technologies are near-infrared spectroscopy (NIR) and radio frequency and identification (RFID)



Source³⁶

Automatic sorting system of mixed post-consumer textiles (simultaneously by colour and fibre type) using near infrared spectroscopy (NIRS) which allows the detection of garments from cotton, wool, viscose, polyester, acrylic and nylon³⁷



Source³⁸

Swedish project with the aim of implementing the use of digital information carriers (RFID tags) integrated in garments to increase future traceability throughout the supply chain and facilitate subsequent sorting processes prior to recycling³⁹

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REFERENCES

- 1 <https://ec.europa.eu/docsroom/documents/46954/attachments/8/translations/en/renditions/pdf>
- 2 <https://www.pexels.com>
- 3 https://static1.squarespace.com/static/582d0d16440243165eb756db/t/5dcd14454658fc2b8e087c6a/1573721165094/LEARN_Sourcing_ENG_Nov2019.pdf
- 4 <https://www.textileinfomedia.com/blog/textile-waste-recycling-know-textile-recycling-process/>
- 5 <https://euratex.eu/wp-content/uploads/Recycling-Hubs-FIN-LQ.pdf>
- 6 <https://recyclenation.com/2014/05/recycle-fabric/>
- 7 <https://www.thebalancesmb.com/the-basics-of-recycling-clothing-and-other-textiles-2877780>
- 8 Utebay B. et al. Textile Wastes: Status and Perspectives. DOI: <http://dx.doi.org/10.5772/intechopen.92234>
- 9 <https://sourcingjournal.com/topics/sustainability/heres-zero-waste-daniel-elevating-sustainable-unisex-apparel-82405/>
- 10 <https://www.greenqueen.com.hk/meet-queen-of-raw-the-blockchain-powered-marketplace-turning-textile-deadstock-into-dollars/>
- 11 <https://textiledetails.com/manufacturing-process-of-textile-industry/>
- 12 <https://textileapex.blogspot.com/2018/12/what-is-textile-waste-definition.html>
- 13 <https://www.intechopen.com/chapters/66213>
- 14 Md.Mahbubul Haque et al. Study on Material Wastes in Air-jet Weaving Mills. Journal of Textile and Apparel, Technology and Management, Volume 10, Issue 3, 2018
- 15 <https://www.fibre2fashion.com/industry-article/6277/various-wastage-areas-of-a-knitting-floor-and-minimizing-procedure>
- 16 <https://medium.com/@stitchdiary/classify-the-fault-defects-in-knit-fabric-cc28640f5668>
- 17 Jahan I. A study on waste management and minimization in ready made garmnets (RMG) industry. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) (2017) Volume 35, No 1, pp 266-273
- 18 Waste Management in the Fashion and Textile Industries, Editors: Rajkishore Nayak, Asis Patnaik, 1st Edition - January 7, 2021, 9780128187586

MODULE 4 Waste Management and Recycling

Unit 4.2 Textile and Clothing Waste

- 19 <https://www.fibre2fashion.com/industry-article/8696/harmful-effects-of-textile-waste>
- 20 <https://www.tradeindia.com/products/textile-waste-cones-c1863345.html>
- 21 <https://www.questhardware.co.uk/workshop-essentials/packaging-materials/cardboardpaper-packaging/corrugated-cardboard-rolls-75m>
- 22 <https://www.fibre2fashion.com/industry-article/3451/effluent-treatment-in-textile-wet-processing-technology-option-and-effluent-treatment-plant>
- 23 <https://bitesizebio.com/10470/ten-bad-chemicals-in-the-lab-and-what-they-do-to-you/>
- 24 <https://www.fibre2fashion.com/industry-article/198/some-issues-of-ecological-hazards-in-textile-industry>
- 25 <https://www.freepik.com/>
- 26 <https://circabc.europa.eu/sd/a/82f3142a-dbe2-4502-865b-a5f307bc760f/Understanding>
- 27 <https://datastream.org/en/guide/total-suspended-solids-and-total-dissolved-solids>
- 28 Kishor R. et al. Ecotoxicological and health concerns of persistent coloring pollutants of textile industry wastewater and treatment approaches for environmental safety. Journal of Environmental Chemical Engineering 9 (2021) 105012
- 29 <https://www.globaltextiles.com/info/Potential-Wastes-from-Textile-Wet-Processing-Industries-and-their-Management-26757.html>
- 30 <https://www.nationalgeographic.org/encyclopedia/air-pollution/>
- 31 Tiwari, Meenaxi and Babel, Sudha (2013). Air Pollution in Textile Industry. Asian J. Environ. Sci., 8 (1): 64-66.
- 32 <https://www.thomasnet.com/articles/plant-facility-equipment/understanding-air-pollution-control-equipment/>
- 33 <https://airtight.com.au/product/wet-scrubbers/>
- 34 Köhler, A., Watson, D., Trzepacz, S., Löw, C., Liu, R., Danneck, J., Konstantas, A., Donatello, S. and Faraca, G., Circular Economy Perspectives in the EU Textile sector, EUR 30734 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-38646-9 (online), doi:10.2760/858144 (online), JRC125110.
- 35 <https://arisa.nl/wp-content/uploads/TextileRecyclingUnravelled.pdf>
- 36 <https://www.texaid.ch/>

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37 Fibersort Project. <https://www.fibersort.eu/>

38 <https://textilevaluechain.in/news-insights/fibersort-technology/>

39 <https://www.ri.se/en/what-we-do/projects/rfid-information-system-for-future-textiles>



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You can tell how high a society is by how much of its garbage is Recycled.
-Dhyani Ywahoo

