Cleaner Production Training for EPD Punjab

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

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

3. Introduction to Cleaner Production as tool to reduce environmental pollution

12:00 – 13:00

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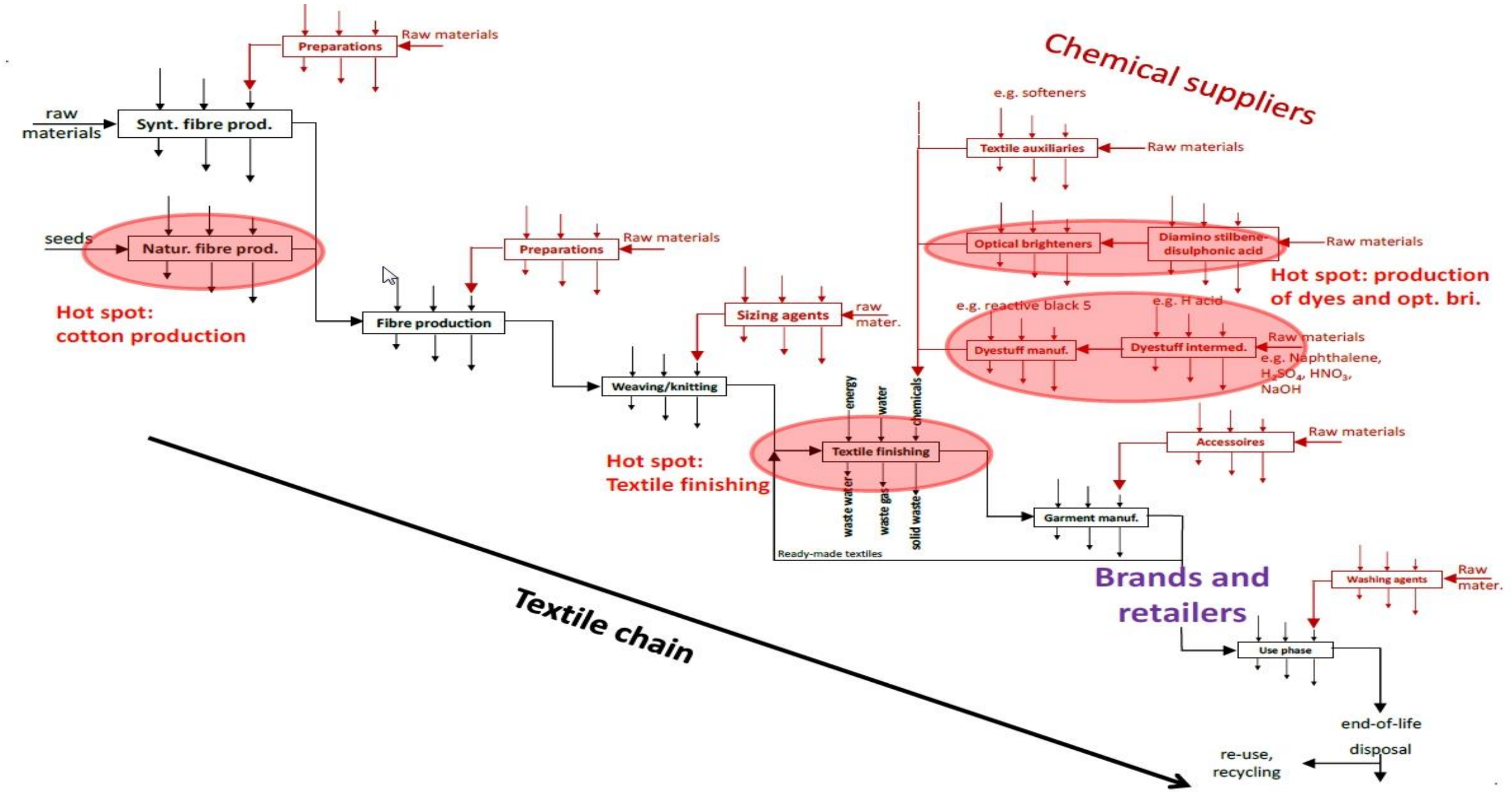
on behalf of GIZ FABRICS and Espire Consult

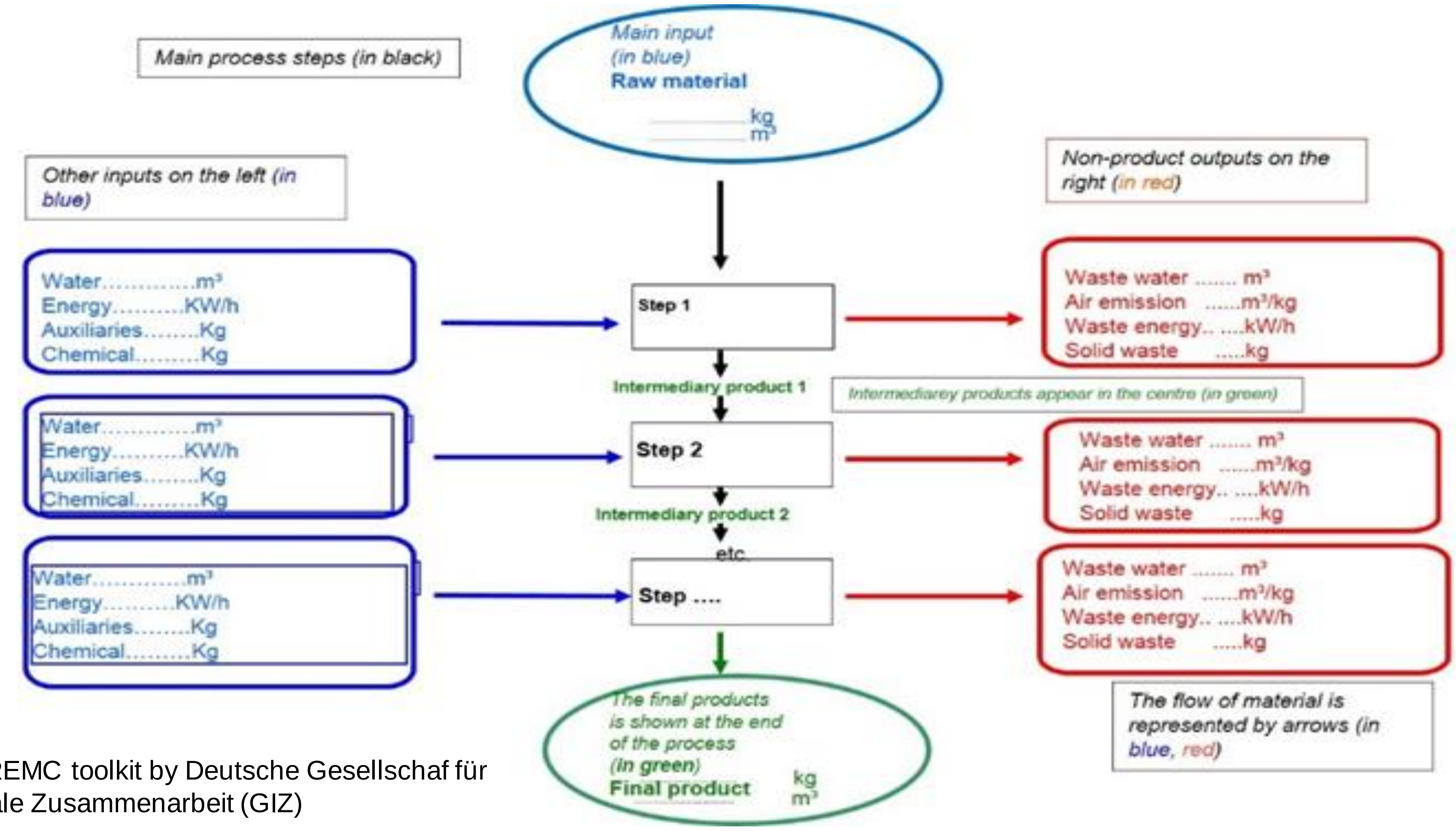
Agenda

- Change of Input
- Technology Change
- Good Operational Practice
- Product Modification
- On-site reuse and recycling
- Introduction to Best Available Techniques and their effects on Environmental Pollution for Textiles

Hotspots in the textile chain



Concept of Process Flow Mapping



Source: e-REMC toolkit by Deutsche Gesellschaf für Internationale Zusammenarbeit (GIZ)

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Change of Input

The compilation of relevant basic data on input and ouput streams of resources (e.g. inputs like materials, energy, water, and outputs like waste gases, waste waters, wastes, energy losses, etc.). Basic data for streams include the information on environmentally important characteristics, like presence of hazardous substances, their toxicity, composition and quantities. These data are used in mass balances, efficiency plans and for monitoring of emissions.

Avoidance of hazardous chemicals

Substitution

Change of Input

MRSL - restriction of chemical input
Use of screening tools based on restricted substance lists and environmental labelling to reduce the amount or presence of hazardous substances or to find alternative chemicals and preparations containing substances with a lower environmental impact (e.g. toxicity, biodegradability/ eliminability).

Restricted substances are chemical substances whose use and/or presence has been banned or otherwise restricted by organizations, authorities or producers. In order to avoid using dyestuffs or chemicals that contain these substances, the textile plants can use products that are labelled or certified as appropriate for use in a certain labelling scheme (e.g., Type I, II or III product labels according to ISO 14 020). There are various voluntary labelling (restriction) schemes like EU Ecolabel, and schemes provided by ZDHC, OEKO-TEX, Bluesign, GOTS, AFIRM, etc.

Substitution of Harmful Chemicals

Table 1. Some Harmful Textile Chemicals and Their Eco-friendly Substitutes

Existing Chemicals	**Uses**	**Proposed substitutes**
Polyvinyl alcohol (PVA)	Yarn size	Potato starch or carboxymethylcellulose (CMC)
Pentachlorophenol, formaldehyde	Size preservative	Sodium silicofluride
Carbon tetrachloride (CTC)	stain removers	Detergent stain-removers Detergent (non-ionic, ethoxylates) and water miscible solvent (glycol ethers) mixtures Enzymatic stain-removers.
Calcium and sodium hypochlorite	Bleaching	Hydrogen peroxide, ozone at cold
Sodium silicate, phosphorous-based compounds	Peroxide stabiliser	Nitrogenous stabilisers
Nonyl phenyl ethylene oxide adducts (APEO)	Detergent, emulsifier	Fatty alcohol ethylene oxide adducts, alkylpolyglycosides
Synthetic non-biodegradable surfactants	Various purposes	Sustainable and highly biodegradable surfactants from dextrins
Synthetic non-biodegradable surfactants + solvent	Coatings and degreasing	'solvosurfactants' acting both solvent and surfactant, derived from glycerol (bio diesel)
Dichloro and trichloro benzene	Carriers in dyeing	Butyl benzoate, benzoic acid
Kerosene	Pigment printing	Water-based thickeners
Formaldehyde	Finishing, dye fixing	Polycarboxylic acid, non-formaldehyde products
Sodium dichromate	Oxidation in dyeing	Hydrogen peroxide
Silicones and amino-silicones + APEO emulsifier	Softener	Eco-friendly softeners, wax emulsions
Functional synthetic finish	Finishing	Bees wax, aloe vera and Vitamin A (Hazardous Substance Research Centers/ South & Southwest Outreach Program,

Technology Change

BAT / BREF

Cleaner Production

Production optimisation

- optimised combination of processes (e.g. pretreatment processes are combined, bleaching of textile materials is avoided before dyeing in dark shades);
- optimised scheduling of batch processes (e.g. dyeing of the textile materials in dark shades is carried out after dyeing in light shades in the same dyeing equipment)
- implementation of water optimisation techniques (e.g. control of water usage, reuse/recycling, detection and repair of leaks).
- Water audits are carried out at least annually to ensure the objectives of the water management plan are met.

Innovative Technologies

Energy efficiency measures

- burner maintenance and control;
- cogeneration;
- energy-efficient motors;
- energy-efficient lighting;
- optimising steam distribution systems, e.g. by using point-of-use boilers;
- regular inspection and maintenance of the steam distribution systems to prevent or reduce steam leaks;
- process control systems;
- reducing heat losses by insulating equipment components and by covering tanks or bowls containing warm process liquor;
- optimising the temperature of the rinsing water;
- avoiding overheating of the process liquors;
- variable speed drives;
- optimising air conditioning and building heating.

Good Operational Practice

Production optimisation

- optimised combination of processes (e.g. pretreatment processes are combined, bleaching of textile materials is avoided before dyeing in dark shades);
- optimised scheduling of batch processes (e.g. dyeing of the textile materials in dark shades is carried out after dyeing in light shades in the same dyeing equipment)
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- Water audits are carried out at least annually to ensure the objectives of the water management plan are met.

Energy efficiency plan and energy audits

An energy efficiency plan is part of the EMS and includes:

- energy flow diagrams as part of the inventory of inputs and outputs;
- setting objectives in terms of energy efficiency (e.g. MWh/t of textile materials processed);
- implementing actions to achieve these objectives.

Energy audits are carried out at least annually to ensure that the objectives of energy efficiency plan are met.

Waste water

In order to reduce the waste water volume, the pollutant loads discharged to the waste water treatment plant and the emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of process-integrated techniques, techniques to recover and reuse process liquors, and treatment techniques.

The integrated waste water management and treatment strategy is based on the information provided by the inventory of inputs and outputs

In order to reduce emissions to water, BAT is to (pre)treat waste water containing pollutants that cannot be treated adequately by a biological treatment.

Pretreatment of poorly biodegradable organic compounds

The treatment is carried out as part of an integrated waste water management and treatment strategy and is generally necessary to:

- protect the (downstream) biological waste water treatment against inhibitory or toxic compounds;
- remove compounds that are insufficiently abated during biological waste water treatment (e.g. toxic compounds, poorly biodegradable organic compounds, organic compounds that are present in high concentrations, or metals);
- remove compounds that could otherwise be stripped to air from the collection system or during biological waste water treatment (e.g. sulphide);
- remove compounds that have other negative effects (e.g. corrosion of equipment; unwanted reaction with other substances; contamination of waste water sludge).

The treatment is carried out on site or off site. On-site treatment is generally carried out as close as possible to the source in order to avoid dilution. The techniques used depend on the pollutants targeted and include adsorption, chemical oxidation and chemical reduction.

Waste water which may contain toxic or poorly biodegradable compounds includes:

- spent liquors from sizing, dyeing and finishing;
- spent printing pastes.

Emission levels (BAT-AELs) for direct discharges to a receiving water body

Substance / Parameter		Activities / Processes	BAT-AEL (mg/l)
Adsorbable organically bound halogens (AOX)		All activities / processes	0,1 – 0,5
Chemical oxygen demand (COD)			40 - 120
Hydrocarbon oil index (HOI)			1 - 10
Metals / metalloids	Antimony (Sb)	Pre-treatment and / or dyeing of polyester	0,1 – 0,4
		Finishing with flame retardants using SbO3	
	Chromium (Cr)	Dyeing with chromium containing dyes	0,01 – 0,3
	Copper (Cu)	All activities / processes	0,03 – 0,4
	Nickel (Ni)		0,01 – 0,5
	Zinc(Zn)		0,04 – 0,5
Sulphide, easily released (S^{2-})		Dyeing with sulphur dyes	0,3 - 1
Total nitrogen (TN)		All activities / processes	5 – 20
Total organic carbon (TOC)			13 – 40
Total phosphorus (TP)			0,4 – 5
Total suspended solids (TSS)			5 - 45

Product Modification

Green design
Benign by design

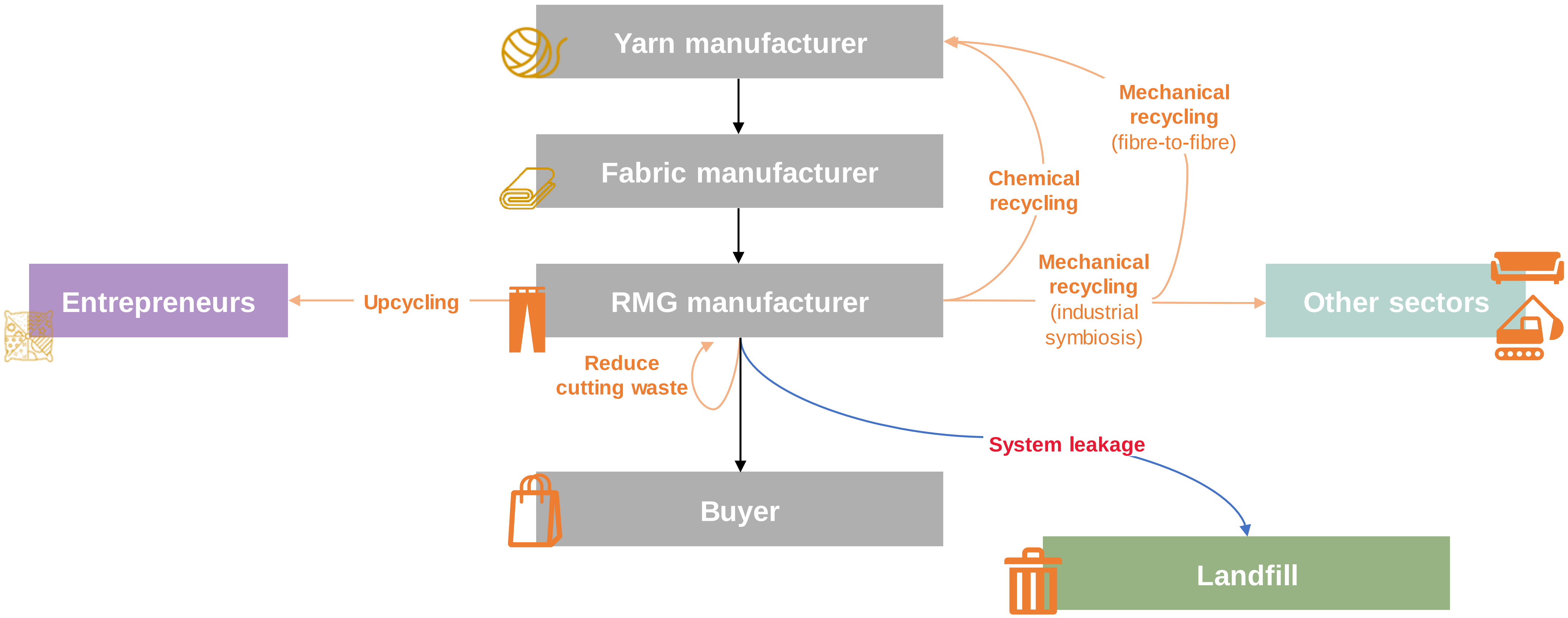
1. Addressing toxic pesticide and chemical use
2. Using and / or developing eco- friendly fabrics and components
3. Minimizing water use
4. Recycling and addressing energy efficiency and waste
5. Developing or promoting sustainability standards for fashion
6. Resources, training and/ or awareness raising initiatives

Seven strategies

1. Redesign manufacturing processes and products to use less material and energy
2. Redesign manufacturing processes to produce less waste and pollution
3. Develop products that are easy to repair, reuse, remanufacture, compost, or recycle
4. Eliminate or reduce unnecessary packaging
5. Use fee-per-bag waste collection systems
6. Establish cradle-to grave responsibility
7. Restructure urban transportation systems

Way forward for the textile sector

Circularity options



Circular Economy as a paradigm shift

Linear	Circular
Raw materials & waste	Raw materials only
Competition	Collaboration
Individuals	Ecosystem
Do less bad	Do good and positive
Added value	Shared value
Standardised production	Local and adapted production
Downcycling	Upcycling

CIRCULAR	SERVITIZATION	SUFFICIENCY
CREATE VALUE FROMM WASTE The concept of waste is eliminated by turning waste streams into useful and valuable input for other processes.	**FUNCTIONALITY OVER OWNERSHIP** Provide services that satisfy users' needs without having to own physical products.	**ENCOURAGE EFFECTIVE RESOURCE USE** Solutions that actively seek to reduce consumption and production.
CLOSED LOOP MODELS	REPAIR & WARRANTY	DEMAND MANAGEMENT
REUSE	RENTING & LEASING	CO-CREATION
RECYCLE	PAY FOR RESULT	USE EXCESS CAPACITY

Figure 2: Framework for circular business models in the textile industry (Circle Economy 2015)

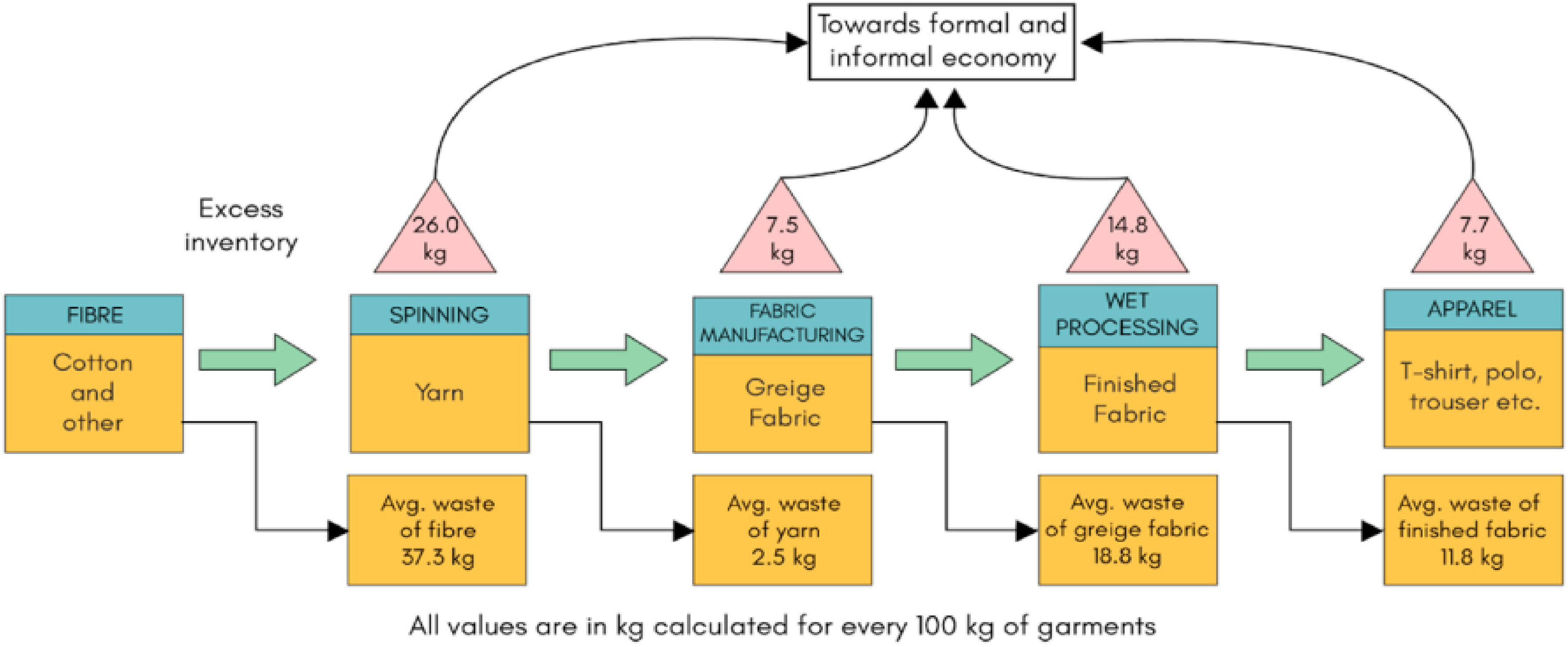


Fig. 4. Amount of material lost in the textile-apparel production chain.

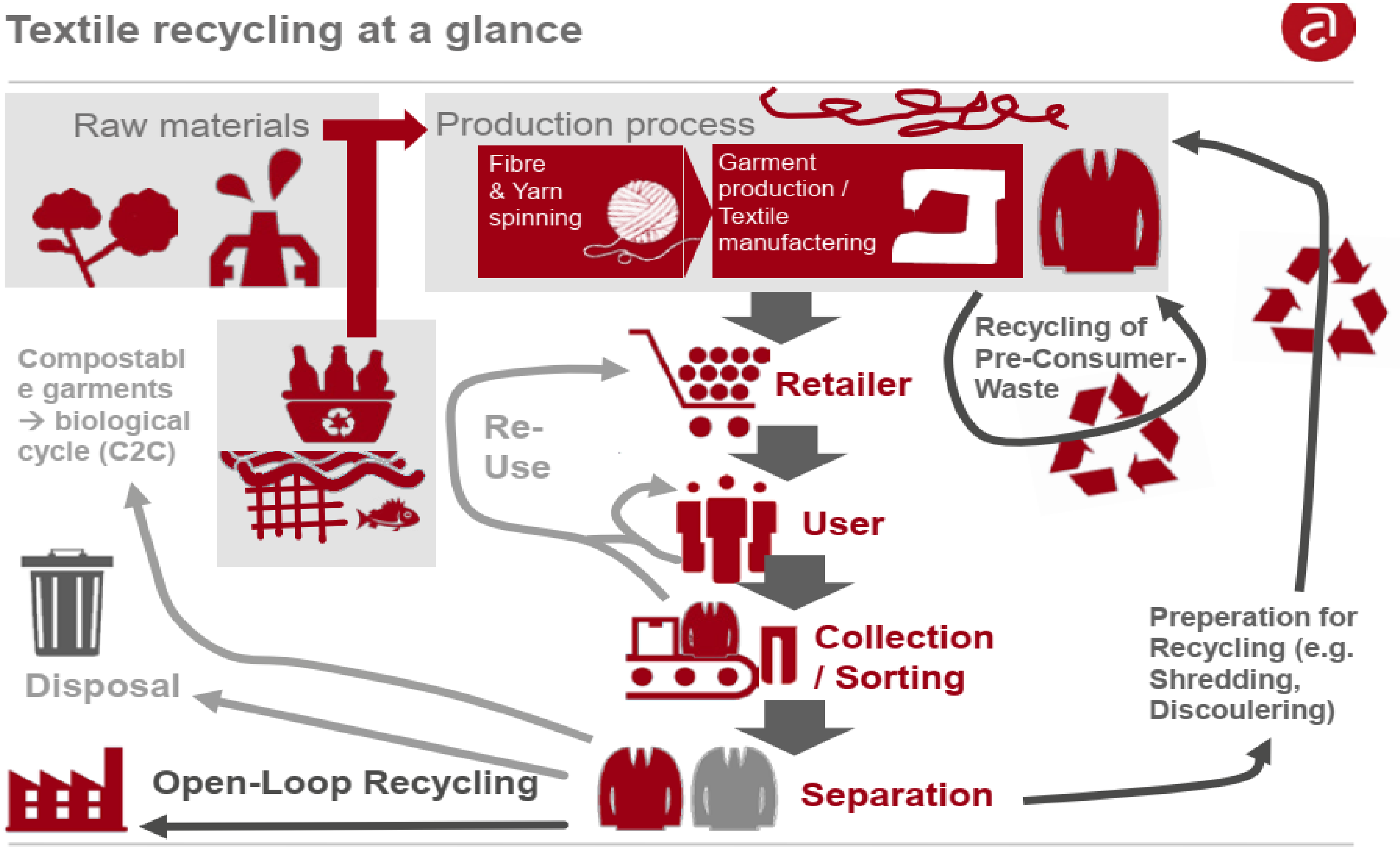
Maeen Md Khairul Akter, Upama Nasrin Haq, Md Mazedul Islam, Mohammad Abbas Uddin, Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh, Cleaner Environmental Systems, 10.1016/j.cesys.2022.100070, (100070), (2022).

Circular Economy Model

4Rs–

- Re-design
- Reduce
- Reuse
- Recycle

On-site reuse and recycling



Textile recycling approaches as well as technologies and their integration into product life cycle (own depiction based on Ellen MacArthur Foundation 2017a, Greenblue 2017, Norden 2014, Norden 2017,Re:newcell 2018)

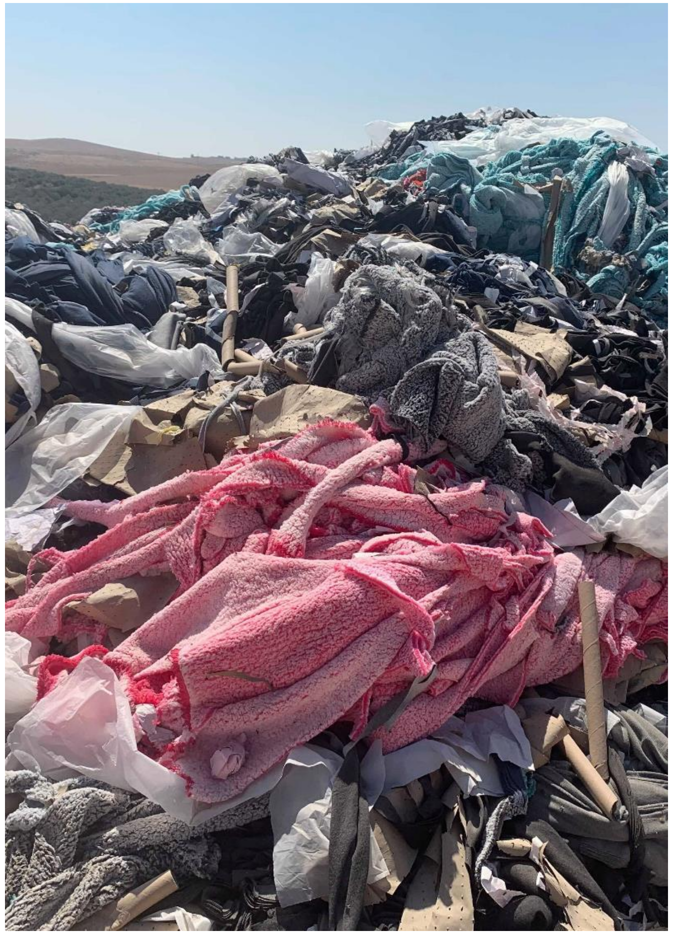
Recycling technologies

- Chemical recycling
- Mechanical recycling

Innovative closed-loop recycling technologies

- Infinited Fiber (Relooping Fashion Initiative)
- re:newcell pulp
- Refibra (Lenzing)
- Innovative chemical polymer recycling (Worn Again/HKRITA/Evrnu)

Circularity Options at the factory level



a) Reducing Manufacturing Waste

- apply innovativ CAD cutting devices,
- Avoid overproduction and deadstocks,
- Re-cutting and sewn to lower sized products and the local market,
- Apply eco-design principles to optimise resource use, consider recyclability in the design process,

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Circularity Options at the factory level

b) Collection, Separation and Recycling

- At site sorting, by colour, type of fiber, size of cuttings,
- Fluffing on factory level
- Develop a joint fluffing initiative within clusters,
- Downcycling of non-reusable fraction into industrial rags, upholstery filling and insulation

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Circularity Options at the factory level

c) Upcycling

- Develop initiatives with SME‘s and start ups to use large and medium sized cuttings for the production of new products
- Reuse recycled mono fibre fractions for respinning together with virgin fibres (so far yarn production is part of the factories value chain – degree of vertical integration))

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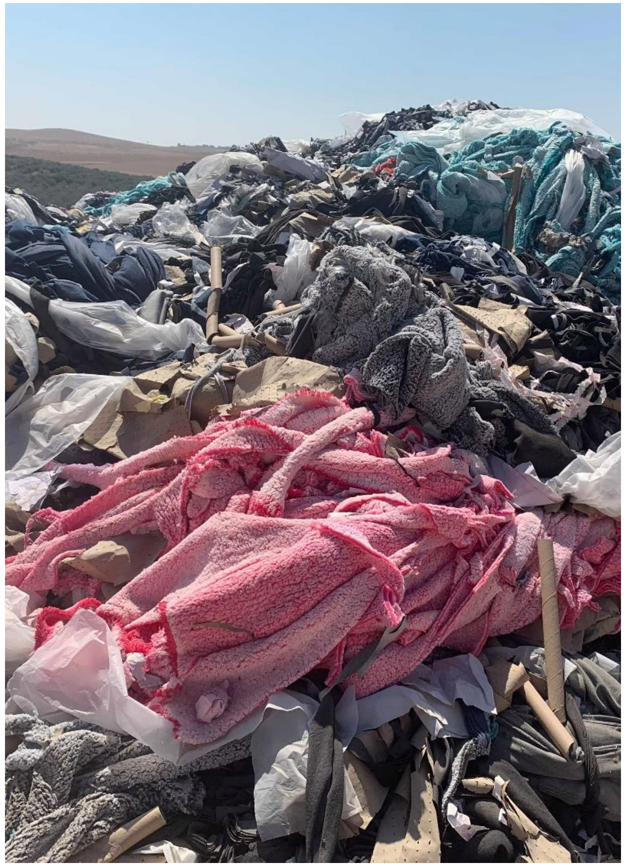
Upscaling potentials



- Development of a platform for waste exchange to get parties (factories, suppliers, handlers, recycler, brands) connected,
- Identify and develop initiatives to use large and medium sized cuttings for the production of new products ,
- Develop a joint fluffing initiative within HIE and byond including manufacturing capacities for downcycle products,
- Explore reuse and export oportunities for well sorted and clean mono fractions, like cotton…

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Questions for you

1. How circular economy is different from other concepts?
2. What are the 4Rs concept here?
3. How can Pakistan apply to some extent Circular economy on textile material context?

Introduction to Best Available Techniques and their effects on Environmental Pollution for Textiles

BAT / BREF
The purpose of the Directive is to achieve integrated prevention and control of pollution arising from the activities, leading to a high level of protection of the environment as a whole.

Best Available Techniques (BAT) Reference Document for
the Textiles Industry Industrial Emissions Directive 2010/75/EU
(Integrated Pollution Prevention and Control)
JOINT RESEARCH CENTRE
Directorate B – Growth and Innovation Circular Economy and Industrial Leadership Unit
European IPPC Bureau
Draft 1 (December 2019)

https://eippcb.jrc.ec.europa.eu

BAT - BREF

A BREF – a Best Available Technique (BAT) Reference Document – is a publication resulting from a series of exchanges of information between a variety of stakeholders, including regulators, industry and environmental non-governmental organisations.

BREFs bring together users' real-world experiences of BAT to provide reference information for regulators to use when determining permit conditions.
The documents describe, in particular, applied techniques, present emissions and consumption levels, techniques considered for the determination of best available techniques as well as BAT conclusions and any emerging techniques.

BAT conclusions are the final evaluations of Best Available Techniques and form part of every BREF. They determine the reference points used to set permit conditions for installations covered by the IED (**Industrial Emissions Directive**).

BAT conclusions include:

- a description of each conclusion;
- an assessment of its appropriate application;
- emission levels associated with the best available techniques;
- associated monitoring;
- associated consumption levels;
- relevant site remediation measures, where appropriate.

The BREFs are a series of reference documents covering, as far as is practicable, the industrial activities listed in Annex 1 to the EU's IPPC Directive. They provide descriptions of a range of industrial processes and for example, their respective operating conditions and emission rates. Member States are required to take these documents into account when determining best available techniques generally or in specific cases under the Directive.

The link address is: http://eippcb.jrc.ec.europa.eu/reference/

This presentation addresses a selection of textile finishing processes and their options for chemicals recovery on the basis of the BAT / BREF document.

Recovery of PVA

Neither enzymatic nor oxidative desizing allows size recovery, while for some synthetic sizing agents size recovery is technically feasible, but difficult to apply for commission companies working on commission.

Description

When desizing is carried out by washing with hot water, water-soluble sizing chemicals (e.g. polyvinyl alcohol and polyacrylates) are recovered from the washing water by ultrafiltration. The concentrate is reused for sizing, whereas the permeate is reused for washing.

Technical description

Sizing agents are applied to warp yarn in order to protect it during the weaving process and have to be removed during textile pretreatment, thus giving rise to 40-70 % of the total COD load of woven fabric finishing mills.

Water-soluble synthetic sizing agents such as polyvinyl alcohol, polyacrylates and carboxymethyl cellulose can be recovered from washing liquor by ultrafiltration. More recently, it has been confirmed that modified starches such as carboxymethyl starch can also be recycled.

Recovery of PVA

The sizing agents concentration in the washing liquor is about 20-30 g/l. In the ultrafiltration plant, they are concentrated to 150-350 g/l. The concentrate is recovered and can be reused for sizing, whereas the permeate can be recycled as water in the washing machine. Note that the concentrate is kept at a high temperature (80-85 °C) and does not need to be reheated, which results in less energy consumption.

Achieved environmental benefits

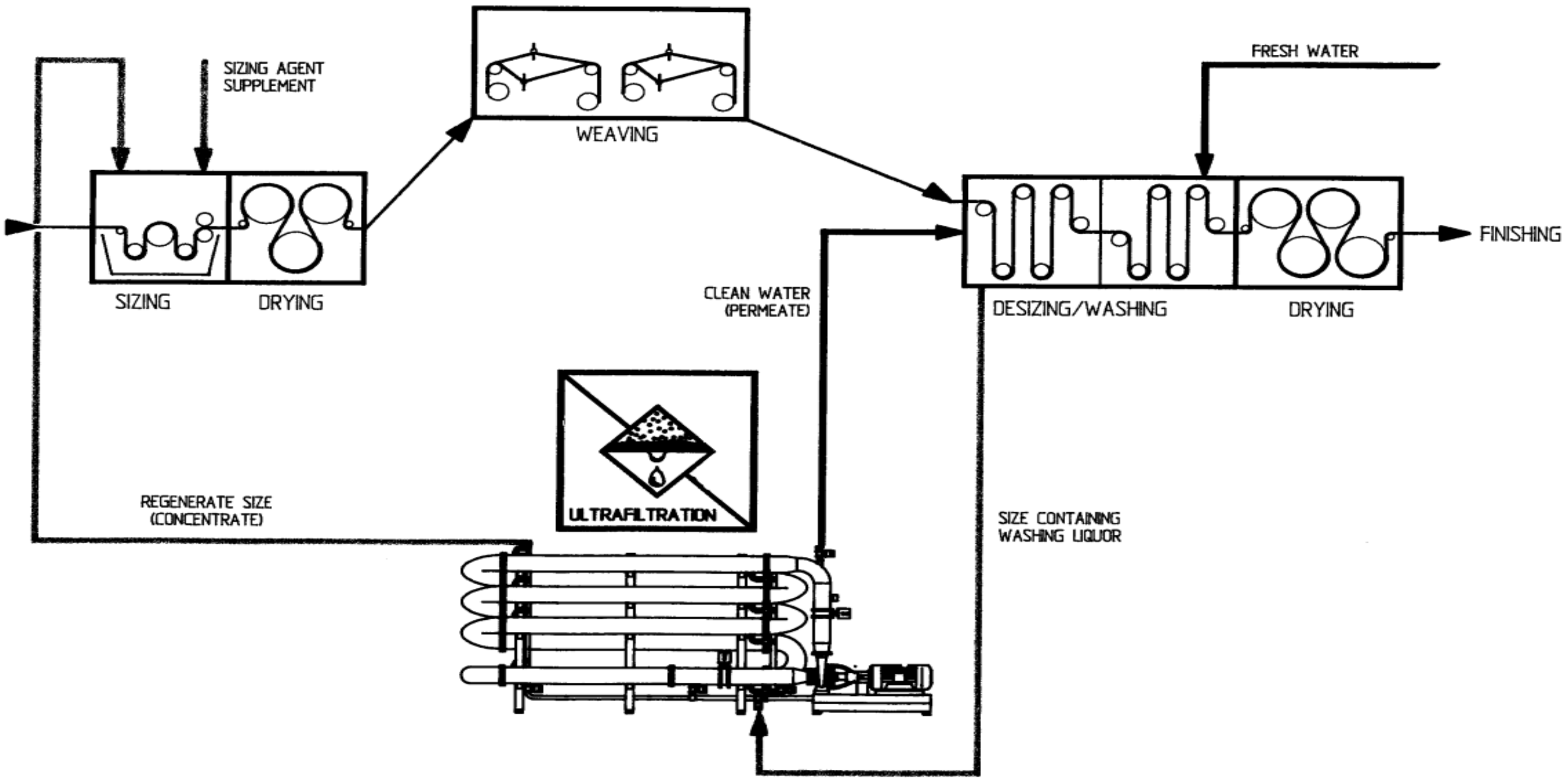
- Resource efficiency as sizing agents are recovered.
- Reduction of the pollutant loads in the wastewater.
- Reduction of energy consumption.

In addition, sizing agents in wastewater do not need to be treated. Thus, energy consumption for treatment is reduced significantly as well as quantity of sludge to be disposed of [179, UBA, 2001].

Environmental performance and operational data

It can be noticed that, even with recovery, some losses of sizing agent still occur at various stages of the process, especially during weaving. Furthermore, a certain amount of sizing agent still remains on the desized fabric and a fraction ends up in the permeate. The percentage of sizing agents which can be recovered is 80-85 %.

Recovery of sizing agents by ultrafiltration



Source: [179, UBA, 2001]

Caustic Recovery Plant

Mercerising

Mercerising is responsible for a large amount of strong alkali that is discharged in waste water and needs to be neutralised. The corresponding salt is formed after neutralisation. In this respect, the cold process involves higher emission loads than the hot one. In order to allow the required retention time and make possible the cooling of the bath in continuous mode possible, a portion of the bath needs to be taken out removed and cooled down in continuous mode. This means that higher volumes of bath are necessary in cold mercerising, which also result in higher emissions if the caustic soda is not recovered. Mercerising baths are usually recovered and reused. When this is not possible, they are used as alkali in other preparation treatments (caustic soda recovery is discussed in Section 4.4.8.2).

Description

Caustic soda is recovered from the rinsing water by evaporation and further purified, if needed.

Technical description

During the mercerisation process, cotton yarn or fabric (mainly woven fabric but also knitted fabric) is treated under tension in a solution of concentrated caustic soda (270-300 g NaOH/l, or also 170-350 g NaOH/kg textile substrate) for about 40-50 seconds. The textile substrate is then rinsed in order to remove caustic soda. This rinsing water is called weak lye (40-50 g NaOH/l) and can be concentrated by evaporation for recycling. The principle is shown in the figure Figure 4.43 below

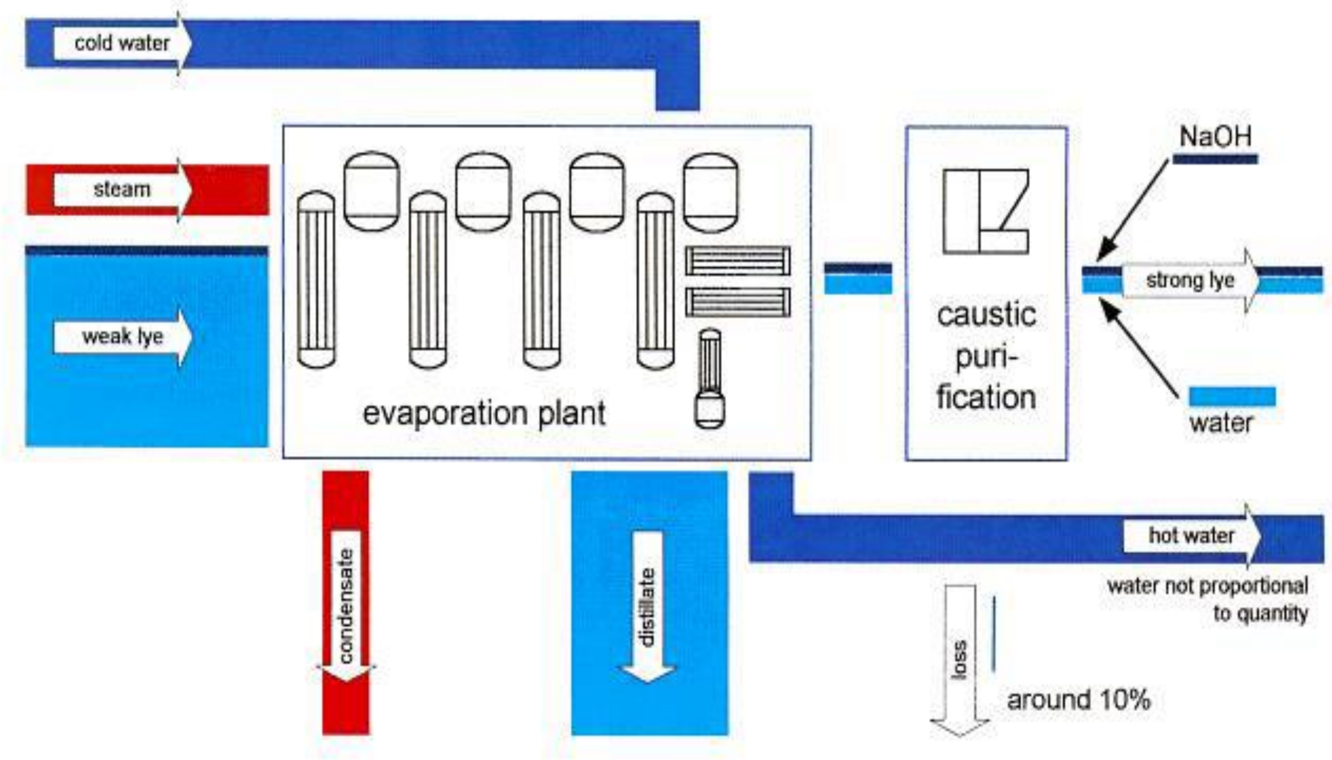
Caustic Recovery Plant

Before evaporation, fibres, and other solid particles are removed by self-cleaning curved screens and microfiltration. In the pre-cleaning stage with curved screens, crystallization of caustic soda occurs via contact of the lye with the carbon dioxide contained in air, resulting in a higher cleaning efficiency compared to rotary filters. More pollution is reduced by the installation of a sedimentation tank.

Weak lye is concentrated in two, three or four steps in the downstream evaporation plant. In the final purification stage, oxidation with hydrogen peroxide destroys the unwanted yellow colour of the strong lye. If the lye is reused after oxidative desizing decolouring can be achieved without any addition of auxiliaries because the bath contains an excess of hydrogen peroxide.

Subsequent cleaning is done by flotation. The recovered lye is cooled before reuse. Subsequently, the cooling water can be used for hot processes. [ÖKOPOL 2011]

Caustic soda recovery process by evaporation followed by lye purification



Caustic soda recovery process by evaporation followed by lye purification

Main Achieved environmental benefits

The alkaline load of the waste water is reduced drastically and the acid required for waste water neutralisation is minimised.

Concentration of the weak lye results in savings of resources (no add-on of new products) and energy (less energy consumption compared to white liquor production).

Environmental performance and operational data
The concentration of weak lye is usually 5-8 °Bè (30-55 g NaOH/l) and is increased may be up to 25-40 °Bè (225-485 g NaOH/l), depending on the mercerising process applied. When mercerisation is carried out on the greige dry textile substrate (raw mercerisation), it is possible to the achievable a concentration of caustic soda is not higher than 25-28 °Bè, whereas a concentration of 40 °Bè can be obtained in non-raw mercerisation. In raw mercerisation, the concentration of impurities is significantly higher, as is the viscosity, which makes it difficult to reach higher concentrations (because the circulation in evaporators is less efficient disturbed).

Main Achieved environmental benefits

For example, a four-step evaporation plant with a capacity of approximately 5 t/h is run by an excess pressure of 2 bar, is charged with lye concentrated at 8 °Bé (approximately 5 % lye) and returns lye at a concentration of 40 °Bé (approximately 35 % lye), for the concentration in the mercerising bath to be 28 °Bé.

For the evaporation, approximately 0.3 kg steam per kg vaporised water are needed corresponding to 1 kg steam/kg recovered NaOH at 28 °Bé or 1.85 kg steam/kg NaOH at 40 °Bé.
The higher the number of stages for evaporation, the more often the heat is reused, the lower the steam consumption and, therefore, the running cost. Investment, however, obviously increases with the number of stages.

Mercerising baths are usually recovered and reused. When this is not possible, they are used as alkali in other preparation treatments

Main Achieved environmental benefits

Economics
Investment costs mainly depend on the plant size and purification technique and typically vary from EUR 200 000 to EUR 800 000 euros. The payback time depends on the plant size and operating time per day. Usually, if mercerisation is practised carried out around 400 hours per year full-time, the payback period is less than 1 year. In companies where non-recovered caustic soda lye has to be neutralised with acid, the payback time is less than 6 months. Thus, from the economic point of view, caustic soda recovery may be very attractive.
In one plant, maintenance costs for curved screens and microfiltration are around EUR 80/week. Investment costs for recovery of 4 000 kg/h of lye are around EUR 330 000 and for 5 700 kg/h around EUR 350 000.

Driving force for implementation
High alkali content of wastewater and economic aspects of caustic soda losses

Recovery of printing paste

There are techniques available that can help to reduce paste residues and techniques for recovery/reuse of the surplus paste. Their efficiency success is, however, limited due to a number of inherent technological deficiencies of analogue printing technology. Most of these deficiencies are related to the analogue transfer of the pattern, the unavoidable contact between the surface of the substrate and the applicator (screen) and the need for thickeners in the formulation (paste rheology), which limits the ultimate potential for paste reuse.

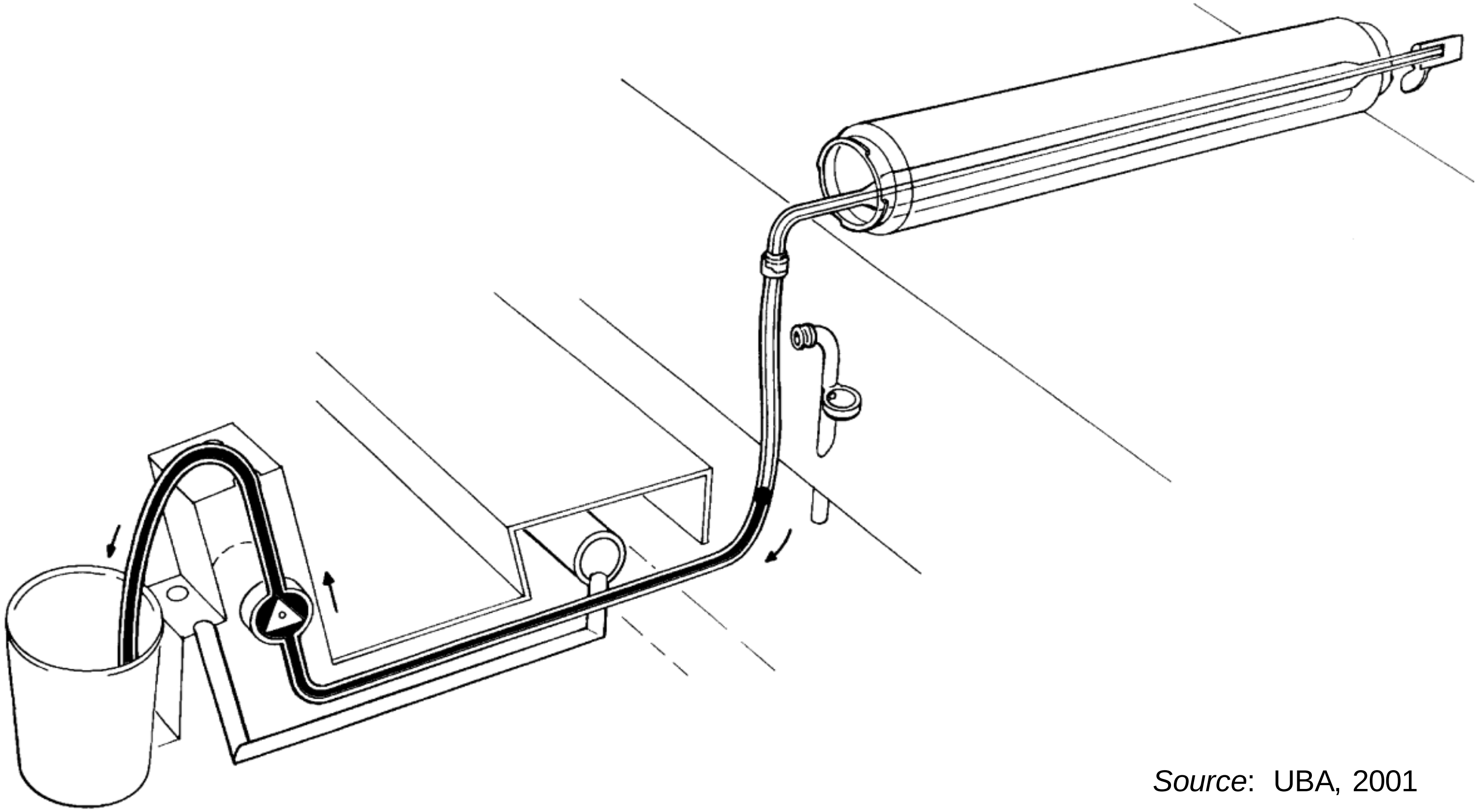
Description

Residual printing paste in the supply system is pumped back or pushed back to its original container (e.g. by a ball controlled by air pressure).

Technical description

This technique allows the recovery of the printing paste remaining in the supply system in rotary screen printing machines at the end of each run. Before filling the system, a ball is inserted in the squeegee and then transported by the incoming paste to its end. After finishing a print run, the ball is pressed back by controlled air pressure, pumping pushing the printing paste in the supply system back into the drum for reuse. Systems available for reusing residual printing paste are described in Section 4.6.1.7. The technique is illustrated in the figure below, showing the ball during the phase in which the pump is transporting the paste back to the drum.

Recovery of printing paste from the paste supply system by back-pumping an inserted ball



Source: UBA, 2001

Recovery of printing paste

Achieved environmental benefits
Reduced generation of waste and of waste water.

Environmental performance and operational data
Printing paste losses are reduced dramatically. In textiles, for instance, at a printing width of 162 cm, the loss is reduced from 4.3 kg (in the case of a non-optimised printing paste supply system) to 0.6 kg.

Rotary screen printing machines have up to 20 supply systems, although in practice, for fashion patterns, 7 - 10 different printing pastes are common. Therefore, the 3.7 kg of printing paste saved per supply system have to be multiplied by 7 - 10. Water pollution can thus be minimised considerably.
To achieve maximum benefit from this measure, modern printing machines with minimum-volume feed systems are should be used

Recovery of printing paste

Technical considerations relevant to applicability

The push-back system is only applicable to rotary screen printing. Certain existing machines can be retrofitted.

The technique is applied in textile finishing mills (for flat fabrics). In principle this system can also work for carpets, but it is not applied for various reasons. Probably The main reason is related to the type of thickeners most commonly used in carpet printing pastes. These are based on guar gum, which is quite relatively inexpensive, but has a limited shelf life and therefore cannot be stored for a long time before reuse (it is biodegradable and the growth of bacteria and other organisms such as yeasts rapidly alters destroy the viscosity).

Economics

The investment for retrofitting this recovery system to a rotary screen printing machine with 12 new squeegees and pipes (for a printing width of 185 cm) is about EUR 42 000. The next table below shows the savings achievable in the reference a typical mill.

Recovery of printing paste

Calculation of savings achievable in a typical textile mill by installing the referenced printing paste recovery system (the number of changes as well as the number of printing pastes per design may be higher in industrial practice)

Number of changes of printpastes per day	**8**
Number of working days per year	250
Average number of printig pastes per design	7
Saving of printing paste saved per supply system	3,7 kg
Price of printing paste	EUR 0,6 / kg
Saving per year	EUR 31.080 / yr
Remark: NB: The number of changes as well as the number of printing pastes per design may be higher in industrial practice. *Source: UBA, 2001*	

Recovery of printing paste

The example does not include the investment cost of new pumps, so a certain range of viscosity needs to be maintained. When a wide viscosity range is required, the pumps have to be replaced. The total investment cost is then reported to range between about EUR 90 000 and
EUR 112 000.

A payback time of about 2 years can therefore be considered realistic, but only when all of the recovered printing paste is reused. In practice this does not happen, especially with mills that use several different types of printing pastes. In such mills, due to logistical problems (limited storage and handling capacities), reuse rates of only 50-75 % are reported, which significantly extends the payback period.

Driving force for implementation
Reduction of printing paste losses for economic and environmental reasons.

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