Chapter 7
Input-Oriented Chemicals Management Along the Textile Supply Chain

Thomas Schäfer and Maren Herter

Abstract In the textile supply chain—specifically in textile finishing—chemicals play a crucial role. The amount, kind and the processing conditions of chemicals bear considerable impact on environmental performance as well as occupational and consumer safety. For this reason, chemicals management should be focused upon as well as addressed commonly and in a coordinated manner. In the following, it is investigated to what extent input-oriented chemicals management illustrates a solution for the highly complex and seemingly impenetrable global textile supply chain. The relevant stakeholders—chemical suppliers, textile manufacturers and brands—are defined by means of their tasks and interrelation with each other within the supply chain. Further, instruments for chemicals management—that can reach from meeting legal requirements up to taking voluntary actions such as testing and a system-oriented approach—and their effectiveness will be explained. In specific, foundational elements of a system-oriented approach will be defined by ascribing responsibilities to stakeholders regarding the choice and application of textile chemicals. Thereby, a positive list of analyzed and assessed textile chemicals is introduced as an efficient tool. It will become clear that the concept of 'product stewardship' and its consequent implementation throughout the entire textile supply chain represents the key to an increasingly sustainable textile production. All players in the supply chain need to be willing to approach alternatives and to follow a chemicals management strategy, which goes hand in hand with 'chemicals *change* management' and induces companies to think one step further, rethink and foremost do not think short-term.

Keywords Chemicals management · Environmental performance · Occupational health and safety · Consumer safety · Input stream management · Toxicological assessment · Positive list of chemicals · Product stewardship · Preferred chemicals

A practitioner's perspective

T. Schäfer (✉) · M. Herter
Bluesign Technologies Germany GmbH, Augsburg, Germany
e-mail: Thomas_Schaefer@bluesign.com

M. Herter
e-mail: Maren_Herter@bluesign.com

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7.1 What Does Chemicals Management Mean?

In 2002 on the World Summit on Sustainable Development in Johannesburg for the first time, the UN agreed upon the '2020 goal of chemicals management.' The aim is to minimize the harmful impacts on human health and environment during handling of chemicals in all stages of the life cycle by 2020.

The definition of proper 'chemicals management' encompasses more than the adequate storage of chemicals and should go beyond the sole endeavor of creating a chemicals inventory list in textile finishing companies.

For an integrated chemicals management, all players along the textile supply chain are responsible and must act decisively in a common and coordinated approach. The aim is to minimize harmful impacts on human and environment during production and subsequent application of chemicals in appropriate time. Knowledge and transparency is crucial regarding type and volume of applied chemicals, contained impurities, application conditions and their potential impact on human and environment.

7.2 Textile's Supply Chain

Due to the numerous processing steps (manufacturing of fibers, yarns, fabrics) and processing methods (dyeing, finishing, printing, coating, etc.), the supply chain of textiles can be defined as one of the most complex industrial value chains, where chemicals suppliers—next to raw material producer—can be considered as the very start. Specialty chemicals (e.g., dyestuffs and auxiliaries) as well as basic chemicals (e.g., sodium hydroxide and acetic acid) are involved. Since the apparel industry also processes a multitude of accessories such as metal zippers and plastic buttons, one further needs to consider, among others, metals and plastics processing. For this reason, the textile supply chain rather illustrates a supply 'network,' which is visualized in the following Fig. 7.1.

Irrespective of the production of synthetic fibers and the agricultural production of natural fibers, the supply chain level Tier 2 is certainly the most critical stage, when it comes to the subsequent application of chemicals. Consequently, Tier 2 is—or should—be well-informed and have adequate knowledge about the type and quantity of the used chemicals and their responsible management. In an ideal case, the chemical supplier supports the textile manufacturer for example concerning trace impurities below classification thresholds that are prescribed in a safety data sheet (SDS), but also via a technical data sheets (TDS) when it comes to recipe handling and optimized application conditions.

The brand, as owner of the final product for the market, can and must exert influence in various forms on the chemical management in a supply chain. Tier 2 or the chemical supplier is the most important contact. In Fig. 7.1, it becomes apparent that information exchange between brand and Tier 2 or the chemicals supplier is

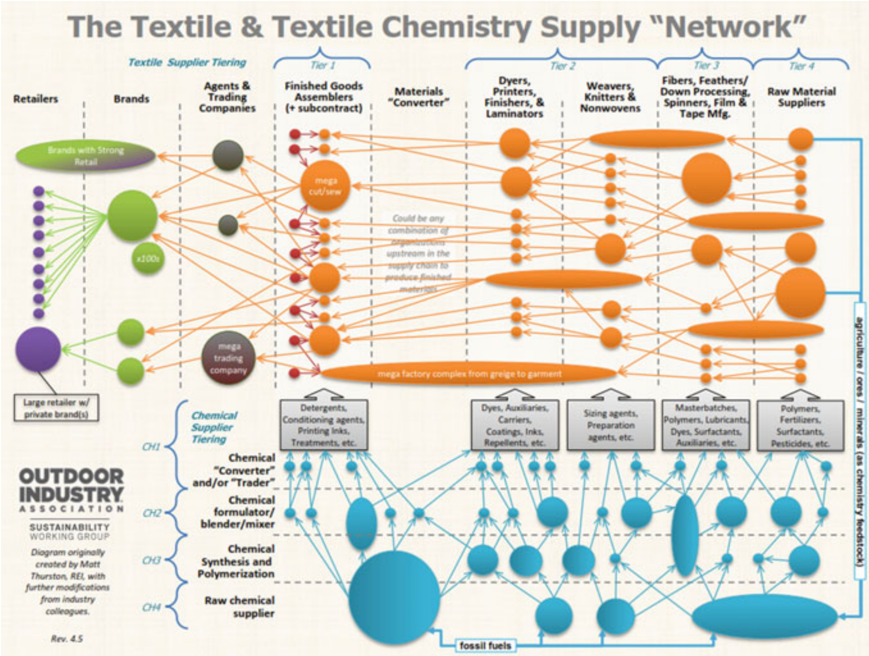

Fig. 7.1 The textile and textile chemistry supply "network", M. Thurston

certainly not simple. Most of the times other players are in between (e.g., agents, converters and trading companies) and deal with the brand, Tier 1 or even other Tiers. Having mostly only access to these respective in between players, brands face an essential obstacle for chemicals management along the entire textile chain.

7.3 Types and Quantity of Chemicals

Auxiliaries and colorants define as 'mixtures,' and for this reason, they differ from basic chemicals, also called 'commodities.' They are, among others, composed of effect-giving substances (also called 'active substance' such as a surfactant with washing effect or a colorant). Next to it, substances are included intentionally in mixtures, which are necessary for processing auxiliaries and colorants (e.g., water or an emulsifier, that emulsifies the active substance, etc.). The active substance might have affinity to the fiber and is to stay on the textile substrate (e.g., colorant, special after-treatment agent, finishing auxiliary) or illustrates merely a process auxiliary (as for instance a washing-, wetting- or a complexing/chelating agent). Figure 7.2 describes mixtures and their components: The intentional active substance and additive as well as the unintentionally contained impurities. An auxiliary or dyestuff consists of several intermediates, which again can represent mixtures. This makes

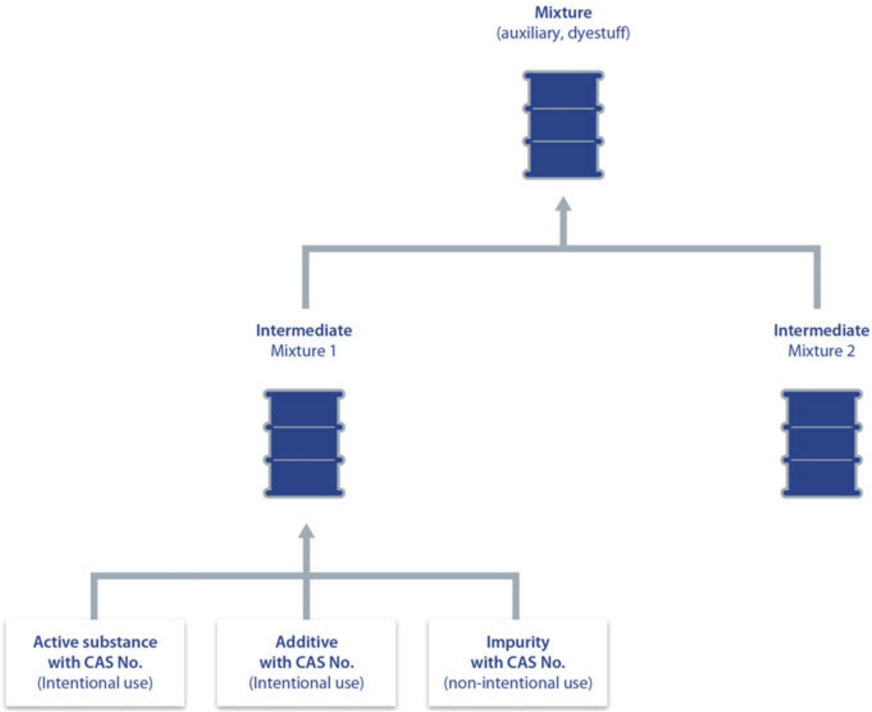

Fig. 7.2 Mixture and its components (Illustration by bluesign technologies)

traceability of impurities, even in the chemical production site, difficult, as an SDS serves as only source of information regarding the intermediates—if no other specifications are required. However, often an SDS lists a hazardous substance only from 1000 ppm onward and may contain insufficient information.

Since nowadays great focus is put on impurities, chemicals management's main task is perceived in minimizing impurities in auxiliaries and colorants (e.g., the possible contamination of disperse dyes with chlorinated benzene or toluene) as well as basic chemicals (e.g., heavy metals in sodium hydroxide) (Ecotextile News 2018). The consolidated European textile supply chain uses roughly 1500 basic chemical substances and 1500 specialty chemical substances, from which again around 15,000 mixtures (textile auxiliaries and dyestuffs) are produced (EnviroTex 2005).

Figure 7.3 illustrates the specific consumption [g/kg production volume (PV)] of auxiliaries, dyestuffs and basic chemicals for the production of woven synthetics during dyeing and finishing in 85 production sites.

Table 7.1 depicts average numbers for a traditional textile company that conducts pretreatment, dyeing and finishing. They serve a purely guiding purpose and even major variations are possible, as it already became clear in Fig. 7.3.

The consumption depends on the used textile substrates (polyester, cotton, etc.), the fabric type (woven or knitted) and the complexity of processes, but also on

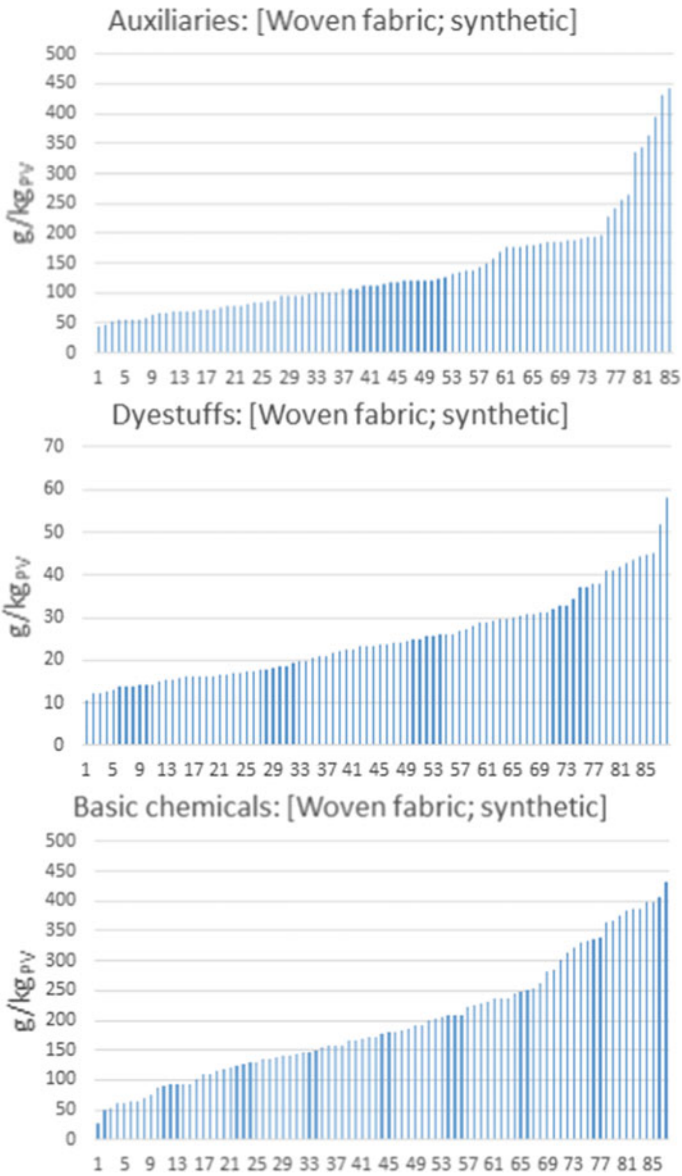

Fig. 7.3 Specific consumption of auxiliaries, dyestuffs and basic chemicals at 85 textile finishing mills (Illustration by bluesign technologies)

Table 7.1 Consumption and number of chemicals in textile finishing [2]

Chemical	Consumption (g/kg textile)	Number of chemical products
Auxiliaries	120	80
Dyestuffs	30	200
Basic chemicals	250	20

companies' performance regarding resource efficiency. When only one substrate-type is used, the number of applied chemicals can be significantly lower, specifically when it comes to colorants. According to the average values, a company, processing 5000 tons of textile annually, needs 2000 tons of chemicals per year.

7.4 How Chemicals Are Applied

The importance of chemicals management in the textile supply chain is not only derived from the type and quantity of the used chemicals (see Sect. 7.3), but also from their application. Except for some processes of finishing, printing and/or coating, all chemicals are supplied in water-based formulations and applied in continuous or batch machines. The machinery (dye unit, continuously working washing machines or foulards (impregnating units) with subsequent drying units, etc.) normally does not consist of 'closed' processes. Also, preparation stations for applied chemicals such as the 'dye kitchen' are not often fully automatized.

Two main consequences can follow from that: First, workers can be significantly exposed to chemicals at their workplace. Second, the waste water path as well as off-gas plays an essentially important role for the environmental performance of a textile production step. Except for colorants and few auxiliaries, with a fiber affinity, nearly all chemicals that are applied in pretreatment and dyeing processes as well as residuals from printing and finishing enter finally waste water. Thermal aggregates, which are often not equipped with off-gas cleaning and work in a range of temperature above 200 °C, can cause considerable off-gas pollution.

Ecological and workplace relevance becomes even more apparent regarding textile coating from solvent-based pastes, which are currently state-of-the-art in Asia. Here, *N,N*-dimethylformamide, which is classified as toxic for reproduction category 1B and other solvents are the choice. Production sites process often 500 tons or more of solvents per annum—and only in particular cases closed systems are installed.

7.5 Instruments for Chemicals Management

7.5.1 Globally Harmonized System (GHS)

The Globally Harmonized System (GHS) of Classification and Labeling of Chemicals of the United Nations is a worldwide uniform system for classifying chemicals as well as labeling both on packaging and in safety data sheets. Harmonizing the classification and the labeling of chemical substances and mixtures paves the way for a consistent and unequivocal communication of hazards. The EU Regulation 1272/2008 (CLP-Regulation) aligns the classification and labeling of chemicals according to GHS. GHS has not been introduced to all countries and classifications and labeling among several countries may differ. Also, not all hazard classes and categories of single countries, which had implemented GHS, have been taken over. GHS conformal safety data sheets represent a minimum requirement for responsible chemicals management, yet the complete and correct classification and labeling is often challenging.

7.5.2 Legal Requirements

In previous times, legislation regulated only a few harmful substances in textile products. Examples include among others:

- 'Worldwide' (Stockholm Convention)
  - POPs (persistent organic pollutants (e.g., PFOS)
- EU
  - Annex XVII REACh (e.g., some flame retardant, 'Azoamine,' PAH, tin-organic compounds, nonylphenol and nonylphenol ethoxylates, PFOA and PFOA-related substances)
- China
  - GB 18401 (e.g., formaldehyde, 'Azoamine')
- Turkey (Notification 29236), Japan (Act No. 112), Taiwan (CNS 15290), USA (CPSIA).

Yet, the number of textile relevant substances regulated by law and applied increases. An example thereof is the restriction of 33 carcinogenic, mutagenic and/or reprotoxic (CMR) substances of the category 1A and 1B for their use in clothing, footwear and other textile articles. In October 2018, the European Commission published Commission Regulation (EU) 2018/1513 which amended REACH Annex XVII by creating a new entry 72 in the Official Journal of the European Union (OJEU).

Another example is the adoption of *N,N*-Dimethylformamide, a typical solvent for the coating of textiles—in the Californian Proposition 65. Further, 350 substances are currently subject for the call of evidence for the preparation of an Annex XV restriction dossier according to Article 69 of REACH.

Alone these, three initiatives of authorities illustrate how dynamic legislation adoption can be in the field of chemicals management. Based on such undertakings, a crucial question arises: How can a textile producer or a textile trader ensure compliance with legally binding limit values? A safety data sheet alone, individual testing on textiles or textile chemicals, sheer conformity to restricted substances lists (RSLs) or manufacturing restricted substances lists (MRSLs) will neither be sufficient nor practical nor effective.

Input-oriented chemicals management represents a solution for the textile supply chain: It starts already at the chemicals manufacturer, with the result of a positive list of chemicals, which guarantees under proper use the statutory limit values. Indeed, not only a set of rules concerning consumer safety regulate chemicals management, but also national and subordinated environmental and workplace regulations exert either direct or indirect influence on chemicals management.

7.5.3 Restricted Substances List (RSL)

A reason for the existence of a Restricted Substances List (RSL) is surely the current deficit of statutory regulations when it comes to harmful substances in textiles. An RSL focuses on consumer safety and regulates the presence of certain chemical substances in articles (for example textiles, trims, leather) by defining concentration limits (e.g., mg substance per kg textile). Because the amount of a substance in an article depends often on the amount of applied substance during production, often an RSL indirectly regulates the use of substances in production.

Since most brands have their own RSL, a great number of different RSLs exists. This illustrates a great challenge concerning chemicals management: such a big number of RSLs cannot be handled in a responsible way by the supply chain and RSL management can turn into a paper tiger of bureaucracy (Patterson 2013).

Brands oblige their supply chain to confirm that the delivered products meet the RSL requirements. Principally, a confirmed or signed RSL qualifies as a legitimate minimum evidence and documentation for authorities. However, Fig. 7.1 demonstrates that often these confirmations—also called ‘compliance declarations’—on the part of the suppliers are signed on Tier 1-level or even later (on a level between Tier 1 and the brand). Consequently, far too little information is available to assure RSL conformity in a credible way. It would be highly constructive when the supplier explains in a supplementary way by which means limit values are met and ensured permanently in the long-run (e.g., by establishing and maintaining an appropriate quality management system including a testing program and by input stream management regarding the used raw materials).

7.5.4 Manufacturing Restricted Substances List (MRSL)

A Manufacturing Restricted Substances List (MRSL) is a list of chemical substances that should not be intentionally used in facilities that process materials (e.g., textiles, trims). Typically, it defines concentration limits (often detection limits) for chemical substances in a mixture (e.g., mg substance per kg dyestuff or mg substance per kg textile auxiliary). The focus lies on environment as well as safety for workers and consumers.

One result of the Greenpeace Detox campaign in 2011 (Greenpeace 2011) is the first MRSL, being published in 2014. This MRSL focuses currently on the 'Greenpeace Detox' substances, respectively, substance groups with some supplements, e.g., a few glycols (ZDHC 2015).

It is to be welcomed that the MRSL approach has paved the way for the demand of an industry-wide input-oriented chemicals management that takes the finished textile and the applied chemicals into account.

The MRSL limit values refer to chemical products and are partly much lower than concentration values that are considered during creating a safety data sheet. Because of that, the user (e.g., the textile finisher) has no adequate mean to determine, whether the applied chemicals comply with MRSL limits. Only the chemical supplier can—by means of commensurate knowledge—provide information on MRSL listed substances and potential impurities in lower 'parts per million' range. An impurity management, that solely grounds on MRSL compliance, bears similar boundaries like the RSL. It should reach the chemical suppliers, but often only rare contact with the brand exists and, in most cases, chemical suppliers are unknown to the brand.

The choice of preferred auxiliaries and colorants depends not only on the ban of some substances. The first deficit of a chemicals management which is based purely on an MRSL approach is the missing environmental parameters (e.g., VOC content, biodegradability or aquatic toxicity) in chemicals assessment of a mixture. A second deficit is when a chemical supplier shall sign an MRSL but does not have sufficient knowledge. Only chemical suppliers with an appropriate product stewardship performance are able to answer an MRSL request in a reliable, complete and correct manner. A third deficit is that MRSL conformity does not automatically ensure that the environmental and OH&S prospects of the chemical production site are on an appropriate or even optimized level (Schäfer 2018).

7.5.5 Testing on Impurities

7.5.5.1 Products (textiles)

Random testing of textiles identifies single substances and can constitute an appropriate tool to prove the fulfillment of legal requirements and RSL conformity. Though it is often required by authorities, the significance of testing is small and cannot provide solution, as the reason for a 'pass' or 'fail' after testing is normally not known. Above, regular and intense testing can be costly.

7.5.5.2 Chemical Products

While only few years ago, impurity testing focused almost entirely on product testing (textiles, etc.), now increasingly more testing labs can identify chemical substances (impurities) in chemical products, though standardized procedures are lacking and not every lab result can guarantee the necessary solid evidence. Tests on specific single chemical substances or substance groups but also the so-called screenings are offered, which capture numerous substances semi-quantitatively and mostly via gas chromatography.

Some brands conduct testing on chemicals in their own responsibility and create an individual 'positive list,' which prescribe mandatory chemicals for their supply chain. Laboratories and labels conduct testings on textile auxiliaries and colorants, too. In case of successful testing (often based on few selected parameters), 'eco-certificates' for specific chemical products are granted for a given time. Yet, it is obvious that a testing for impurities on a sample, without knowing how a chemical product was produced (Were raw materials of equal purity used? How is this guaranteed? How is the quality management of the chemical supplier? Can consistent quality of supplied products be guaranteed? Is the safety data sheet significant and informative?) illustrates only a short-term statement with limited predictive value. Further, an impurity test of a chemical—equal with textiles—does not state anything about the environmental performance of a production site and a 'clean factory' approach is therefore not given.

7.5.6 NGO Campaigns

Campaigns with political background often provide a clear impetus specifically for big brand to take chemicals management within their supply chain into consideration. While they successfully refer to drawbacks and raise awareness in the public, it is up to the industry to develop and implement solutions.

7.5.7 System-Oriented Approach

A system-oriented approach consists of following components:

- Integration of all players (but foremost chemical supplier, textile manufacturer and brand), which expend effort to ensure the best possible traceability in the supply chain

- Requirements for environmental protection and OH&S as well as resource efficiency at all production sites (chemical suppliers, textile companies, etc.)
- Continuous optimization of the environmental performance and resource efficiency as well as worker and consumer safety and a continuous monitoring of the implementation of measures
- Focus on knowledge transfer and capacity building instead of plain 'pass/fail' audits
- Scientific methods that prioritize and assess chemicals and enable the derivation of limit values for critical substances in chemical products
- A chemical assessment of auxiliaries and dyes, based on an intelligent conjunction of hazard end-points and risk evaluation, which again considers ecological, OH&S as well as consumer safety aspects
- An input-oriented chemicals management system
- A positive list of preferred chemicals (e.g., textile auxiliaries and colorants).

7.6 Components of Good Chemicals Management

Good chemicals management is realized, when all relevant players in the textile supply chain fulfill their (product) responsibility and an appropriate information exchange between the players take place.

The pivotal task of input-orientated chemicals management is the integration of chemical suppliers. A first big milestone toward an effective chemicals management is achieved, when critical chemicals are not applied in textile finishing or—even better—assessed and chemicals of optimized qualities are applied. Figure 7.4 visualizes the input stream management approach with the three key players in the supply chain, where harmful substances are eliminated from the very beginning.

Further, it is essential that chemicals management is not only done on the paper (e.g., via RSL and MRSL conformity declarations), but also implemented demonstrably in the textile supply chain, which takes time and manpower. Necessary awareness, persuasion and the relevant knowledge are of equal importance. The following depicts a broadened concept of product stewardship for the individual players.

Fig. 7.4 Input-oriented approach for chemicals management according to bluesign technologies (Illustration by bluesign technologies)

7.6.1 Chemicals Supplier

The chemical supplier—in many cases, when there is an intermediate trader–the producer of auxiliaries and colorants must:

- take adequate precaution to minimize the environmental impacts on water, air and soil in the production site
- conduct the necessary organizational and technical measures to ensure workplace safety
- take the greatest possible effort to produce resource efficiently
- develop and manufacture products based on 'Best Available Technique' (BAT) to continuously increase and improve environmental protection and occupational health and safety at downstream use
  - Further, banned substances (e.g., Alkylphenol ethoxylates) through legal or voluntary initiatives must be not applied as active substance for products
  - This also foresees to maintain contamination with harmful substances in products on the lowest possible level
- label accurately and completely final products according to GHS
- provide recommendation for application by means of a technical data sheet (TDS).

The chemical supplier should take and permanently guarantee this responsibility. It is essential that the company installs a 'product stewardship management' paired with sufficient knowledge and experience based on the aim of continuously improving it. Often the question arises, whether new molecules are developed, like in the pharmaceutical industry. One can respond that revolutionary developments in this field have been falling short for the last years, due to the low average price of auxiliaries and dyes (5–50 USD/kg) and textile industry's outward move from Europe.

From Fig. 7.5, it becomes apparent that 'product stewardship' starts already at the purchase of raw materials and intermediate products (input-oriented chemicals management). The main tasks comprise the selection and assessment of suppliers, a certificate of analysis, specifications on impurity content, an impurity analysis of raw materials. In addition, knowledge and control of processes are prerequisites for consistent quality. When all modules of a product stewardship are introduced and developed, adequate know-how exists to create a basis for a successful chemicals management along the textile supply chain and to finally communicate the hazards.

7.6.2 Textile Finisher

Input-oriented chemicals management illustrates the preferred way for the textile finisher. By preventing hazardous substances to access the production site—due to either legislation or voluntary initiatives—one rectifies the problem at source. The

Fig. 7.5 Product stewardship at the chemical company according to bluesign technologies (Illustration by bluesign technologies)

textile finisher can save resources by using auxiliaries and colorants, whose applications consume less water and energy. With these chemicals, which are potentially less volatile or have a high degree of biological degradability, cleaning systems for waste water and off-gas can be made more efficient and cost-saving.

From a global perspective, it is right to state that the textile finishing industry is not able to conduct input stream management of chemicals on its own. Or differently said: it takes time and effort for the textile finisher to differentiate and identify complete and correct safety data sheets from sheets of low quality. Regular information flows from the chemicals supplier to the textile finisher are often missing. This lack, however, can be balanced out through referring to the so-called 'positive list' that comprises assessed auxiliaries and colorants, which were produced responsibly and whose impurity content and characteristics regarding occupational health and safety and environmental aspects were assessed and classified as recommendable by a third party.

Still, it is essential that the textile finisher, in the role as the chemical user, takes all necessary actions for environmental protection and OH&S to finally ensure a responsible application of the chemical. Despite the optimization of a chemical: a chemical remains a possibly hazardous substance, whose risks must be minimized.

The main tasks for a textile finisher are to:

- install, maintain and continuously improve an appropriate quality and environmental management system that includes chemicals management and chemicals change management
- define purchase conditions and to invest in trustful relationships with chemical suppliers
- select chemicals from a 'positive list'
- be aware of the best available techniques (BATs) and continuously improve resource efficiency.

At this point of the subsequent application, it becomes apparent that chemical management must often go hand in hand with 'chemicals change management.' The production site needs to install substitution measurements, for instance, when the applied chemical is supplied without an SDS or an inadequate one, when impurities are contained or when there are alternative products available with lower hazardous impact on humans and environment. Substitution requirements represent often the retarding factor, when looking closely on the global supply chain's chemicals management: old trade relations—mostly to local suppliers—would be at stake, costs and price increases could come up, which are barely communicable in the short-term, recipes for colorants must be revised, etc.

7.6.3 Brand

Only a few years ago, when the brand came into contact with the chemical supplier, only requirements concerning performance and effects were typically communicated.

Due to some well-known campaigns, chemical management has gained importance in brands' sustainability policy and in their environmental programs. Almost all production processes are outsourced, and the brand's main task is to manage the supply chain.

Core tasks for a brand are to:

- acquire sufficient knowledge on 'chemistry'
- set focus on the necessary chemicals for manufacturing a product next to material efficiency and 'life cycle' arguments, when weighing ecological aspects at product design and development
- achieve traceability in the supply chain (including Tier-2 and the chemical supplier) based on responsible selection of supplier with the prospect of long-time relationships (in order to avoid 'supply chain tourism')
- consider the aspect to what extent the supplier creates an appropriate chemicals management at the production site. In this regard, it is important to clarify whether adequate disposal companies as well as laboratories for waste water and off-gas analysis exist in the region of production
- ban specific chemicals completely (e.g., long-chain fluorotelomer chemistry)
- nominate auxiliaries and colorants. This means to prescribe chemical products. This can be done for instance by providing the textile finisher with a 'positive list' of assessed preferred chemicals
- implement an adequate RSL management and testing program.

The brand can accomplish these tasks by itself, within the framework of a consortium of brands and/or by joining a system that aims at the continuous improvement of input-oriented chemicals management, resource efficiency, environmental protection, occupational health and safety as well as consumer safety. It is undeniable that a holistic approach toward more sustainable actions is challenging and time-consuming. But simultaneously, it illustrates the only solution in the long-run.

7.7 Outlook

Upon reasonable ground, key players have been focusing on chemicals management along the global textile supply chain. The challenges of a complex global supply chain have been tried to overcome by means of several approaches. Approaches may differ from each other, but they must have one common denominator: the focus must lie on improving environmental performances in the production site and meeting safety standards for workers and consumers. Therefore, the inclusion of the chemical supplier is critically essential to ensure that input-oriented chemicals management starts at the earliest point in the supply chain. It remains to be hoped that based on a possibly common and aligned approach by the players, meaningful measures are developed and implemented. Next to improving knowledge and increasing the necessary awareness along the supply chain, it is crucial to continuously and successfully implement chemicals management in a step-by-step approach—with less focus on individual lighthouse projects and individual interests of single key players.

Literature

Bluesign technologies ag. (2014). bluesign® system Version 1.0. https://www.bluesign.com/de/industry/infocenter/downloads/downloadFile/1/ind-download-criteria/bluesign_system_v1.0.pdf.

Bluesign technologies ag. (2010–2018). Aggregated data from bluesign on-site inspections.

Ecotextile News. (2018). bluesign to tackle commodity contamination. https://www.ecotextile.com/2018102623821/materials-production-news/bluesign-to-tackle-commodity-contamination.html. Accessed October 29, 2018.

EnviroTex GmbH. (2005). Final Report. Analysis of the potential impacts of REACH on European textile supply chains. Available via https://www.mpo.cz/assets/dokumenty/27981/29617/319209/priloha001.pdf. Accessed October 20, 2018.

European Commission. (2018). Commission Regulation (EU) No. 2018/1513 of 10 October 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1513&from=EN. Accessed November 1, 2018.

Greenpeace. (2011). Dirty Laundry—Unravelling the corporate connections to toxic water pollution in China. https://www.greenpeace.de/sites/www.greenpeace.de/files/dirty-laundry-report_0.pdf. Accessed October 20, 2018.

Patterson, P. (2013). Should RSL lists be restricted? Ecotextile News Issue No: 53 February/March 2013.

Schäfer, T. (2018). Preferred chemicals. In *Integrated best available wastewater management in the textile industry*. Colloquium on Textile Wastewater Management, September 19, 2018.

Schönberger, H., & Schaefer, T. (2003). Best available techniques in textile industry. Research Report 200 94 329, UBA-FB 000325/e on behalf of Federal Environmental Agency Germany.

Thurston, M. (REI, Recreational Equipment Inc., Kent, Washington, USA).

ZDHC. (2015). Manufacturing restricted substances list—Version 1.1 Available via https://www.roadmaptozero.com/fileadmin/pdf/MRSL_v1_1.pdf.