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MICROBIOLOGICAL CONTAMINATION MONITORING IN LAUNDRIES – MODERN TRENDS AND BIOLOGICAL CONTAMINATION CONTROL SYSTEMS

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Abstract: Microorganisms inhabiting textile products during use and originating from the environment or human skin can be a source of microbiological contamination in production, services and household practice. To ensure that the appropriate level of microbiological quality is achieved for textiles used in industries like medical, beauty products/cosmetic and food processing, textiles are processed at commercial laundries, where the effectiveness of the cleaning process is monitored for soil removal and biocidal effectiveness against microorganisms. The RKI guidelines, mandatory for hospital-use textiles, RAL-GZ 992 or a RABC system focused on analysing the risk of microbiological contamination of laundered products at all stages of laundry processing, are helpful in assessing the biological contamination of laundered products.

Keywords: RABC, laundry, microbial contamination, microorganisms, textiles.

1. PRESENCE OF MICROORGANISMS ON TEXTILE PRODUCTS

Microorganisms are common in the environment. They inhabit a variety of everyday objects, are found on and in the skin of humans and animals, float on airborne liquid particles as bio-aerosols; microorganisms can be found in nutrient-rich food products and reside on a variety of industrial materials [Potera 2001; Takashima et al. 2004; Kramer, Schwebke and Kampf 2006; Oller and Mitchell 2009]. Clothing products, being materials in close contact with the human body, provide an excellent habitat for microorganisms, which can survive on these textiles for a long time without triggering any reaction. However, under temperature and humidity conditions favourable to microorganisms, they can become active and cause various types of contamination and infection. Several studies have shown that microorganisms can survive on textiles for up to several months even when the temperature and humidity conditions are not optimal for their survival [Nelly and Orloff 2001; Szostak-Kot, Syguła-Cholewińska and Jekiel 2010; Jekiel, Szostak-Kot and Syguła-Cholewińska 2011]. Epidermal fragments, perspiration and body fluids are retained on textiles during use, which promotes the growth and may prolong the persistence of microorganisms on textiles [Fijan et al. 2007].

The microorganisms that make up the natural microbiota of the human skin have a protective function, defending the host against the ingress of pathogenic microorganisms, such as the bacteria, fungi and viruses that cause infections. This activity is related to many factors, including the production of mucin, which inhibits adhesion of pathogenic microorganisms. Furthermore, through the production of enzymes (lipases and esterases), triglycerides are broken down into free fatty acids, which maintain a low pH on the skin surface and provide unfavourable conditions for the growth of pathogenic bacteria [Elsner 2003; Taylor et al. 2003; James et al. 2004; McQueen et al. 2007].

However, a certain side effect of the activity should not be ignored. *Corynebacteria* and *Brevibacteria*, which are part of the skin's natural microbiota, break down perspiration into free fatty acids, resulting in an unpleasant odour during the use of clothing products. Their activity also leads to the formation of hydrophobic stains on clothing that are strongly associated with the fibres of knitted and woven utility fabrics [Austin and Ellis 2003].

The presence of this type of organic soiling can promote the persistence of microorganisms on textiles and reduce their elimination effectiveness during laundering. Materials soiled in this way become a potential reservoir and vector for the spread of microorganisms among textile users, thus posing a significant health risk [Munk et al. 2001; Terpstra 2001; Abney et al. 2021]. Microbiologically contaminated textiles used as protective clothing in manufacturing processes, on the other hand, can adversely affect the quality of manufactured products and consumer health safety.

Textile-to-human cross-contamination is an important phenomenon in the compliance with hygiene standards of healthcare facilities (hospitals and social care facilities), industrial practice and services. The food and beverage sector, catering sector, beauty service industry (beauty salons and spas) and hospitality industry should be mentioned in particular. In non-hospital facilities, the risk of disease appears to be lower due to the number and types of potential pathogens present in the environment, although the textiles used in those settings still remain an effective vector for the transmission of microorganisms that can be hazardous to the health safety of people and commodities.

2. VIABILITY OF MICROORGANISMS ON UTILITY TEXTILES

The problem of microbial survival on textiles only received attention in the second half of the 20th century. Particular focus was placed on textile products used in hospitals, especially in the patient-medical staff relationship [Perry, Marshall and Jones 2001; Sattar et al. 2001; Chacko et al. 2003; Sherburn and Jenkins 2005; Lacroix et al. 2007; Wilson et al. 2007]. In the studies by Neely and Maley, it was found that bacterial strains isolated directly from patients, especially those revealing antibiotic resistance, survived on various types of textiles and furnishings for up to three months and could, during this period, be a source of nosocomial infections. It was further noted that the survivability on contaminated materials was strongly correlated with the initial microbial count. The higher the contamination of the material with bacteria, the greater the chances of microbial survival. This was associated with a higher number of viable cells and the fact that the dead cells and metabolites released from them could provide an extra source of nutrients for the surviving microorganisms [Neely and Maley 2000].

Research by Perry et al. clearly highlighted the importance of the problem related to the hygiene of protective clothing used by hospital staff during patient care. The same microbial strains were found in isolates taken directly from patients and from the protective clothing of medical staff at the end of a working day. It was observed that failure to change gowns regularly and their inadequate laundering conditions increased the chances of microbial persistence and thus could increase the risk of cross-infection between patients and hospital staff [Perry, Marshall and Jones 2001]. In a study by Jekiel and Syguła-Cholewińska, it was proven that the selected bacteria of interest, *Pseudomonas aeruginosa*, *Bacillus cereus* and *Staphylococcus aureus*, could survive on fabrics of different material compositions for at least 28 days, even when humidity and temperature conditions were not optimal for their growth [Jekiel and Syguła-Cholewińska 2025].

3. REMOVAL OF MICROORGANISMS DURING THE LAUNDERING PROCESS

To ensure sufficient microbiological purity, textile products should undergo a laundering process that needs to be adapted to the fabric type each time. The selection of the proper physical and chemical parameters of the process, which means the optimum laundry detergent, laundering wash medium temperature, laundering duration and mechanical action, can contribute to a more efficient elimination of microbes from the products being processed by laundering, and thus to ensuring the microbiological purity required in food processing, catering, and medical practice. The contaminated textiles already mentioned can be a source of textile-to-human cross-contamination, contributing to the spread of infection, as well as textile-to-manufactured product cross-contamination, which can consequently lead to the propagation of microbial contamination throughout the production chain. Therefore, in order to reduce the risk of contamination, reusable textile products intended for use as clothing and other protective articles, as well as bed and table linen, must be reprocessed cyclically by laundering.

Laundering as a physical and chemical process is based on the removal of visible contaminants, most often in water-based (aqueous) washes of laundry detergents that are used for the process when emulsified in the water medium. The removal of particles of dirt embedded between the fibres is accompanied by elimination of the microorganisms dwelling there, which, as a result of the laundering process, pass into the solutions of the laundering wash and are discharged with it as waste water. However, the degree of microbial elimination in laundry varies and often is insufficient; therefore, it needs to be monitored based on the downstream (re)use of the laundered product and the laundering method. Depending on what the assumed commercial laundering outcome is, the microbiological purity level is tested at more than one stage of the laundering process according to the standardised recommendations of product quality certification bodies.

If the laundry schedule is not strictly fixed, many textiles are qualified for cleaning based on their visual changes indicative of soiling, which means evident stains, superficial soiling, and unpleasant odours, which the textile wearer finds unacceptable and so decides to replace the garment with an unused one. However, the wearer is rarely aware of the risk posed by the persistence of microorganisms in unwashed and washed products. Indeed, during the visual assessment of the cleanliness of as-laundered products, an absence of soiling is not equivalent to complete elimination of microoroganisms [Munk et al. 2001; Patel, Murray-Leonard and Wilson 2006; O'Toole, Sinclair and Leder 2009; Abney et al. 2021].

Another potential source of microorganisms in the laundering process is the biofilm that develops on the surfaces of laundering machines. Commercial and domestic washing machines are built from a variety of materials with different adhesive properties and topography, such as steel, rubber and plastics – mainly polypropylene, less frequently PVC, ABS or PC. Planktonic cells deposited on these surfaces from microbiologically contaminated textiles being laundered can, to varying degrees, form a biofilm. The biofilm can become a source of contamination for other textiles in the next laundering cycle through the water flowing in the washing machine's system and the laundering wash, especially when high-temperature washing cycles are used infrequently [Callewaert et al. 2015; Jacksch et al. 2021]. The intensity of microbiota growth in a washing machine/laundering equipment system depends not only on the textile, meaning its chemical composition, hydrophobicity, topography and surface roughness, but also on the physiology of the microorganisms and the ambient conditions [Hossain et al. 2019; Osta-Ustarroz, Theobald and Whitehead 2024]. In a biofouling study of four microplastics, PE and PVC were more heavily overgrown by bacteria than the polypropylene most commonly used as a component of washing machines [Cai et al.

2019]. The biofilm formed on the internal surfaces of washing machines can be multi-species. Pathogenic strains that pose health risks can be present, as well as those that produce unpleasant odours.

For loose dirt (sand, dust, free fibres, etc.) found on textiles, mechanical action during laundering is usually the main driver sufficient for cleaning. For any dirt or soiling permanently bonded to textile surfaces (like stains), it is necessary to use laundry detergents along with mechanical action. According to Sinner's guidelines, the course of the laundering process is assumed to be determined by four basic parameters: mechanical action, temperature, duration, and chemicals. For the laundering process to have the desired result, each of these parameters and their interrelationships must be considered. If the contribution of any of the parameters is reduced, the laundering efficiency demands compensation by increasing the contribution of the remaining ones. For example, by reducing the laundering process duration, a similar laundering result can be achieved by increasing the temperature, while by reducing the temperature, a similar result can be achieved by using more chemicals [Kozłowska 2008; Abney et al. 2021].

Soil-associated and non-soil-associated microorganisms can survive the laundering process if the appropriate processing conditions are not met [Syguła-Cholewińska, Jekiel and Szostak-Kot 2015]. The quality of the laundering process, and thus the effective removal of microorganisms, can depend on three different factors, which are mechanical work (physical removal), thermal deactivation and chemical disinfection.

The best results in achieving high textile product hygiene are possible by using thermal and chemical disinfection together. The effectiveness of laundering in this case depends on applying the right temperature parameters and a detergent with an active ingredient. Laundering textiles at high temperatures, which means above 75°C for at least 20 minutes, is considered to be most effective, resulting in the killing of most vegetative forms of microorganisms [PN-EN ISO 15797:2018-04; Abney et al. 2021].

Environmental protection or sustainability trends have led to changes in laundry methods, especially household laundering. The measures to reduce the laundering process temperature have been the most widespread. The 90°C wash recommended for cotton products has been replaced by a 60°C wash in response to cost reductions in electrical power consumption. The laundering of products made of synthetic fibres, like polyester fibres or their blends, required a reduction in the washing temperature to 40°C due to the detrimental action of higher temperatures on the properties of these fibres. Consequently, the reduced laundering temperature ranges used resulted in only a partial reduction of microorganisms in the process, with a significant adverse effect on the final hygienic outcome [Orr et al. 2002; Blenkharn 2006; Jekiel, Szostak-Kot and Syguła-Cholewińska 2010; Szostak-Kot, Syguła-Cholewińska and Jekiel 2009; Hammer, Mucha and Hoefer 2010].

Moreover, reducing the temperature means that some ingredients, such as chemical bleaches, cannot become fully activated, as they require a certain activation threshold temperature in the laundering wash. For example, at temperatures below 60°C, sodium perborate does not break down and does not release the reactive oxygen species that provide bleaching and disinfecting action.

Environmental protection considerations, generally concerning water eutrophication, have forced laundry detergent manufacturers to modify their product formulations, which have also adversely affected the microbiological purity of laundered products [Terpstra 2001; Terpstra and van Kessel 2005; Bloomfield 2006]. The formulation improvements mainly involved replacing ingredients like phosphates and non-biodegradable surfactants with more environmentally friendly substances such as zeolites.

However, this modification has changed the laundering wash pH level to a less alkaline one, which may contribute to the survivability of microorganisms during the laundering process. Note also that reductions in the cost per wash cycle have not only necessitated a reduction in the laundering temperature used but have also contributed to a reduction in the volume of water used in the main wash stage and a reduction in the number of rinse times, making the hygienic result less satisfactory.

The widespread use of disinfectants to ensure health protection in medical practice, water treatment, food manufacturing and distribution, agriculture, and other sectors, and the deposition of residual antimicrobial compounds in the environment have contributed to a widespread acquisition of bacterial immunity to disinfectants, or at least a tolerance of bacteria to low concentrations of disinfectants [Zhu et al. 2020], which may have the effect of reducing the effectiveness of chemical disinfection of laundry. The mechanisms of bacterial resistance to disinfectants are not fully understood.

Among the most commonly postulated, analogous to drug resistance mechanisms, is the protective role of the glycocalyx of the bacterial biofilm, which acts as a buffer against disinfectants, or the reaction of glycocalyx proteins with oxidants in chlorine- and peracetic acid-based disinfectants [Stewart, Grab and Diemer 2010; Yang et al. 2018], a reduction in cell membrane permeability that hinders the penetration of disinfectants into the bacteria [Carlie, Boucher and Bragg 2019], the active efflux pumping of disinfectants from inside the bacterial cells, leading to a reduction of the concentration observed with quaternary ammonium salts, chlorhexidine and others, or even the production specific enzymes by bacteria that degrade molecules or inactivate disinfectant compounds [Chaoyu Tong et al. 2021]. The development of resistance to disinfectants that is described in the literature indicates the need for the rational selection of formulations to achieve the disinfecting effect of laundering, compliance with the specified dosage and continuous monitoring of formulation effectiveness, and prevention of the formation of bacterial biofilms in laundry systems, as biofilms in particular may show increased tolerance to the bactericidal action of laundry detergents [Gattlen et al. 2010; Osta-Ustarroz, Theobald and Whitehead 2024].

4. MICROBIOLOGICAL PURITY CONTROL IN LAUNDERING PROCESSES

Textiles used in food processing and catering require compliance with applicable standards of microbiological purity imposed by food safety systems. It is therefore important to monitor the count of microorganisms remaining in the products after the laundering process, and to establish acceptable limits for the microbial count detected post-laundering. A group of products to which established recommendations apply is hospitals and social care facility laundry [Fijan, Šostak-Turk and Cencič 2005; RAL-GZ 992 2019; RAL-GZ 992 2024]. For this type of articles, thermal and chemical disinfection is performed during the basic washing cycle stage, comprising an 85°C wash with a suitable chemical releasing reactive oxygen species or a chlorine-based agent [Słupczyński 2001; Abney et al. 2021]. Other protective clothing from non-medical facilities is not subject to these stringent reprocessing requirements. Commercial laundries, when accepting garments and other textiles, select the method and parameters for the laundering process to be carried out and the post-laundry treatment (drying, ironing, packaging and, if any, transport).

To comply with high hygiene standards in commercial laundries, microbiological contamination control procedures are introduced for textiles. Among the most recognised are the guidelines of the Robert Koch Institute (RKI), the German Institute for Quality Assurance and Certification, and the principles of the Risk Analysis and Biocontamination Control (RABC) system, which is certifiable according to EN 14065:2016-07, "Textiles. Laundry processed textiles. Biocontamination control system". For the RKI recommendations that are mandatory for textiles used in medical establishments, it is mandatory to prevent pathogenic microbes from remaining on textiles after their laundering.

The procedures for verifying microbiological purity and microbiological disinfection efficiency to be achieved for that purity are based on a laundering performance test. This test is done by adding textile specimens inoculated with bioindicators to a laundry load. The bioindicators are suspensions of reference bacteria, *Enterococcus faecium* ATCC 6057 and *Staphylococcus aureus* ATCC 6538. These specimens are also soiled with blood, which facilitates the evaluation of the laundering efficiency with the intended process parameters. The laundering process performance is evidenced by a 5 log (10^5 cfu) reduction in the test microorganism count with respect to the reference sample, the baseline in a microbiological culture test. Specimens are selected and evaluated from the as-processed textiles (those after washing and ironing) by sampling directly onto microbiological media using an imprint method. A culture is grown from the specimens, followed by a determination of the bacterial count per dm^2 of the textile area. It is recommended that the bacterial count in nine out of ten samples tested should not exceed 2 cfu/dm^2 and pathogenic bacteria should not be present [Fijan et al. 2008]. Note that the RKI guidelines generally focus on the microbiological purity of textiles, ignoring aspects of the microbiological purity of the environment in which the laundering process is done, which means the cleanliness of processing equipment, storage (surfaces in contact with textiles) or the hygiene of the personnel operating the laundering process.

A comprehensive approach to laundry processing and textile microbiological purity is provided by the German Institute for Quality Assurance and Certification, which introduced the hygienic laundering guidelines in RAL-GZ 992, recommended for use in commercial laundries in the European Union. The RAL-GZ 992 guidelines combine the requirements developed by the RKI and the principles of biocontamination control based on quality management, which require the designation of control points (CPs) and critical control points (CCPs) at all stages of the laundering process. The guidelines apply to the final microbiological quality of as-processed textiles while specifying the need to establish CPs in specific laundering process stages in which products can be potentially exposed to contamination. Implementing and certifying a biocontamination control system at a commercial laundry involves annual third-party audits of its operation and the need for continuous monitoring of the laundering and disinfection process.

However, a successful certification does not guarantee that the textiles processed in the laundry, from the moment of inbound delivery to outbound delivery to the customer, conform to the applicable microbiological purity requirements. In system solutions, the laundry process is controlled in multiple stages facilitating faster detection and identification of the stage at which potential contamination may have occurred, and for implementing successful preventive and corrective measures to ensure quality and safety.

The RAL-GZ 992 guidelines currently apply to four areas: RAL-GZ 992/1 for contract and household laundry, RAL-GZ 992/2 for medical and hospital laundry, RAL-GZ 992/3 for food processing laundry, and RAL-GZ 992/4 for daycare/social care laundry [Fijan et al. 2008; RAL-GZ 992 2019; RAL-GZ 992 2024].

The established total microbial count limits for hospital and food processing laundry at the individual CCPs of laundry treatment are listed in Table 1.

As can be seen from the data in Table 1, the CCPs of laundry processing include not only the washed and ironed/pressed laundry ready for return pickup, but also the washing process, the wet laundry (before drying), the tap water used for washing, which is tested after the last rinse, and the surfaces in contact with the laundry after washing, such as conveyor belts, storage shelves, and the hands of personnel. Comparing the requirements established for each CCP, the lowest total microbial count limits were determined for post-washed laundry that is ready for return pickup, for the washing process itself, and as-washed wet hospital laundry. For other CPs, it is recommended to maintain a microbiological purity at 100 cfu (per dm^2 of surface or ml of wash water, as applicable). As expected, hospital/medical underwear is subject to more stringent requirements than those applicable to food processing laundry at the finished and wet laundry stages, which respectively mean 20 cfu/10 cm^2 and less than 30 cfu/10 cm^2 (Tab. 1). In both cases, however, the washing process must not have any potential pathogens (bioindicators) present.

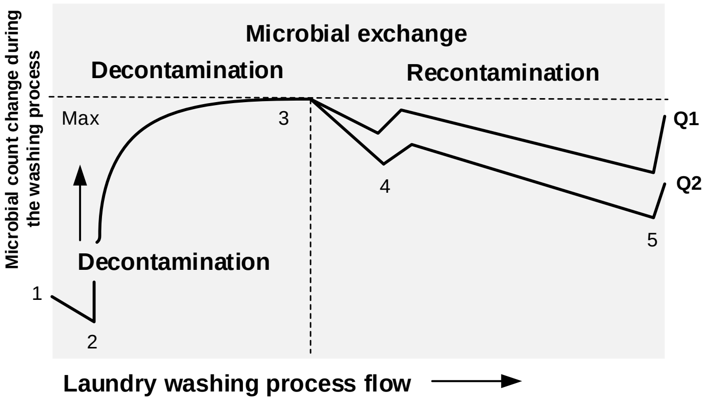
Table 1. Acceptable limits for total microbial counts at critical control points (CCPs) for hospital laundry treatment (RAL-GZ 992/2) and food processing laundry (RAL-GZ 992/3)

CCP	RAL-GZ 992/2	RAL-GZ 992/3
Pressed and folded laundry [b]	9 out of 10 specimens with no more than 20 cfu[c]/10 cm^2 [a]	9 out of 10 specimens with no more than 50 cfu/10 cm^2
Laundry washing process	No detectable bioindicators [a]	No detectable bioindicators
Wet laundry	<30 cfu/10 cm^2	<100 cfu/10 cm^2
Water (tap water; post-rinse)	<100 cfu/ml [d]	<100 cfu/ml
Processing equipment (washing machines; conveying and sorting belts)	<100 cfu/10 cm^2	<100 cfu/10 cm^2
Storage (shelving and areas for ironing and folding), (inner walls of the transport vehicle)	<100 cfu/10 cm^2	<100 cfu/10 cm^2
Personnel hand hygiene (at various stages)	<100 cfu/10 cm^2	<100 cfu/10 cm^2

a – limit value established by the RKI.
b – use of imprint plates with a microbiological substrate for sampling of pressed and folded laundry. No pathogenic or potentially pathogenic microorganisms should be detected, such as *Escherichia coli*, *Enterobacter cloacae,* etc.
c – cfu/10 cm^2 (cfu: colony-forming unit): number of colonies (of bacteria or fungi) grown on microbiological imprint plates after 48±4 h of incubation at 37°C per 10 cm^2.
d – cfu/ml: number of colonies (of bacteria or fungi) determined in 1 ml of water sample, after 24±4 h of incubation at 37°C or on 1 ml of water sample after 72±4 h of incubation at 22°C.

Source: [Fijan et al. 2008].

Achieving the highest microbiological purity standards for the finished hospital/medical laundry is justified by the trend of the microbial count change curve during the laundry treatment shown in Figure 1. The changes indicate that the maximum decontamination level in laundry is achieved after the last stage of the main wash, while downstream stages like rinsing, drying and packaging prior to outbound transport favour re-contamination of the finished laundry [TSA 2021].



1 – dirty laundry delivery
2 – laundry staging period
3 – main wash final step (prior to rinsing)
4 – final drying stage
5 – packaging prior to outbound transport
Q1 and Q2 – the microbiological quality level depends on the actual process and the finished laundry

Fig. 1. Microbiological count changes during laundry treatment (decontamination and recontamination)

Source: [TSA 2021].

5. RISK ANALYSIS AND BIOCONTAMINATION CONTROL (RABC) SYSTEM

The last of the proposed means to standardise the rules for microbiological quality monitoring in laundered textiles could be the implementation of a Risk Analysis and Biocontamination Control (RABC) system, based on the guidelines specified in PN-EN 14065:2016-07 [PN-EN 14065:2016-07].

At present, the RABC is not obligatory, although the increasing consumer pressure on laundry cleanliness and hygiene may drive an increased interest of commercial laundries in implementing the RABC principles. Unlike the guidelines discussed earlier, the RABC and PN-EN 14065:2016-07 do not specify ready-made implementation procedures for laundry operations to indicate what degree of cleanliness and microbiological quality should be achieved. The RABC does not establish acceptable limits for microbial counts or indicate microbiological testing techniques to verify the effectiveness of laundry washing. A RABC implementation in commercial laundries would require a defining and refining the laundry washing requirements based on the material ingredients of the laundered articles, monitoring the laundering process with established CPs and CCPs, along with maximum microbial count limits detectable at the CCPs.

As in the RAL-GZ 992 guideline, the RABC system requires the establishment of CCPs at each stage of laundry processing, the monitoring of which would enable prevention and reduction of biological contamination risks in a fashion similar to the HACCP (Hazard Analysis and Critical Control Point) system that is mandatory in food production.

The RABC system builds in many aspects on HACCP principles and interacts with other quality management systems. RABC is generally aimed at analysing the risk of microbiological contamination in laundry considering the utility applications of laundered textiles. This is especially relevant to the garments and textiles used in the medical, beauty and food processing sectors. The RABC system is designed to eliminate microbiological risks by ensuring regular monitoring of the CPs defined by the laundry at each stage of the laundry processing.

The stages of laundry processing/treatment where risk analysis is carried out include the storage of dirty laundry, its, classification and weighing, the laundry washing process, storage before drying, drying, as well as risk analysis due to the quality of the environmental parameters post-disinfection and the feasibility of recontamination, as well as packaging and outbound transport to customers. It is recommended that a four-point scale be adopted in a RABC risk analysis, concerning the probability (P) and severity (S) of risks. The risk level determined so can be qualified to be low (score of 1 to 4), moderate (5 to 8), high (9 to 12) or very high (13 to 16).

Table 2 shows an example of a risk analysis for a laundry process.

Table 2. Example of a RABC-compliant risk analysis at a laundry processing CCP (washing)

Risk	P	S	R
Insufficient temperature or duration (if thermal disinfection is used)	2	4	8
Insufficient chemical concentration (if thermal disinfection is used) may result in poor physical removal of contaminants from the laundry	2	2	4
Insufficient chemical concentration (if chemical disinfection is used)	2	4	8
Incorrect water levels may affect the efficiency of thermal or chemical disinfection	2	3	6
Recontamination with water or chemicals used after the disinfection stage. This can be a particular problem when using recycled hot water	4	3	12
Washing machine components in contact with process water (or the water stored in the machine) and not disinfected during the washing process. This is particularly problematic for piping and tanks in continuous duty tunnel washers (CTW)	4	3	12
The counterflow of water in the CTW rinse sections can promote rapid microbial growth	4	4	16

Source: [TSA 2021].

According to the data (Tab. 2), the highest level of microbiological contamination risk is posed by the emergence of a counterflow of water in tunnel washer rinsing sections, potentially resulting in recontamination of laundry with microbes and their growth there. Insufficient chemical concentration in the thermal disinfection stage resulting in poorer removal of contaminants was instead rated as the event with the lowest risk level among those considered, both in terms of probability (2) and severity (2).

Different CPs can be specified each time, depending on the intended outcomes with regard to the final microbiological quality of the laundry. This approach ensures that if deviations from preset levels are identified, immediate corrective action can be taken and new preventive measures can be established.

6. CONCLUSION

The continuous monitoring of microbiological contamination of textiles processed in commercial laundries and the implementation of risk analysis and biocontamination control (RABC) systems is a response to increasing customer expectations for hygiene and the microbiological quality of the textiles they use. Of particular importance in this respect are laundry customers in the food and medical industries, where the elimination of potential microbiological contamination risks is a necessary procedure. The implementation and certification of systems like RABC in commercial laundries requires the development of monitoring procedures, the designation of CPs and CCPs, and consistent control of the laundry process at the CCPs, along with increased staff awareness of the issues. Certification to (PN-)EN 14065:2016-07, despite the costs involved, (i) can bring many benefits to the laundry industry by reducing the costs of laundry reprocessing in the event that adequate levels of microbiological quality of textile products are not maintained, and (ii) will allow laundries that have such systems implemented to increase their competitiveness while reinforcing their credibility in the market.

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