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Hygiene in commercial laundries

Summary

Background: Within the presented work laundries working according to the hygiene regulations of the Robert Koch-Institut (RKI, in the following named as RKI laundries) and laundries with implemented RABC system (EN 14065, in the following named as RABC laundries) were analysed. The RKI guideline contains only the limit value for the dry processed textiles but not for relevant areas during the reprocessing (washing procedure, surfaces, hands, wet textiles). In a two-year research project for the RABC system action and orientation values for relevant areas within the laundry (washing procedure, surfaces, hands, water, wet textiles) were set up with their observance a certain hygienic quality of the expedition textiles can be guaranteed. The aim of the presented work was to verify the efficacy of the action and orientation values and the therewith achieved hygienic quality of the expedition textiles and to examine their applicability for RKI laundries.

Method: Therefore 5 RABC laundries and 5 RKI laundries were inspected four times (once a year). In all investigated laundries contact samples from textiles, surfaces and hands of employees as well as water and air samples were taken. Additionally the disinfection effect of washing procedures would be tested with biomonitors.

Results: The comparison of the results showed that in all (40 of 40) inspections the results of the samples of the expedition textiles were clearly below the limit values. This also evidences the meaningfulness and adequacy of the used action and orientation values. Second, the hygienic quality of textiles which are reprocessed either by RABC laundries or RKI laundries is statistically equal well. Third, the results of the air analysis of the laundries with the different hygiene settings are in a similar range and it is not visible that differences in the air content of microorganisms correlates with the presence of a constructional separation between dirty and clean area as it is one prerequisite in the RKI regulations. Consequently a constructional separation is not a prerequisite for the hygienic reprocessing of textiles although the efficacy of the separation for the infection prevention is incontestable. Forth the reduction values of the tested disinfection washing procedures are all > 7 $\log_{10}$ units (7.0 – 8.9 for *E. faecium* and 7.4 – 9.3 for *S. aureus*).

Conclusion: It is recommended to reassess the significance of a limit of 5 $\log_{10}$ units – as it is used very often for the validation of disinfection washing procedures. Commercial laundries can guarantee a specific hygiene of textiles if they fulfil the RKI conditions or the RABC system.

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Introduction

Requirements for hygienic textiles

It has long been known that textiles and work clothing can serve as a ‚vector' for pathogens [1–3]. Hence textiles and work clothing must be incorporated into the hygiene (infection control) management system. Textiles can become highly contaminated with pathogens during and after use, and this contamination can persist for a long time. For example there is evidence that certain pathogens can survive outside their habitats on textiles for long periods of time [4–7]. This underlines the need for strict rules on changing clothing/laundry and for the use of structured procedures to process such items. Likewise, in the food industry textiles can become massively contaminated with pathogens, e.g. with microorganisms transmitted from animals to humans [8, 9]. In this setting, too, processed textiles must meet hygiene requirements to protect foodstuffs, prevent their rapid spoilage and attendant health risks.

As such, effective processes are employed in both the healthcare setting and food industry to kill pathogens on textiles. Furthermore, it is important that structured and controlled processes are used for sub-

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sequent treatment steps (hanging up, drying, flatwork ironing, finishing, folding, etc.) to minimise recontamination of textiles and assure adequate microbiological quality.

The main focus of textile processing in a private household is often solely on how effective a washing process is in reducing the microbial count, while ignoring whether potentially pathogenic microorganisms on unwashed textiles contaminate other areas and what other processing steps are to be conducted after washing. However, both these aspects are taken account of in the hygiene quality assurance systems used in industrial laundries.

RKI conditions

In its Guideline on Hospital Hygiene and Infection Prevention, Subpara. 4.4.3 and 6.4, the Robert Koch Institute (RKI) has set out "Hygiene requirements for textiles from healthcare establishments, the laundry and washing process" [10]. For example, there must be structural separation between the dirty and clean areas of the laundry, passages must be designed as personnel sluices and the washing machines must have separate doors for loading and unloading laundry. Pursuant to this RKI guideline, disinfecting washing processes must be used and under certain conditions must be carried out using agents and processes listed in the official RKI List of Disinfectants [11]. The limit values set here for expedition textiles is 20 cfu/dm^2 in nine out of ten samples as well as the absence of human pathogenic microorganisms. No other limit values are set for laundries, but further studies are needed to that effect [10, 12] to ensure that the hygiene conditions prevailing in the laundries are such that the probability of health risks and damage to patients and staff are reduced to an unavoidable minimum when the pertinent hygiene standards are maintained. What microbiological limit values must be observed e.g. for surfaces and hands, have not been defined.

EN 14065 (RABC system)

The food industry is governed by the Hazard Analysis and Critical Control Points (HACCP) concept, enshrined in EC Directive No. 852/2004 [13]. Detailed conditions have been imposed for implementation of the HACCP concept by international commercial chains, including the International Food Standard (IFS) and the British Retail Consortium (BRC) on the basis of recommendations of the Global Food Safety Initiative (GFSI) and the Global Food Business Forum (CIES) [14]. For example, work clothing in the food industry must be washed as per IFS Version 5 in accordance with a product- or process-oriented risk analysis. Other quality requirements applied to work clothing in the food industry are set out in DIN 10524 (2004), e.g. a microbiological limit value of 50 cfu/dm^2 in nine out of ten samples as well as the absence of human pathogenic microorganisms for processed work clothing [15].

The Risk Analysis and Biocontamination Control (RABC) system based on DIN EN 14065 (2003) is used in many textile processing companies to guarantee the microbiological quality of the end products [16, 17]. This is based on risk analysis and a biocontamination (RABC) control system in which the risk of biocontamination is stipulated for each process step in line with potential hazards and corresponding measures are taken in advance to check and eliminate problems.

The RABC system can be applied as a quality management system in many areas, including for textiles from the healthcare sector. EN 14065 does not contain any microbiological limit values. Within the framework of a two-year research project relevant action limit values and orientation values as well as proposals for control intervals were formulated, and these have been adopted by the Industrieverband Textil Service e.V. (intex) as a basis for obtaining an RABC certificate (Table 1) [18–19]. In this respect, distinctions between limit values, action limit values and orientation values must be borne in mind. Orientation values are used for orientation purposes and if exceeded do not necessarily imply that the microbiological textile quality has not been assured. Limit values, conversely, apply to end products and are the maximum values which, if exceeded, call for immediate imposition of quality management measures to assure once again the microbiological quality. Action limit values apply to moist textiles and remedial measures must be taken if they are exceeded. Measures must not necessarily be taken if orientation values are exceeded. However, if there is repeated or continuous overshooting of values, measures should be taken so as not to jeopardise the microbiological quality. That such overshooting of these values can also result in defective end products has already been demonstrated [20].

In the study presented here these action limit values and orientation values were reviewed and their suitability for textile reprocessing as per the RKI guidelines put to the test.

To that effect, five RABC laundries and five RKI laundries were each inspected on four occasions (once per year). The RABC laundries were engaged predominantly in processing work clothing for the food industry, and the RKI laundries mainly processed flat textiles for the healthcare sector and for hotels. There were only a few structural differences between the RKI and RABC laundries. For example all RKI laundries had structural separation and ironing processes for flat textiles. The RABC laundries had tunnel finishers for drying work clothing, but no structural separation. Four out of five RKI laundries had a continuous batch washer, followed by a press for water removal from textiles, whereas only two out of five RABC laundries had a continuous batch washer, followed by a centrifuge. The RKI processed textiles using washing process parameters based on the RKI list [11], while most RABC laundries did not use any listed process parameters. However, the RABC system calls for defined setpoint values for the various process and measuring parameter (also for dying procedures), thus facilitating an easy check of such processes.

In all laundries inspected, contact samples were taken from textiles, surfaces and hands as well as water and, in some cases, air samples. Furthermore, the disinfection efficacy of washing processes was verified using biomonitors.

Material and Methods

Bioindicators for washing processes

When inspecting the laundries, the disinfection efficacy of washing processes was verified using biomonitors. In accordance with the provisions of Standard Method No. 17 of the German Society of Hygiene and Microbiology (DGHM) and the RKI guideline, the biomonitors consisted of cotton cloths contaminated with bacteria and defibrinated sheep blood [10, 22]. Five contaminated cloths were used for each species of bacteria. The bacteria *Staphylococcus aureus* ATCC 6538 and *Enterococcus faecium* ATCC 6057, which are stipulated by the RKI for validation of washing processes, were used [10] and dried in sheep

Table 1: Microbiological requirements for test points in laundries.

Test point	RKI (only healthcare sector)	RABC requirement (healthcare sector)	RABC requirement (food industry)	DIN 10524 (only food industry)	Drinking Water Reg. 2001 [21]
Disinfection efficacy of washing processes	All test bacteria killed	All test bacteria killed	All test bacteria killed	–	–
Expedition textiles	20 cfu/dm² [b]	20 cfu/dm² [b]	50 cfu/dm² [b]	50 cfu/ dm² [b]	–
Water	Consult Drinking Water Reg.	100 cfu/ml, no *E. coli*, enterococci or coliform bacteria in 100 ml	100 cfu/ml, no *E. coli*, enterococci or coliform bacteria in 100 ml	–	100 cfu/ml, no *E. coli*, enterococci or coliform bacteria in 100 ml
Moist textiles	[a]	30 cfu/dm² [cd]	100 cfu/dm² [cd]	–	–
Surfaces close to textiles	[a]	100 cfu/dm² [e]	100 cfu/dm² [e]	–	–
Hands of personnel	[a]	100 cfu/dm² [e]	100 cfu/dm² [e]	–	–
Air	–	–	–	–	–

[a] No specifications, but tests needed [10, 20] to ensure that the hygiene conditions are such that the probability of health risks and damage to patients and staff are reduced to an unavoidable minimum when the pertinent hygiene standards are maintained
[b] In nine out of ten samples as well as absence of human pathogenic microorganisms
[c] In four out of five samples
[d] Action limit value
[e] Orientation value

blood on the cotton material. The baseline microbial count on the biomonitor cloths had to be more than 1.0×10^7 cfu/cloth (measured on the basis of the bacterial concentration of the transport control used for the biomonitors, cfu = colony forming units), in order to be able to illustrate a reduction of the test bacteria in the washing processes of > 7 $\log_{10}$ levels. The individual cloths were transferred for evaluation to 5 ml trypticase soybean broth and shaken. The quantity of test bacteria remaining on the cloths was determined by means of surface cultures on selective media (Baird Parker agar for *S. aureus* and kanamycin aesculin azide agar for *E. faecium*) and incubation at 36 °C ± 1 °C for 20 ± 4 h. Qualitative detection of test bacteria was performed through incubation of the TSB, incl. cloths at 36 °C ± 1 °C until growth was noted, but for a maximum of one week. The test bacteria used were then identified using selective growth media.

Samples from textiles, surfaces and hands

The risk of recontamination after the washing process was identified using contact plate tests (trypticase soybean agar (TSA) with polysorbate 80 and lecithin) taken from the hands of staff and from various surfaces close to the textiles (tables, shelves, conveyor belts, etc.). In addition, contact samples were taken from moist and dry textiles at different processing steps as well as from the expedition textiles. Samples were taken from moist textiles immediately on completion of the washing process or immediately after removing water from the laundry. All contact samples were incubated for 44 h ± 4 h at 36 °C ± 1 °C and then counted. The colonies from dried textiles were selected so as to investigate for the presence of certain human pathogenic microorganisms.

Microbiological testing of water

Microbiological analysis of rinse and softened water was performed to determine the risk of microbial recontamination of disinfected textiles posed by the water. To that effect, water samples were tested in accordance with the German Drinking Water Regulation of 2001 to determine the total microbial count at 22 °C and 36 °C, and to verify the absence of coliform bacteria and *Escherichia coli* as well as enterococci in 100 ml water. The softened water samples were taken mainly after the softening unit, provided that a sampling tap was available at that point. Otherwise the first sampling point in the distribution network after the softening unit was used. The rinse water was sampled directly from the washing machine.

Microbiological testing of air

The airborne microbial count was determined using an air sampler (MAS-100 Eco, MBV, Switzerland). To that effect, each 100 litres of air were applied to two nutrient media using an impaction method (trypticase soybean agar (TSA) and malt extract agar (MEA)) and incubated for 44 h ± 4 h at 36 °C ± 1 °C (TSA) and 30 °C ± 1 °C (MEA) and counted. Air sampling was done during running operations at four locations at which the textiles were exposed to the air.

For each laundry inspection two washing processes were investigated with biomonitors and a sample taken of both the softened and rinse water. In addition, a total of 40 contact plate samples were taken, of which at least ten from dry textiles and five from moist textiles. While no limit values apply for microbiological contamination of the air in laundries, the microbiological air quality was measured using spot checks (for 20 laundry inspections at four locations in each laundry).

Results and Discussion

Investigating washing processes with bioindicators

It was not possible to detect test bacteria on the process challenge devices after any of the disinfecting washing processes.

The baseline microbial counts of the transport controls ranged between $1.0 \times 10^7 - 6.5 \times 10^8$ cfu/cloth for *E. faecium* and $2.5 \times 10^7 - 2.0 \times 10^9$ cfu/cloth for *S. aureus* (cfu = colony forming units). This demonstrates that industrial disinfecting washing processes are very well able to achieve reduction factors of > 7 $\log_{10}$ levels. Microbial reduction by > 7 $\log_{10}$ levels is also required for testing (phase 2 / level 2) disinfectants for chemothermal textile disinfection as per the DGHM standard methods [23]. Here only the main wash cycle, and none of the subsequent steps of the washing process, is tested. Hence the insights afforded by a limit value of 5 $\log_{10}$ levels, as commonly used in practice to validate disinfecting washing processes, should be reviewed [24].

Contamination of dry expedition textiles

The mean values illustrated in Figure 1 for samples taken from dry textiles show that all laundries complied with the limit values set for expedition textiles, and these were even markedly lower. Although limit values of 20 cfu/dm² and 50 cfu/dm² applied for nine out of ten samples, these were observed for all inspections of RABC laundries in ten out of ten samples and only in one out of 20 inspections of RKI laundries was this not complied with in ten out of ten samples (RKI laundry D, 3rd inspection). Furthermore, all samples of expedition textiles were free of the human pathogenic microorganisms targeted (data not shown), hence this requirement addressed to expedition textiles was met by all laundries.

The microbiological quality achieved for the dry expedition textiles did not depend on whether the laundry was operated in accordance with the RKI criteria or had introduced the RABC system with relevant limit values and control procedures. Both systems can attain an average microbiological quality of < 17 cfu/dm². The microbiological quality of expedition textiles for RKI laundries was found to be 0–17 cfu/dm², and that of RABC laundries was 0–16 cfu/dm². The mean values of expedition textiles for the 1st inspection were slightly higher for RABC laundries B, C and E as well as for RKI laundries B and E than for subsequent inspections. Accordingly, it was possible to reduce the mean values of expedition textiles in inspections 2 to 4, in some cases even to < 10 cfu/dm². This underlines the importance of proper operation of laundries, with tests, includ. microbiological analyses, conducted at regular intervals and documented in a certificate.

Contamination of moist laundry

The mean values obtained for moist textiles are illustrated in Figure 2. These show that in 100 % of inspections of RABC laundries and in 95 % of inspections of RKI laundries the action limit values were complied with, and were even markedly lower. While action limit values of 30 cfu/dm² and 100 cfu/dm² applied for four out of five samples, these were observed in 100 % and 95 % of the samples taken here.

The samples for RKI laundry D overshot once the limit value of 30 cfu/dm². This contamination of the moist textiles at RKI laundry D correlated with contamination of the rinse water at the time of the inspection (Figure 5). Contamination of moist textiles and of the rinse water was in all probability attributable to the use of starch in the last chambers of the continuous batch washer.

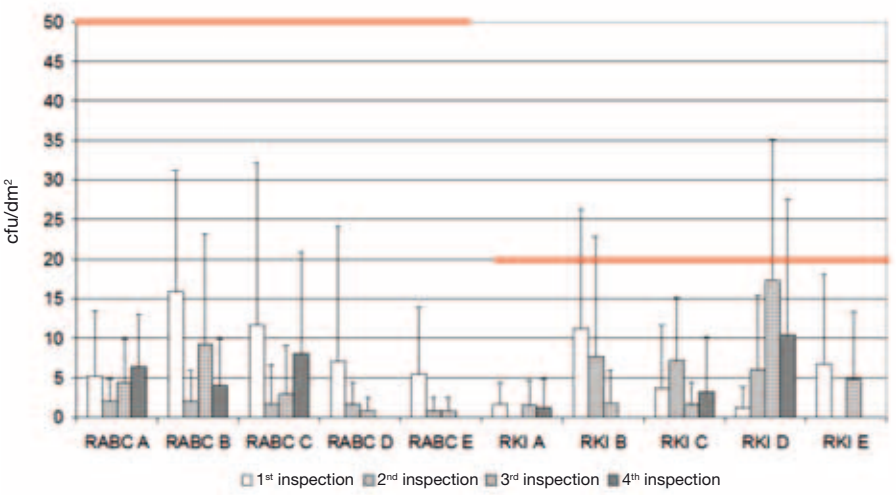

Figure 1: Mean values and standard deviations of samples from expedition textiles. A bar denotes one inspection. RABC A–E / RKI A–E are different laundries. The red lines denote the limit values to be observed by the laundries.

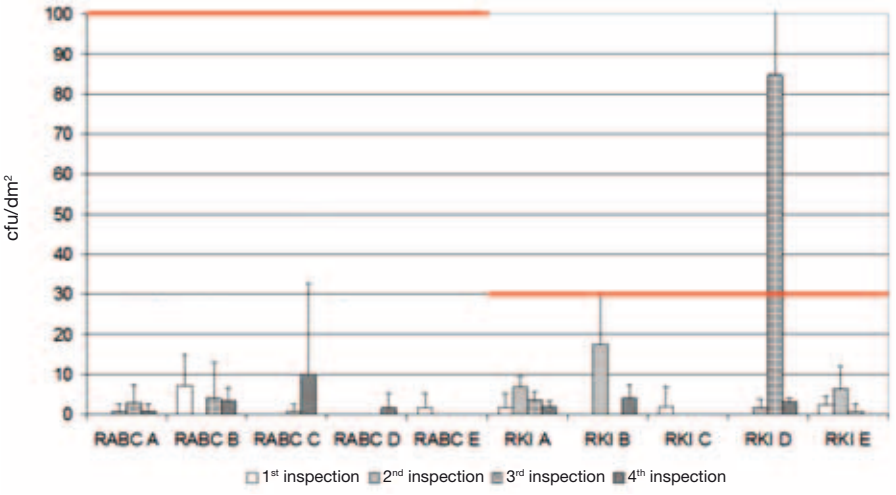

Figure 2: Mean values and standard deviations of samples from moist textiles. A bar denotes one inspection. RABC A–E / RKI A–E are different laundries. The red lines denote the action limit values to be observed by the laundries.

Starch was applied e.g. to tablecloths and napkins to increase the stiffness of textiles. Starch residues in the machine could then have expedited growth of microorganisms. Overall, starching finish were reduced and any starching finish used were carried out in washer extractors. Just how successful these measures proved to be was soon demonstrated in a subsequent investigation (data not shown). The 4th inspection of RKI laundry D also attested to the continued success of these measures since both samples of moist textiles and those of water continued to be markedly below the required action limit values.

Contamination of surfaces and hands

The average microbiological contamination of surfaces and hands is shown in Figures 3 and 4. The orientation value of 100 cfu/dm² was rarely overshot, even though these values serve only for orientational purposes and are not limit values. Increased surface values were obtained e.g. for the press membrane or container bottom. Increased values were measured for the press membrane at RKI laundry D during the 3rd inspection because of microbiological contamination of the rinse water in the continuous batch washer. There were major fluctuations in the mean values obtained for surface and hands since, because of a few high values (values of up to 500 cfu/dm² were measured), the mean values had a tendency towards high figures.

The impact of hand hygiene on the microbiological quality of dry textiles was limited, which explains why in this study, too, despite occasional overshooting of the hand hygiene orientation value, no increased values were found for the expedition textiles. The same conclusion was drawn from the research project mentioned above [19]. That meant that the hand hygiene orientation values were classified as orientation values. Nonetheless, the laundry staff should be made aware of the role and importance of hand hygiene since in laundries – despite widespread automation – there are also some manual working steps. There is therefore an absolute need for regular training to make staff aware of hygiene requirements. In line with an RABC quality management endeavour, assessments of the need for staff training, training policies and subsequent training must be documented so as to minimise any recontamination of textiles.

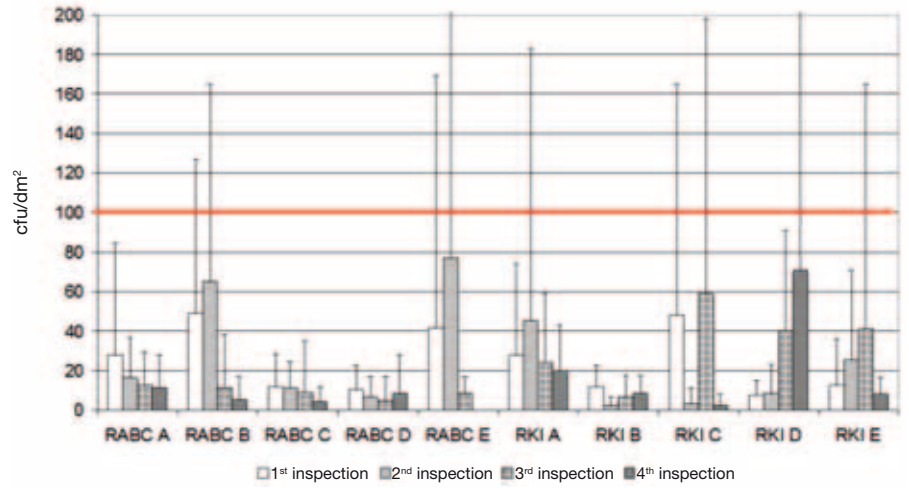

Figure 3: Mean values and standard deviations of samples from surfaces. A bar denotes one inspection. RABC A–E / RKI A–E are different laundries. The red lines denote the orientation values to be observed by the laundries.

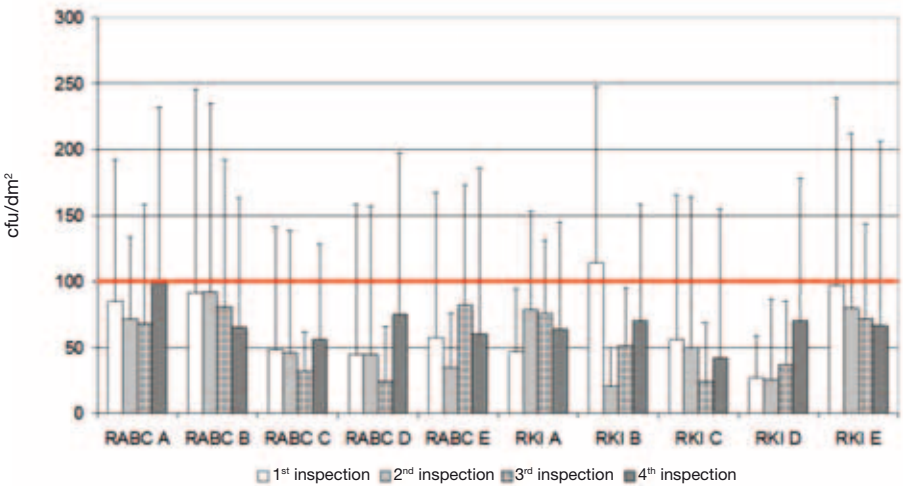

Figure 4: Mean values and standard deviations of samples from personnel. A bar denotes one inspection. RABC A–E / RKI A–E are different laundries. The red lines denote the orientation values to be observed by the laundries.

Microbiological quality of the process water

Figure 5 shows the results of water analyses. In 100 % of inspections of RABC laundries and in 95 % of inspections of RKI laundries the requirements addressed to the microbiological quality of the rinse water were observed, or even markedly lower values than the limit values were obtained. Only the water samples collected during the 3rd inspection of RKI laundry D showed overshooting of the limit value of 100 cfu/ml. This was due – as already pointed out above – not to the water itself (see results of softened water samples), but rather to contamination of the water in the continuous batch washer because of starch residues.

Microbial contamination of the room air

The results of air analyses are shown in Figure 6. No limit values apply for these tests, but nonetheless measurements were performed for orientational purposes. The microbial counts of the air in the clean zone were between 53 and 1050 cfu/m³ (total microbial count) and 5 and 647 cfu/m³ (yeasts and moulds). Because of the very good results obtained for the samples from dry textiles in all laundry inspections it can be assumed these airborne microbial counts

pose no risk of recontamination of textiles by airborne microbes.

In general, the results of the air analyses demonstrate there is ofen greater contamination of the air in the dirty zone (washing section / unclean side) of laundries than in the clean area. In the cases investigated the airborne microbial count did not appear to be correlated with the presence of a structural separation between the clean and unclean zones since no significant differences were seen in the mean values of the airborne microbial count in RKI laundries (415 ± 307 cfu/m^3 total microbial count and 111 ± 59 cfu/m^3 for yeasts and moulds) and those of the RABC laundries (232 ± 108 cfu/m^3 total microbial count and 191 ± 200 cfu/m^3 for yeasts and moulds). Nonetheless, such air analyses merely serve to describe the situation prevailing at the time of inspection and do not constitute a systematic analysis of air movements. That would necessitate further comprehensive air tests, e.g. also at various times of the year and under varying operating conditions. However, it must be noted that spatial separation is not a basic prerequisite for hygienic processing of textiles even if the effectiveness of a spatial separation cannot be disputed in terms of infection prevention for laundry staff [25].

Conclusion

The results of the tests presented here demonstrate that the action limit values and orientation values are suitable for ensuring that the limit values stipulated by the RKI and DIN 10524 for expedition textiles are observed. Hence the RABC system has become an established feature in laundries thanks to its effectiveness at controlling biocontamination.

Industrial laundries that have implemented a hygiene system based on the RKI requirements or an RABC quality management system can guarantee the microbiological quality of their expedition textiles.

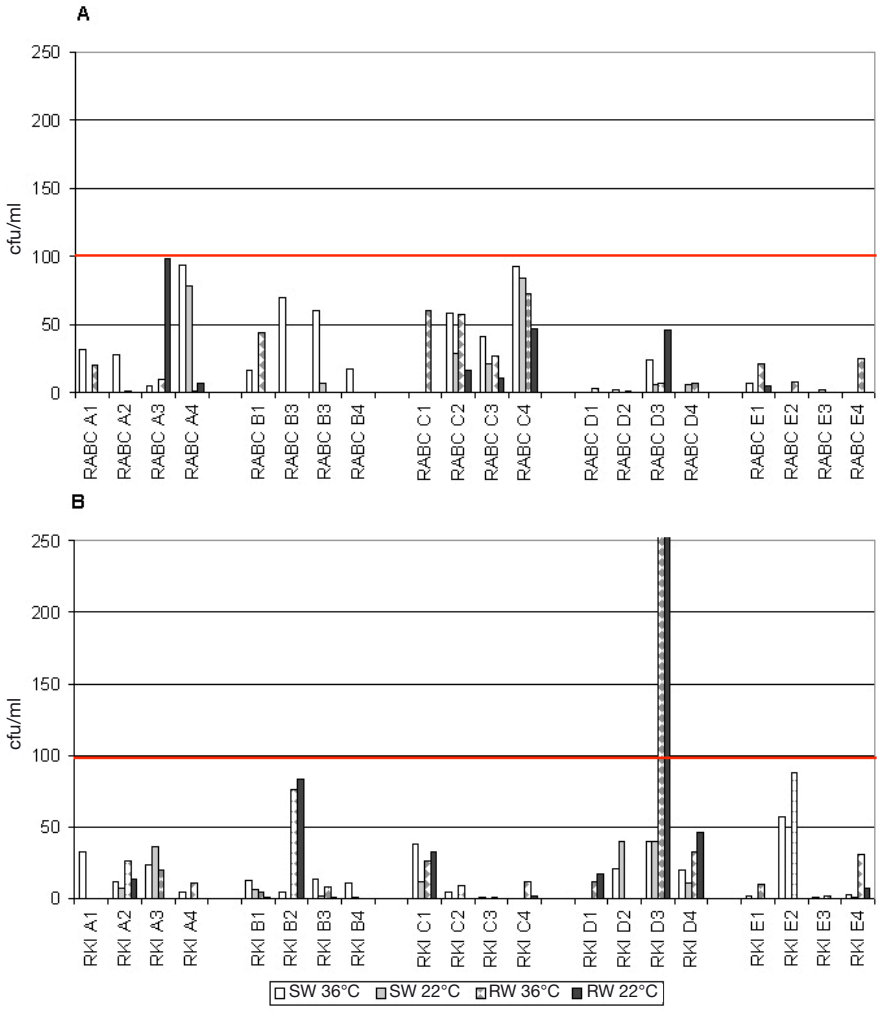

Figure 5: Total microbial counts at 22° C and 36 ° C of water samples from one inspection. Shown in the upper section A are the RABC laundries (A–E), and in the lower section B the RKI laundries (A – E). The red lines denote the values to be observed by the laundries. SW = softened water, RW = rinse water.

Interessenkonflikt

Die Autoren erklären, dass kein Interessenkonflikt im Sinne der Richtlinien des International Committee of Medical Journal Editors besteht.

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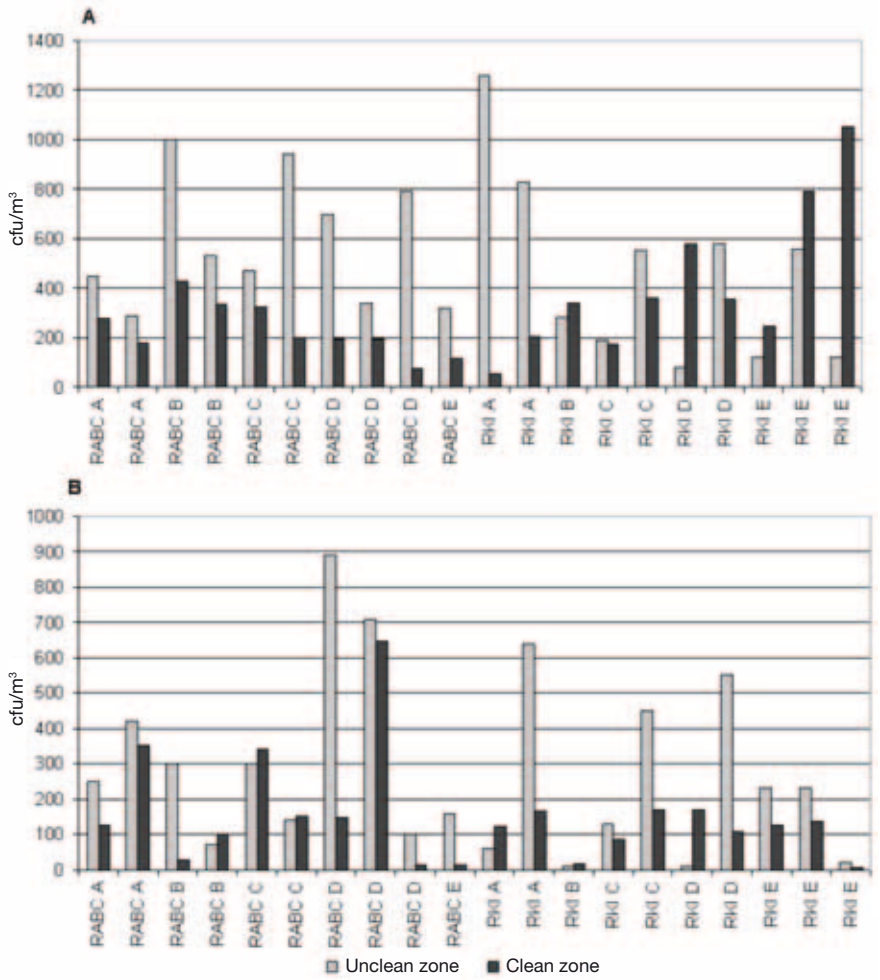

Figure 6: Mean values of airborne microbial counts from several inspections, in which air analyses were performed. Shown in the upper section A are the results of the total microbial count of the air analysis, and in the lower section B the results of the microbial count of yeasts and moulds.

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