



A woman with long blonde hair, wearing a dark blue and white striped sweater, is leaning against the front of a stainless steel washing machine. She has a neutral or slightly weary expression. In the background, there are several more washing machines and dryers in a laundry room setting.

**Warum riecht meine
Waschmaschine (nicht) ?**

Article

A Comprehensive View of Microbial Communities in the Laundering Cycle Suggests a Preventive Effect of Soil Bacteria on Malodour Formation

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Abstract: Microorganisms are an important factor in the wash-and-use cycle of laundry. They can cause unwanted aesthetic effects, such as malodour formation, and even pose a health risk. Therefore, a comprehensive view of the microbial communities in washing machines is needed to understand the formation of malodour. So far, neither the compositions of biofilms leading to the formation of malodour nor protection against malodour have been investigated. Moreover, microbial communities on used towels have not been analysed after normal use. This study presents a qualitative and quantitative analysis of microbial communities in washing machines with towels with the occurrence of malodour and thus not only allow for a better risk assessment. The results suggest bacterial colonizers of washing machines that might prevent malodour formation. It was shown that soil bacteria such as *Rhizobium*, *Agrobacterium*, *Bosea*, and *Microbacter* are found in non-odourous machines, and that *Rhizobium* species are able to prevent malodour formation in an in vitro model.

Keywords: washing machine; malodour; next-generation sequencing; *Rhizobium*



1. Introduction

Laundering is seen as a role model for circular processes by aiming to restore the quality of textiles and to make laundry more sustainable. A lot of available literature highlights the

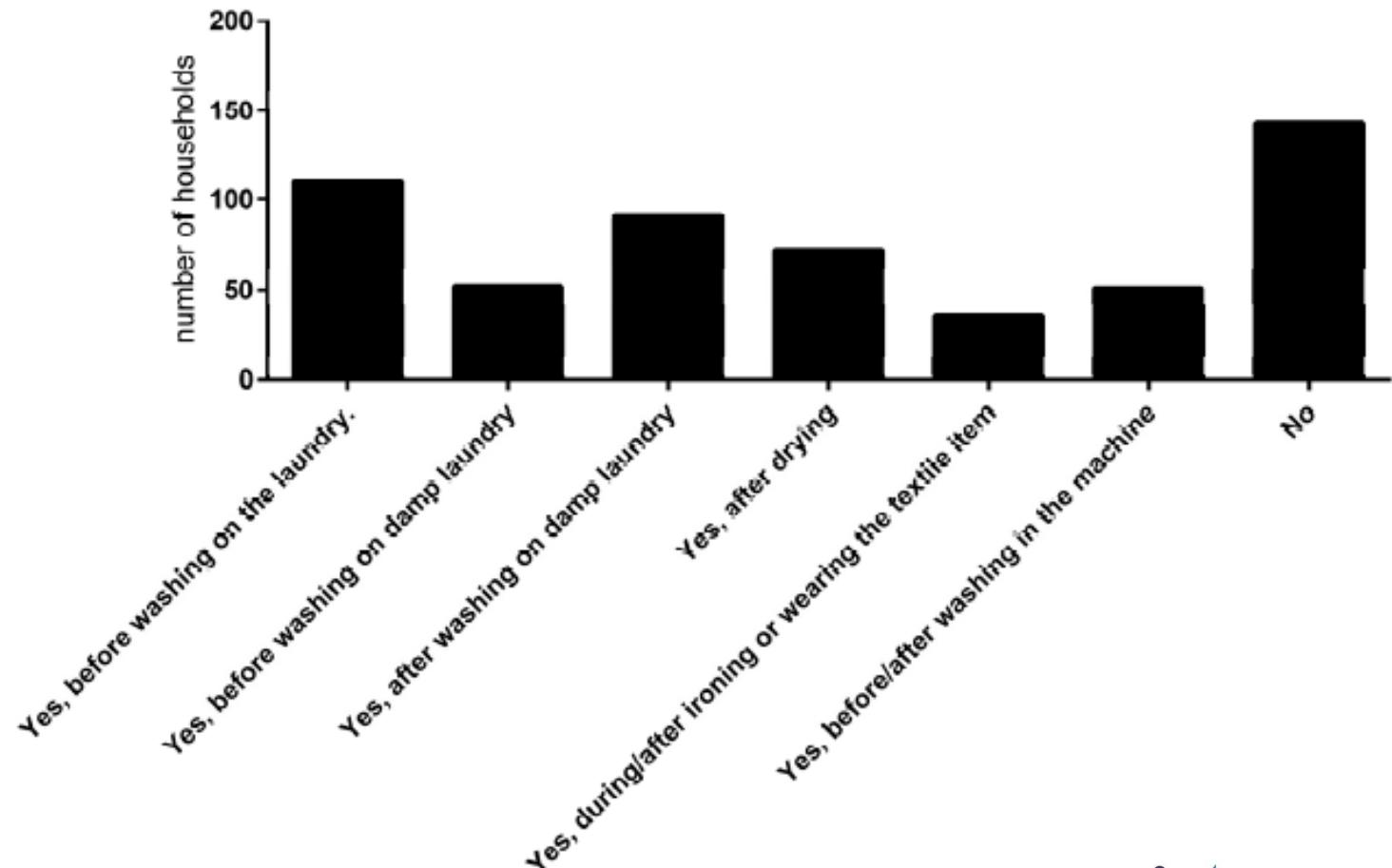
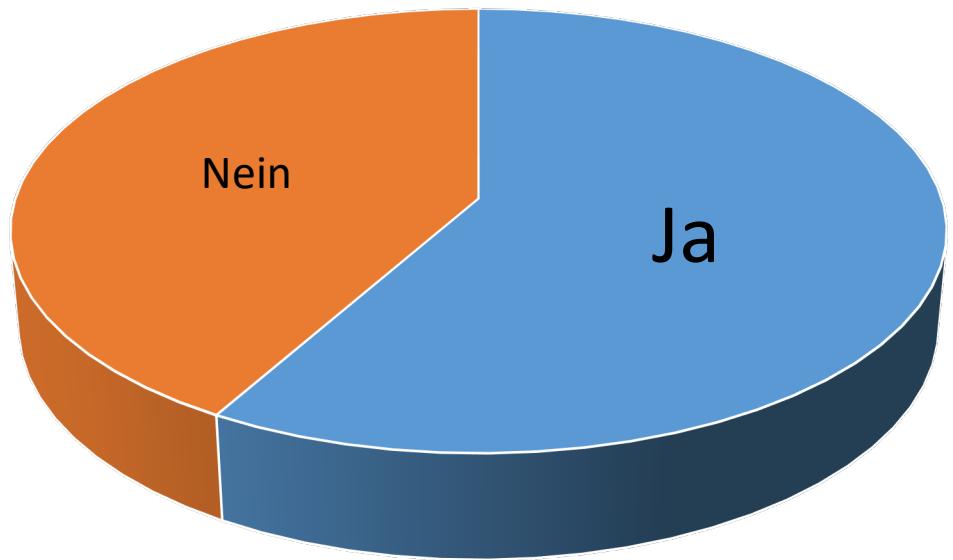


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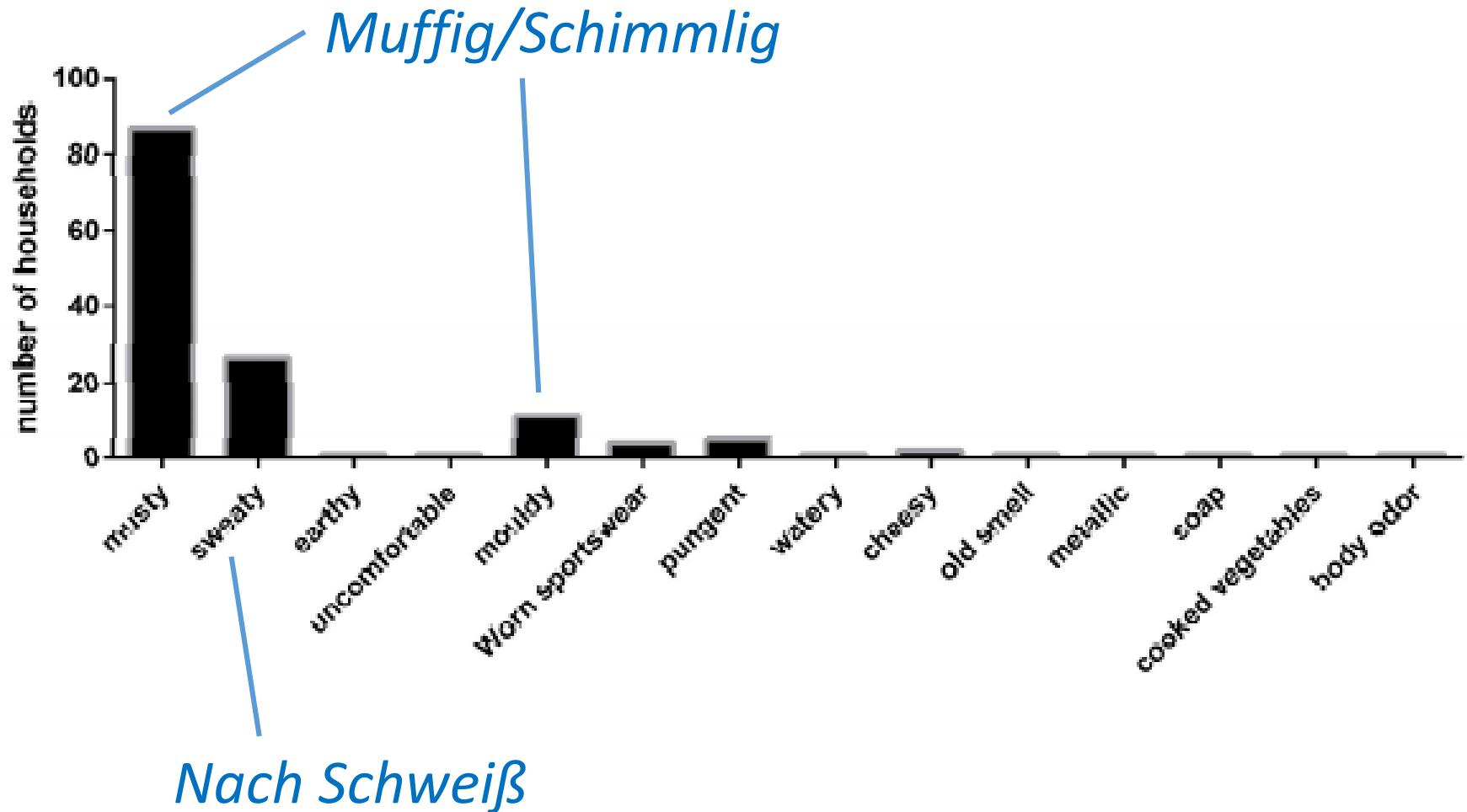
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Manuscript

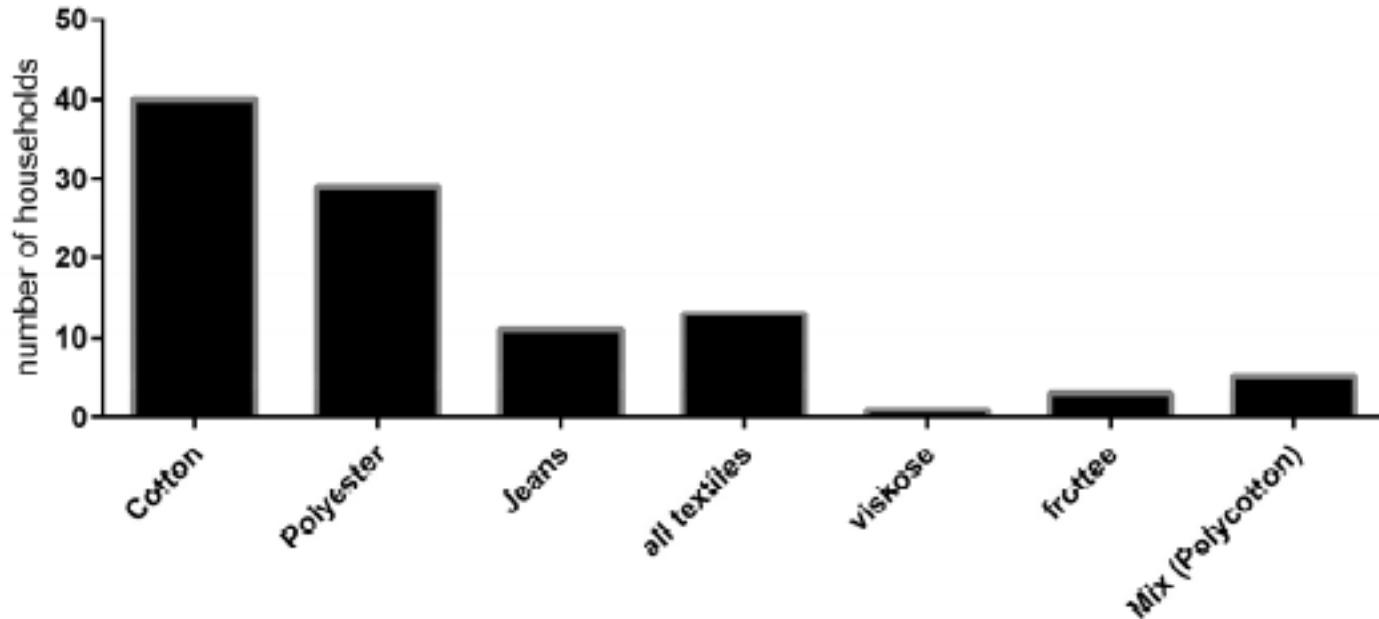
Probleme mit Wäschegeruch?



Geht's ein bißchen genauer?

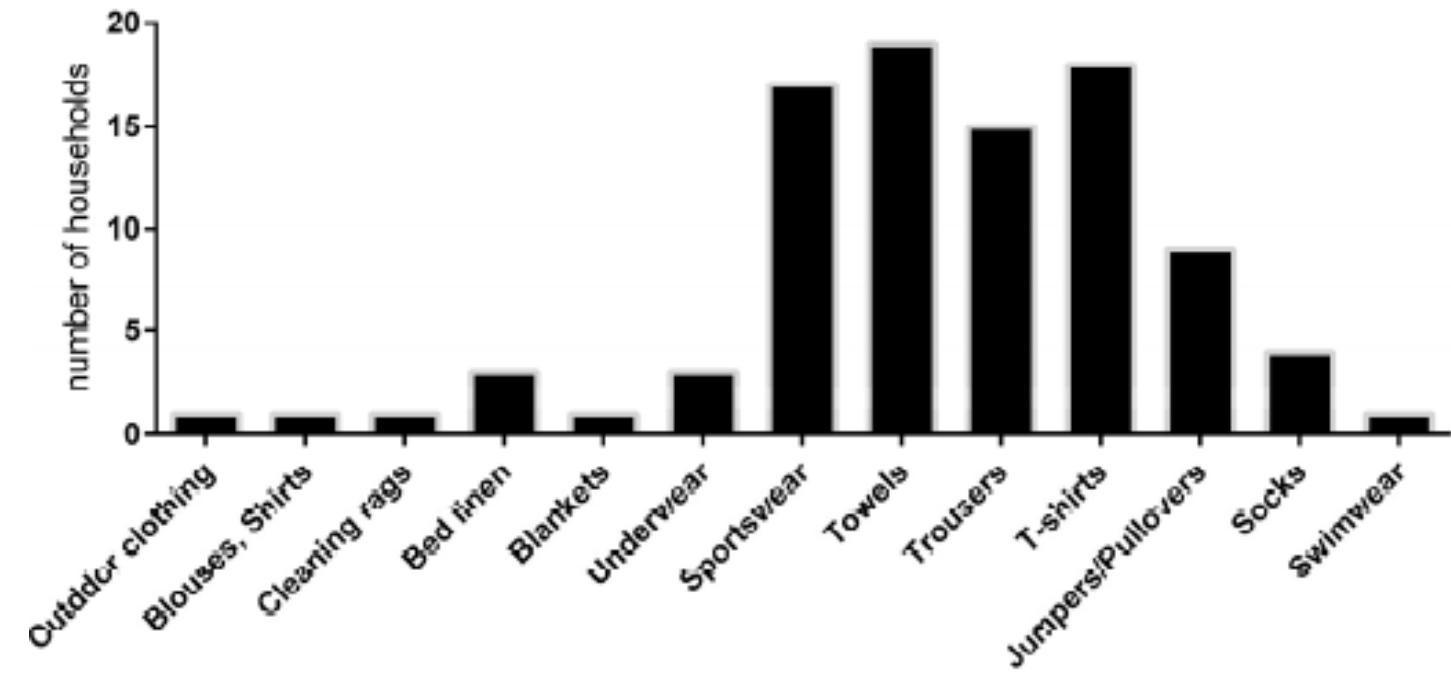


Geruch ist kein Kunstfaserproblem....



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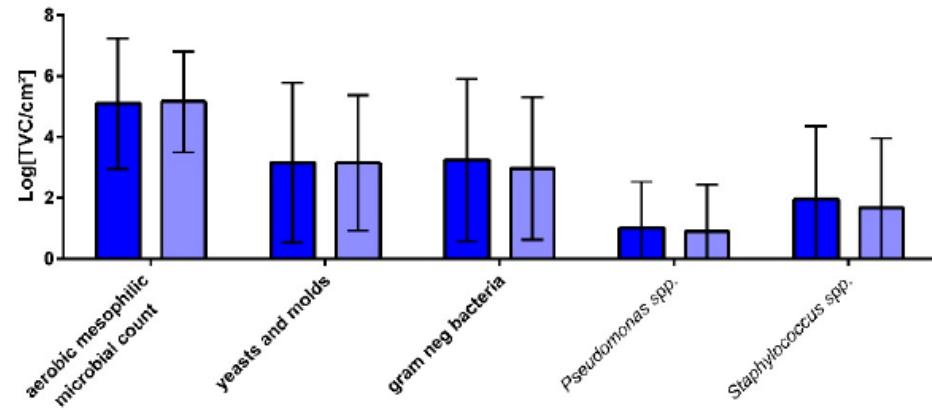
...und kein Sportkleidungsproblem



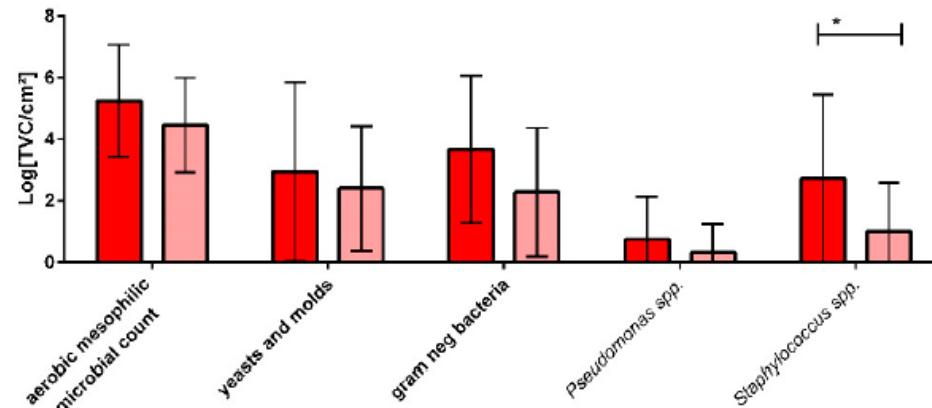
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Nicht-riechend vs. riechend: Keine Frage der Menge...

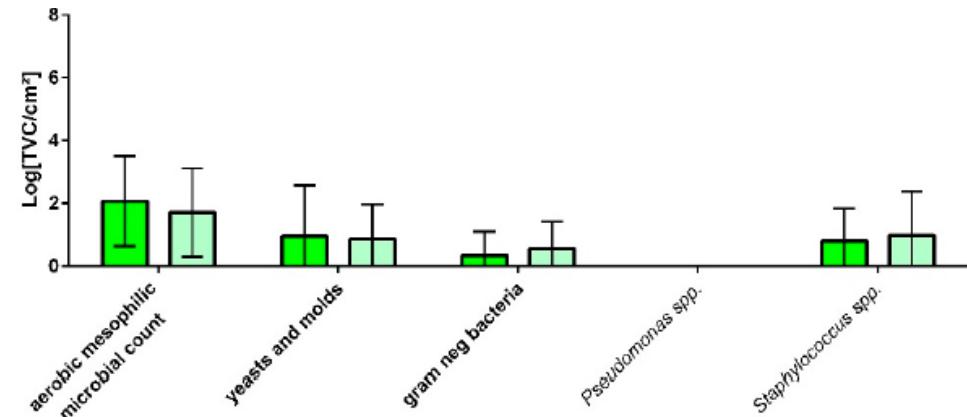
Einspülkammer



Gummidichtung



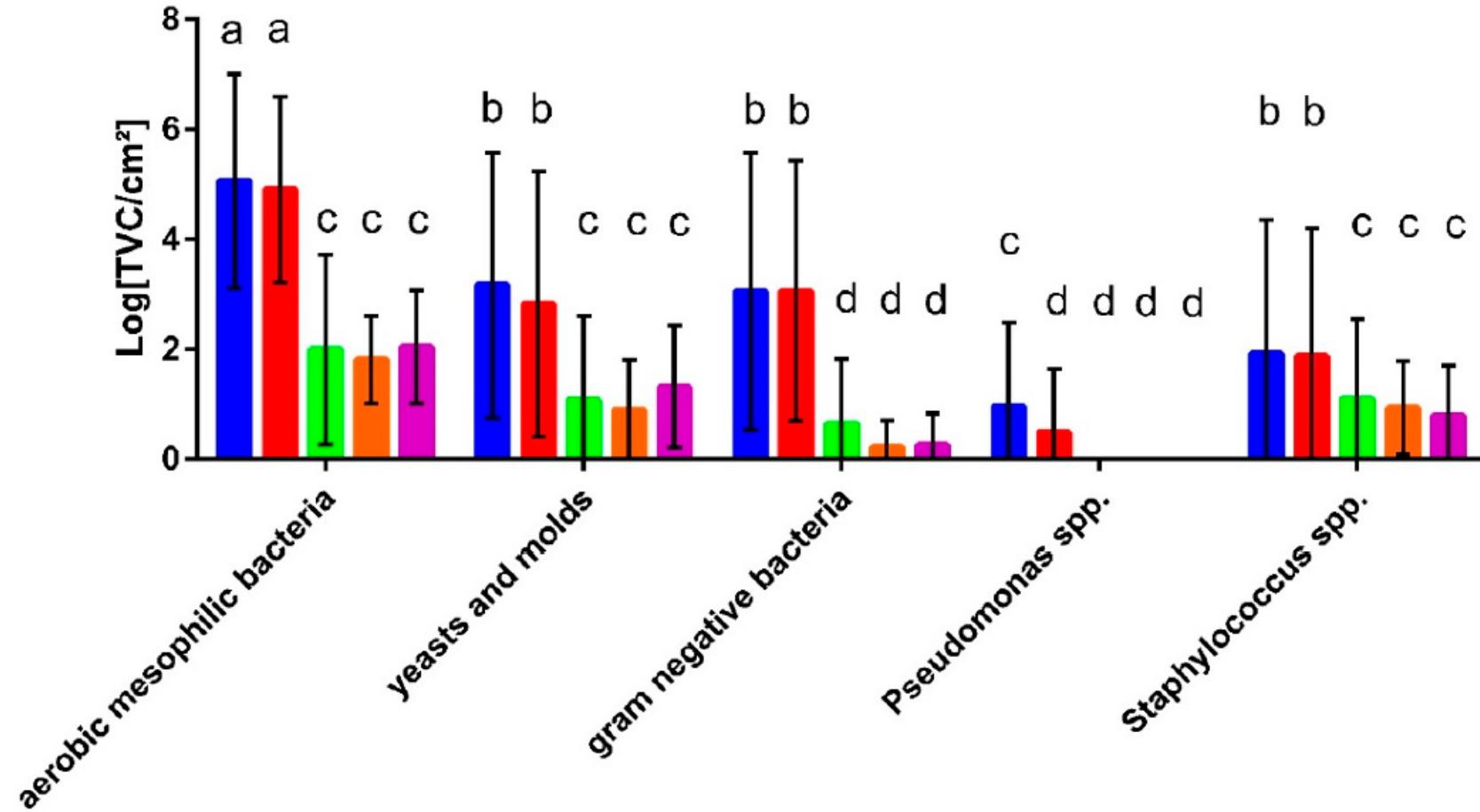
Benutzte Handtücher



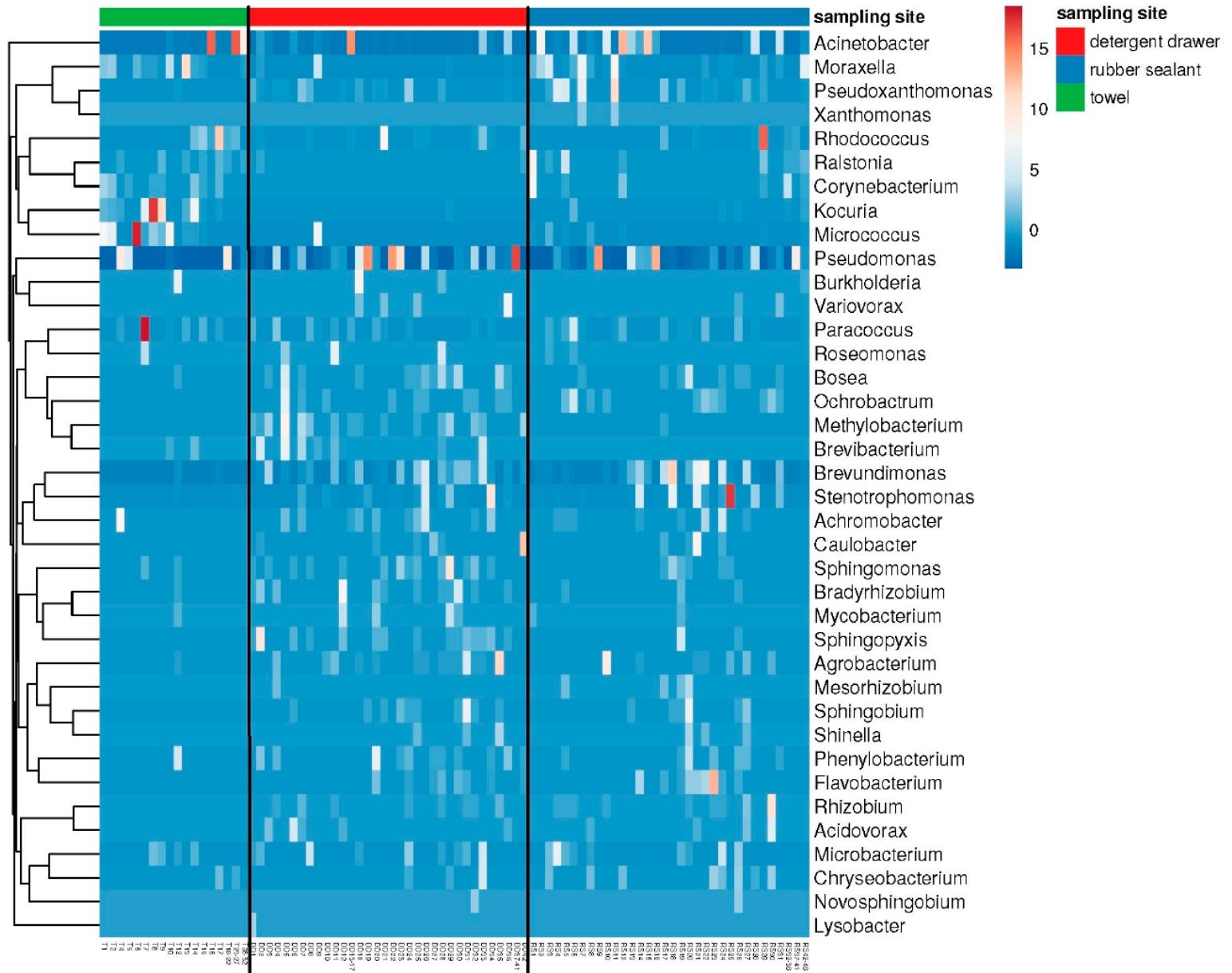
Dunkle Balken: HH mit Geruchsproblemen (n=16)
Helle Balken: HH ohne Geruchsprobleme (n=26)

Wieviele Mikroorganismen sind tatsächlich auf der Wäsche?

- Einspülkammer
- Gummidichtung
- Handtücher
- Duschtücher
- Küchentücher



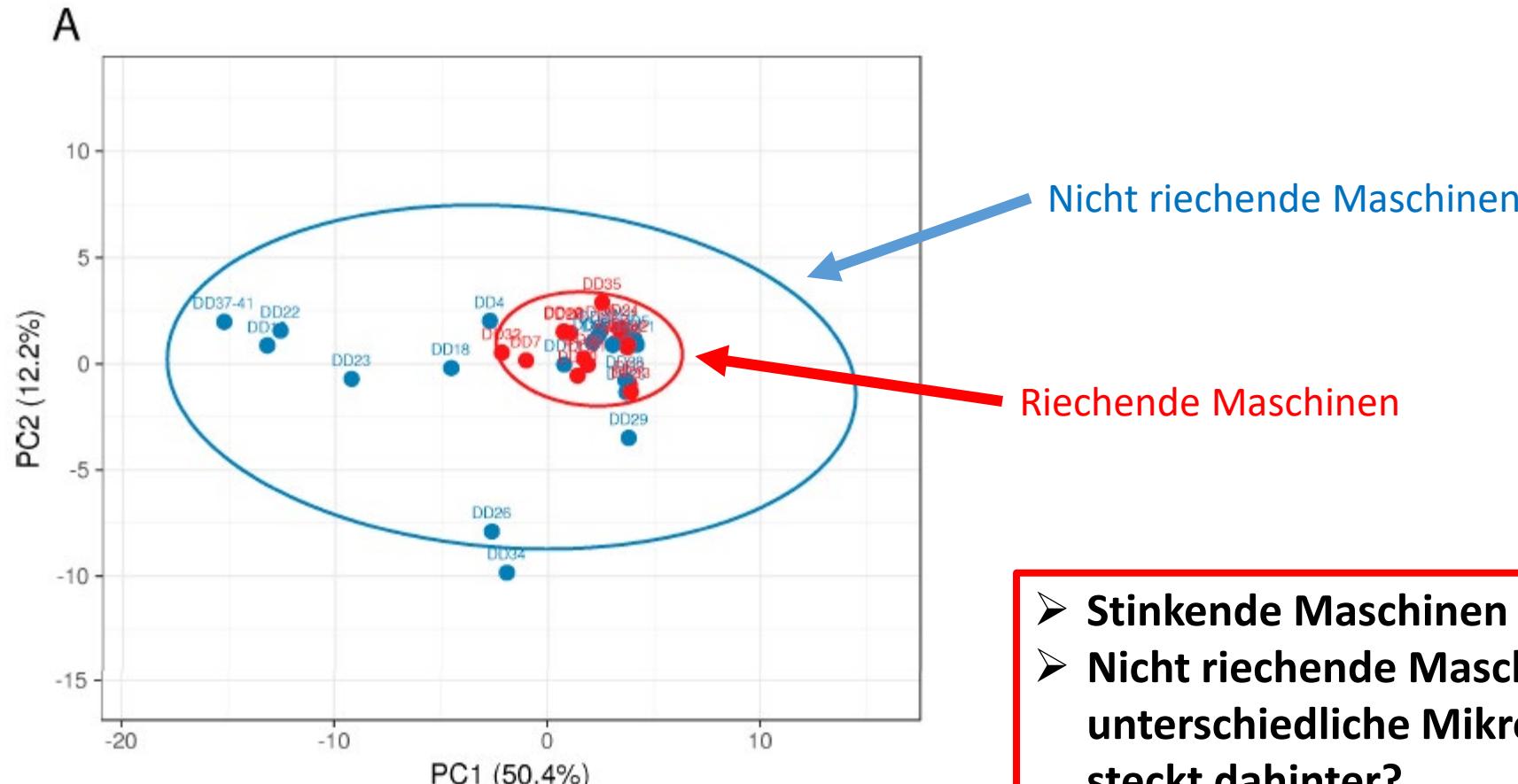
Zusammensetzung der mikrobiellen Gemeinschaft



Aber jetzt: Zusammensetzung der mikrobiellen Gemeinschaft

	Einspülkammer		Gummidichtung		Handtuch	
	Geruch	kein Geruch	Geruch	kein Geruch	Geruch	kein Geruch
<i>Pseudomonas</i>	Geruch	kein Geruch	Geruch	kein Geruch	Geruch	
<i>Acinetobacter</i>	Geruch		Geruch	kein Geruch	Geruch	kein Geruch
<i>Pseudoxanthomonas</i>	Geruch	kein Geruch	Geruch	kein Geruch		
<i>Brevundimonas</i>	Geruch	kein Geruch	Geruch	kein Geruch		
<i>Bosea</i>	Geruch	kein Geruch				
<i>Sphingomonas</i>	Geruch	kein Geruch				
<i>Stenotrophomonas</i>			Geruch	kein Geruch		
<i>Microbacterium</i>	Geruch					
<i>Staphylococcus</i>					Geruch	
<i>Micrococcus</i>					Geruch	
<i>Moraxella</i>			Geruch		Geruch	
<i>Agrobacterium</i>		kein Geruch		kein Geruch		
<i>Rhizobium</i>				kein Geruch		

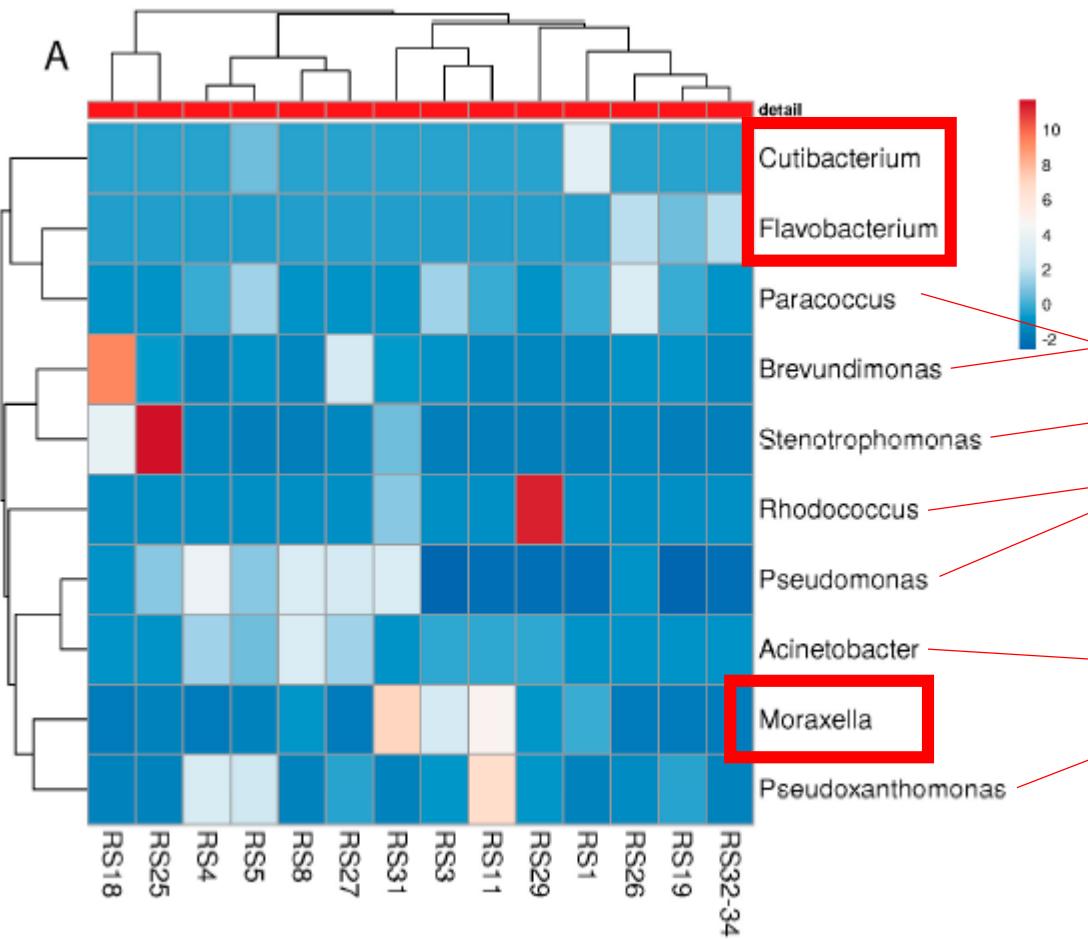
Kolonialisierungsmuster bei riechenden Maschinen



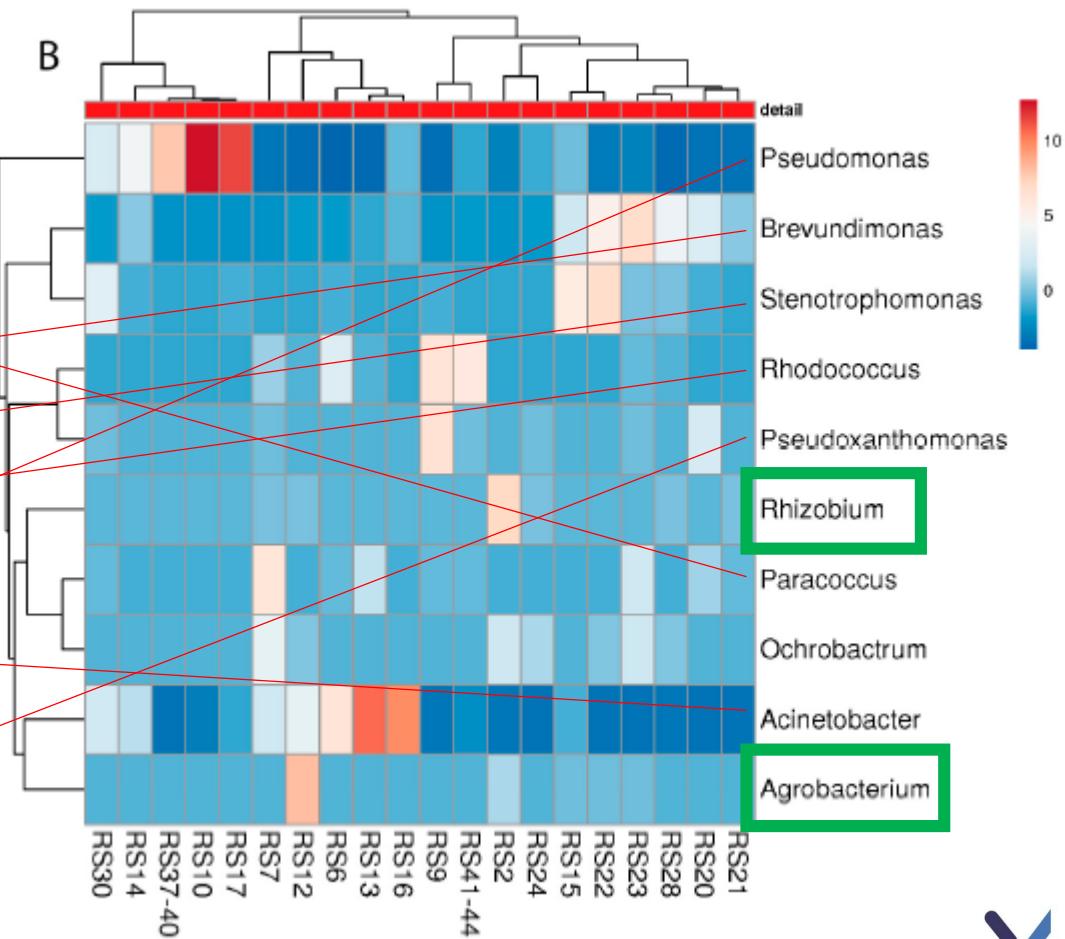
- Stinkende Maschinen sind ähnlich besiedelt
- Nicht riechende Maschinen haben mehr unterschiedliche Mikroorganismen: wer steckt dahinter?

Keine Bodenbakterien in schlecht riechenden Maschinen

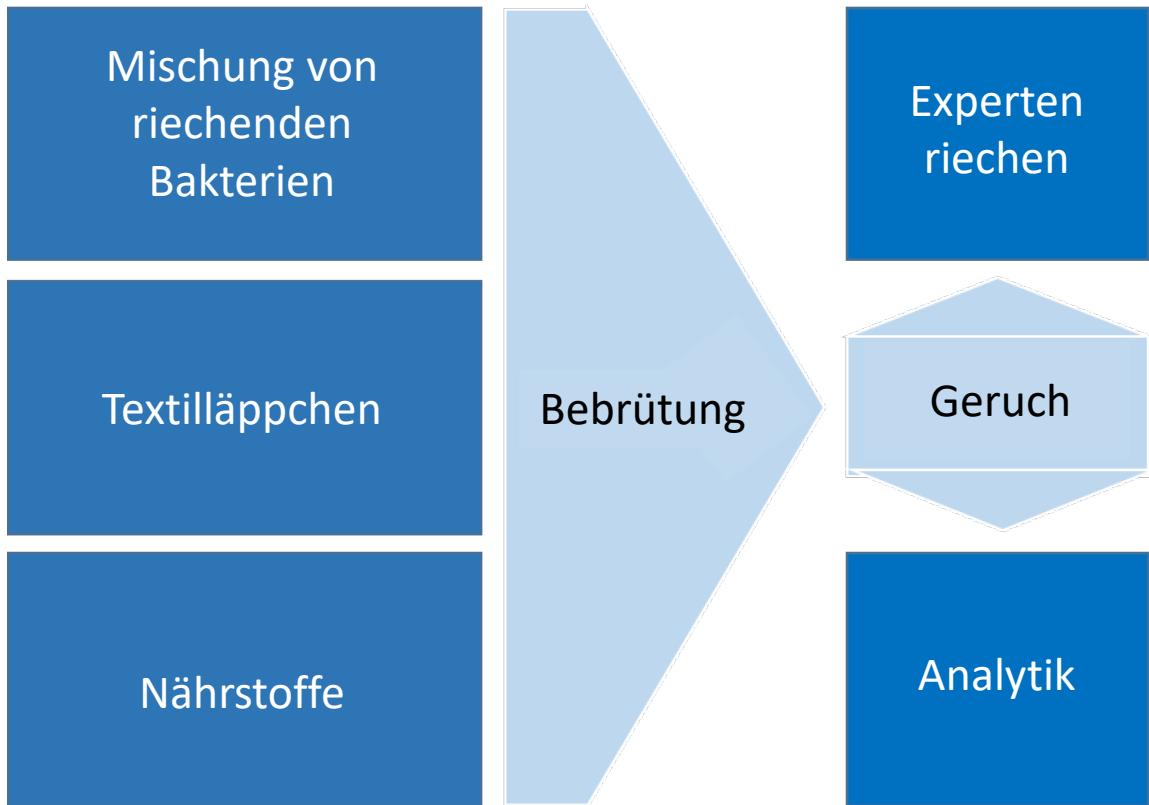
Maschinen mit Schlechtgeruch



Maschinen ohne Schlechtgeruch



Schützen Bodenbakterien vor Geruch? → Geruchsmodell



Schützen Bodenbakterien vor Geruch? → Geruchsmodell

Kombi von Bakterien	Abk.	Geruch nach 3 Tagen	Geruch nach 7 Tagen
<i>M. luteus</i> + <i>S. epidermidis</i> + <i>M. osloensis</i>	MlSeMo	0	1
<i>M. luteus</i> + <i>S. epidermidis</i> + <i>S. hominis</i>	MlSeSh	0	3
<i>M. luteus</i> + <i>S. epidermidis</i> + <i>P. aeruginosa</i>	MlSePa	0	2
<i>M. luteus</i> + <i>S. epidermidis</i> + <i>C. jeikeium</i>	MlSeCj	0	2
<i>M. luteus</i> + <i>M. osloensis</i> + <i>S. hominis</i>	MlMoSh	2	0
<i>M. luteus</i> + <i>M. osloensis</i> + <i>P. aeruginosa</i>	MlMoPa	0	0
<i>M. luteus</i> + <i>S. hominis</i> + <i>C. jeikeium</i>	MlShCj	3	3
<i>M. luteus</i> + <i>P. aeruginosa</i> + <i>C. jeikeium</i>	MlPaCj	1	1
<i>S. epidermidis</i> + <i>M. osloensis</i> + <i>S. hominis</i>	SeMoSh	2	1
<i>S. epidermidis</i> + <i>M. osloensis</i> + <i>P. aeruginosa</i>	SeMoPa	2	2



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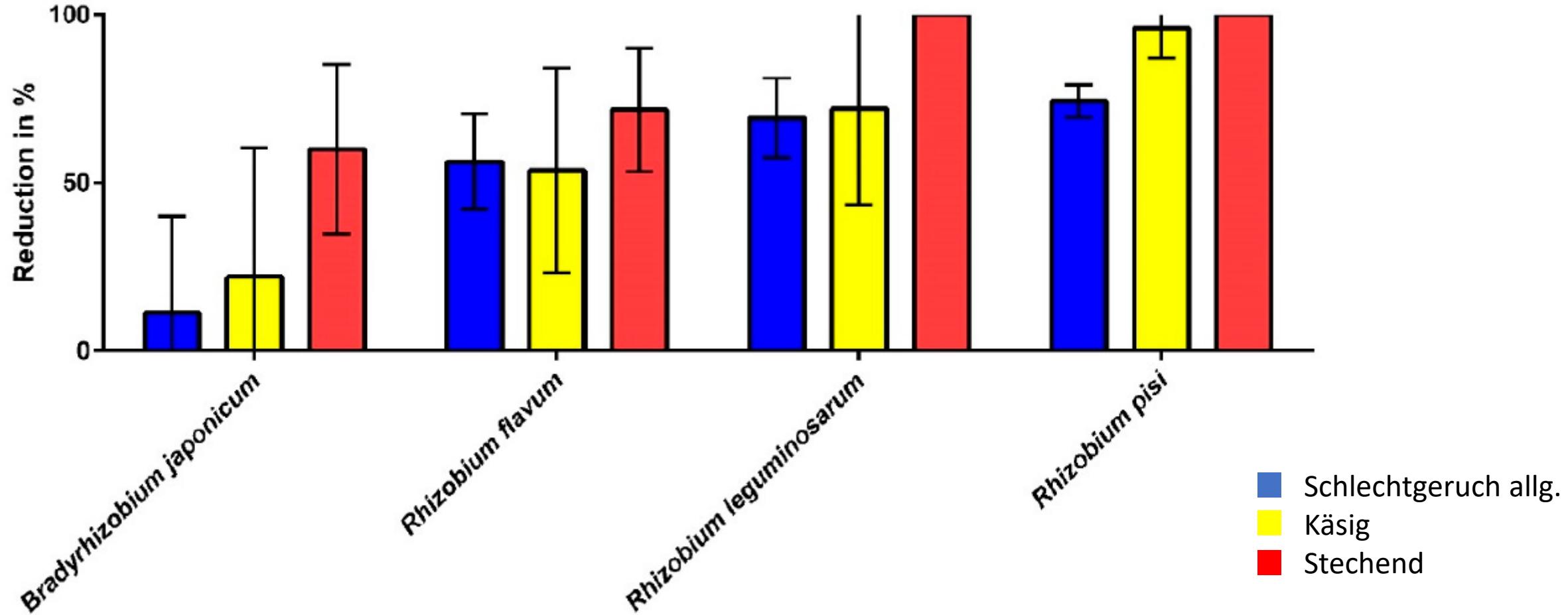
Schützen Bodenbakterien vor Geruch? → Geruchsmodell

Sample	Dimethyl Disulphide (%)	Dimethyl Trisulfide (%)	Indole (%)
MlShCj	0.36	0.10	0.24
MlSeCj	0.08	0.00	0.17
SeMoPa	0.07	0.00	0.56
MlSeSh	0.04	0.01	0.12
SeShCj	0.06	0.00	0.07
MoShPa	0.03	0.00	0.23
Ml	0.05	0.01	0.13
Mo	0.02	0.00	0.03
SeMoCj	0.04	0.02	0.15
ShPaCj	0.02	0.00	0.13

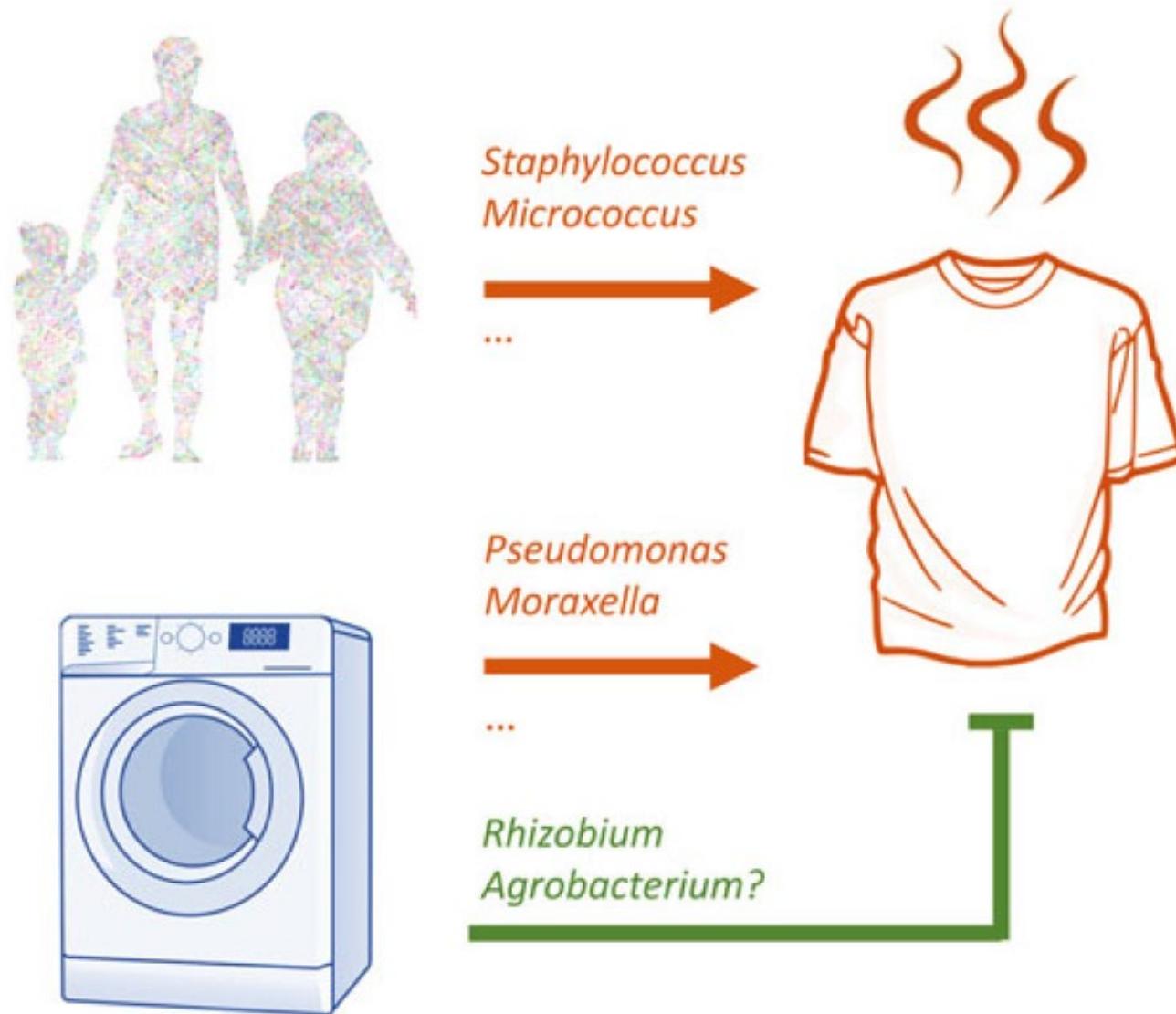


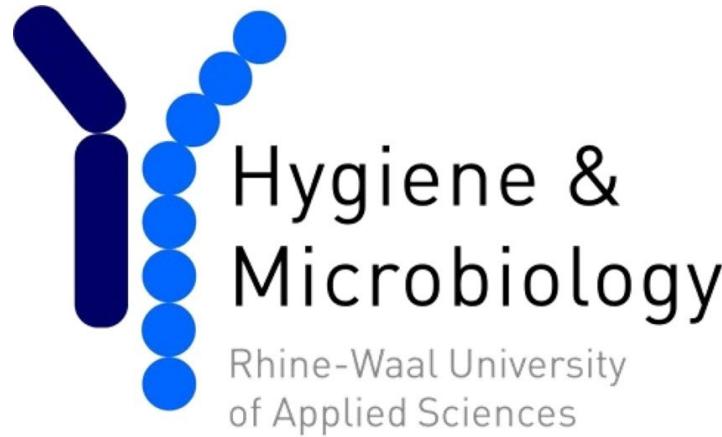
<https://www.chemietechnik.de>

Bodenbakterien schützen vor Schlechtgeruch im Labormodell



Die Gesamtsicht....





Danke!

Dr. Marc-Kevin Zinn

Dr. Nadine Merettig

Dr. Britta Brands

Ralf Lucassen

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