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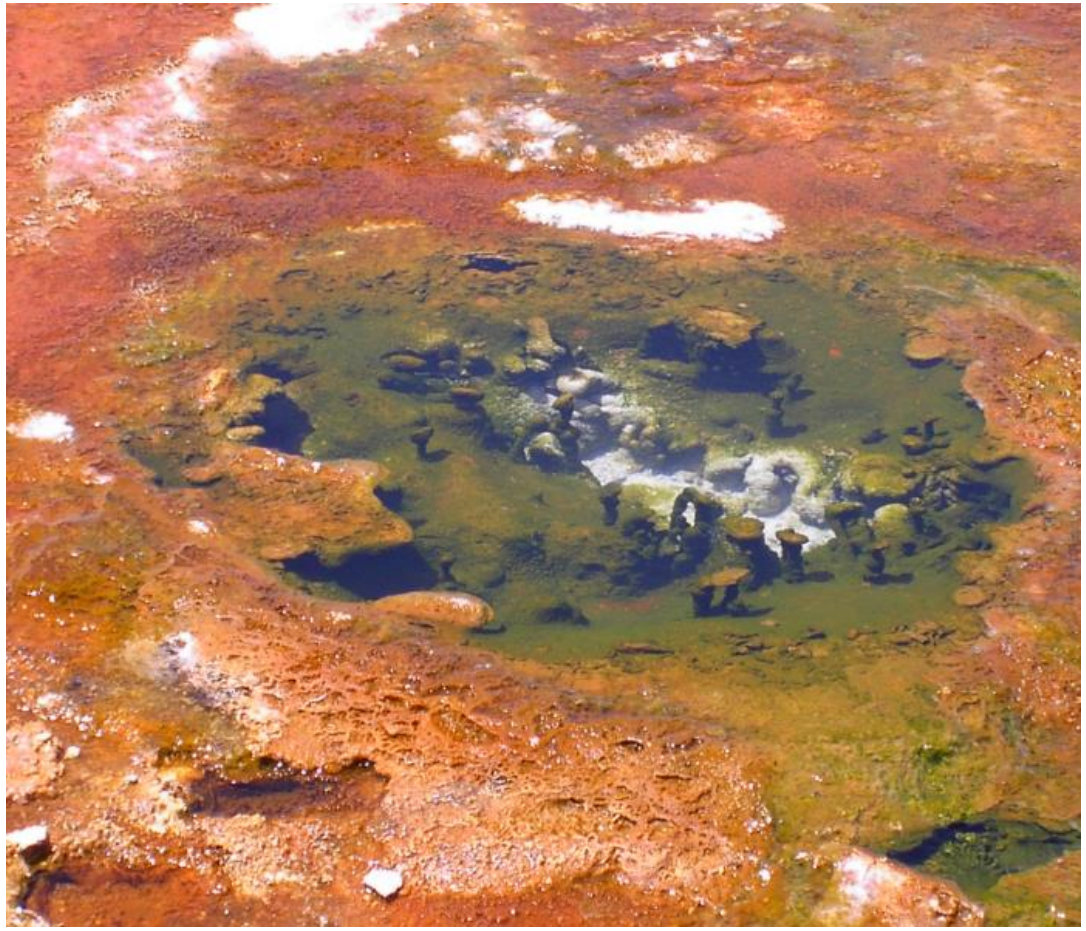
Recycled packaging board microbiology

KCL BIOHUB WEBINAR
17TH OF SEPTEMBER, 2024

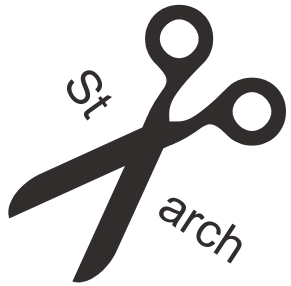
Recycled fiber is totally different



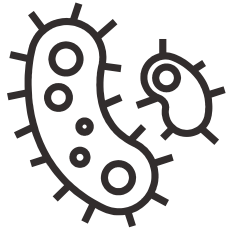
Process issues due to starch degradation

Starch

Amylase enzymes
in process water



Bacteria



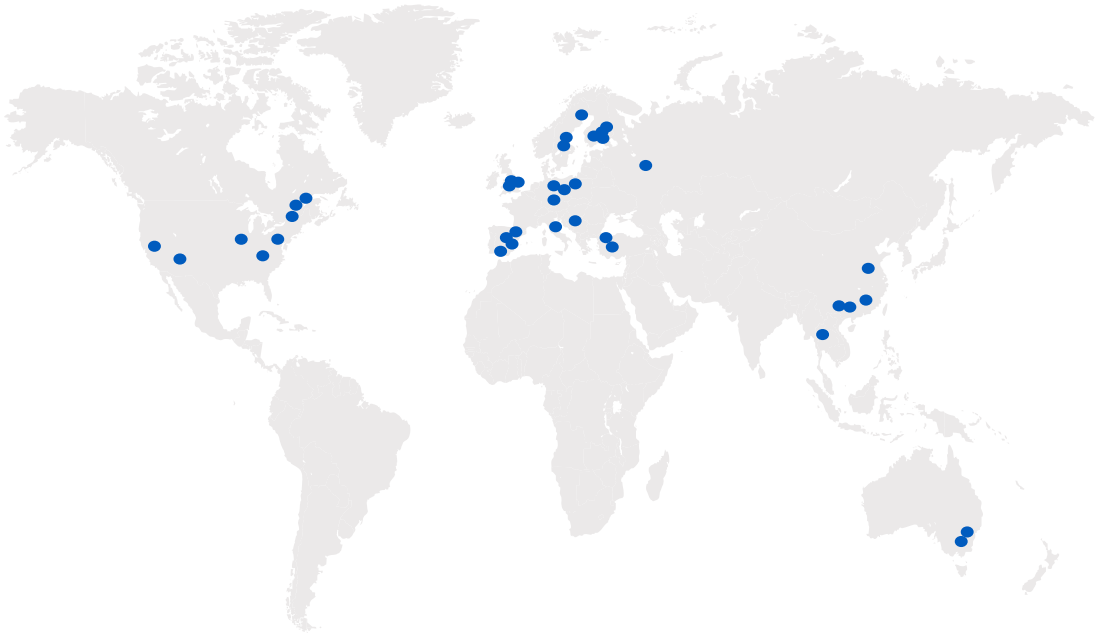
\+
Sugars

Organic
Acids

- pH depression
- Increased dissolved calcium concentrations
- Strength issues
- Runnability problems due to reduced chemical efficiency
- High COD loading
- Calcium scaling in wastewater treatment
- Bad smells

Bacteria in recycled board machines

- 3 continents and 16 countries
- >50 different machines
- The microbial community was analyzed
  - Using DNA sequencing and quantitative PCR
  - >50.000.000 individual bacteria were identified



Sites and countries in the research

THIS RESEARCH REVOLUTIONIZED OUR KNOWLEDGE ABOUT MICROBIOLOGY IN PAPER INDUSTRY – PROBLEM CAUSING BACTERIA HAVE BEEN REVEALED

Harmful bacterial groups identified for RCF

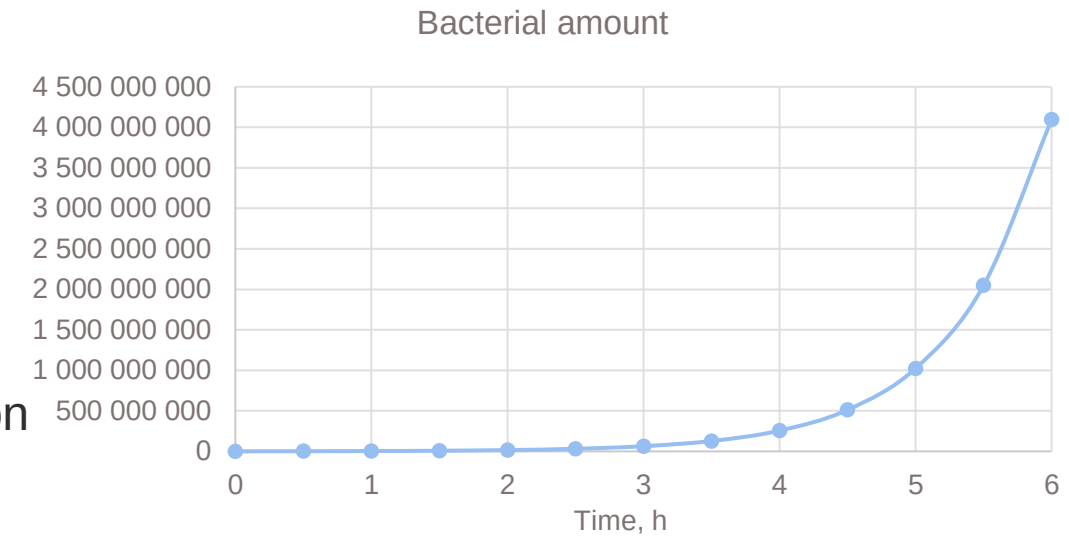
Bacterial group	Harmful properties	Growth temperature in paper machines
Anaerobic Bacteroidales	Starch and cellulose degradation, acid production, growth only in anaerobic conditions	<45°C
Anaerobic Firmicutes	Starch and cellulose degradation, acid production, dangerous gases and bad smells, growth only in anaerobic conditions	>35°C
Thermicanus	Starch and cellulose degradation, acid production	>45°C
Lactic acid bacteria	Starch and cellulose degradation, acid production	<45°C
Facultative Bacillales	Starch degradation and acid production, end-product spores	>30°C

Sub-targets of microbe control in a paper/board machine

Treatment block	**Specific target**
1. In-coming cold and warm water	Low microbe amounts
2. BM water loops	Focus on preventing slime (biofilm) formation on surfaces – Not only looking at killing of all free-swimming microbes
3. RCF pulp and broke system	Keep microbe activity at a level causing no pH drop or odor issues. Prevent starch & cellulose degradation
4. Shower waters	Low microbe amounts – to maintain clean frames in splash areas
5. Preservation of starch (+ other additives if needed)	Control microbial activity to a level not impacting functional properties of the material.

Process volume and residence times matter!

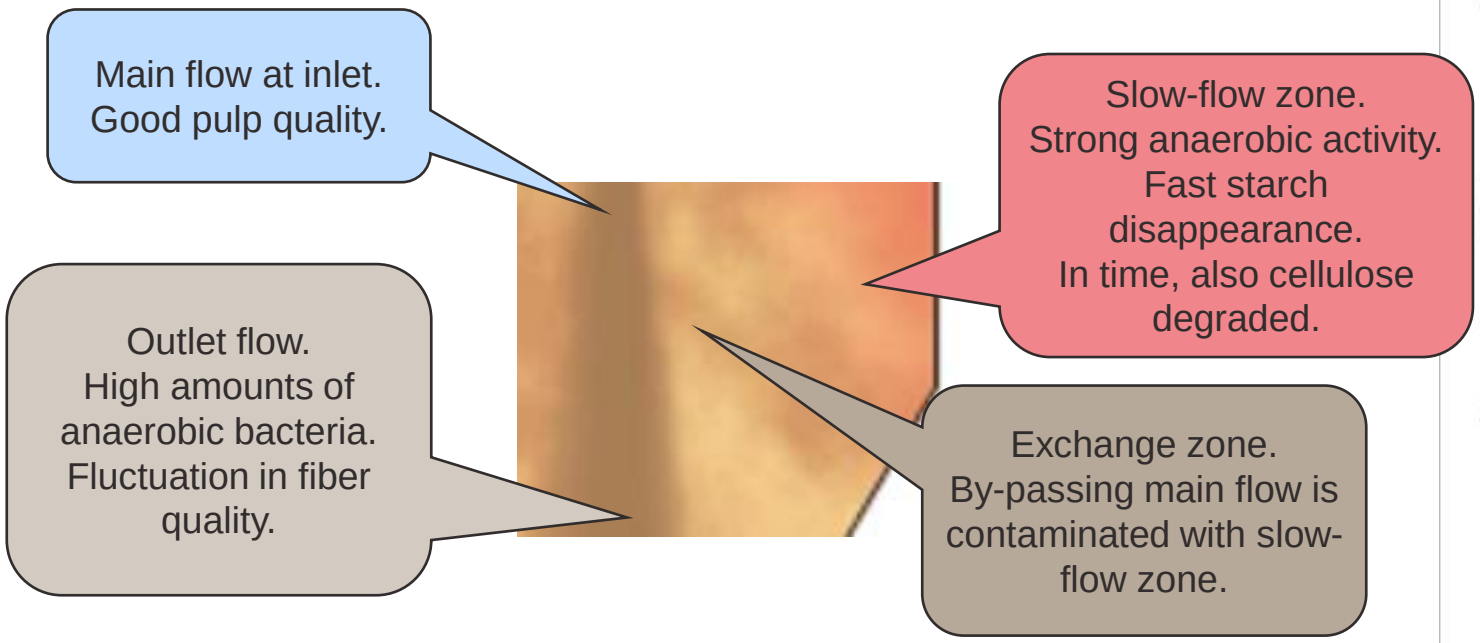
- Bacteria grow
  - Fast
    - One generation can be less than 30 min
  - Exponentially
    - The amount of cells doubles every generation

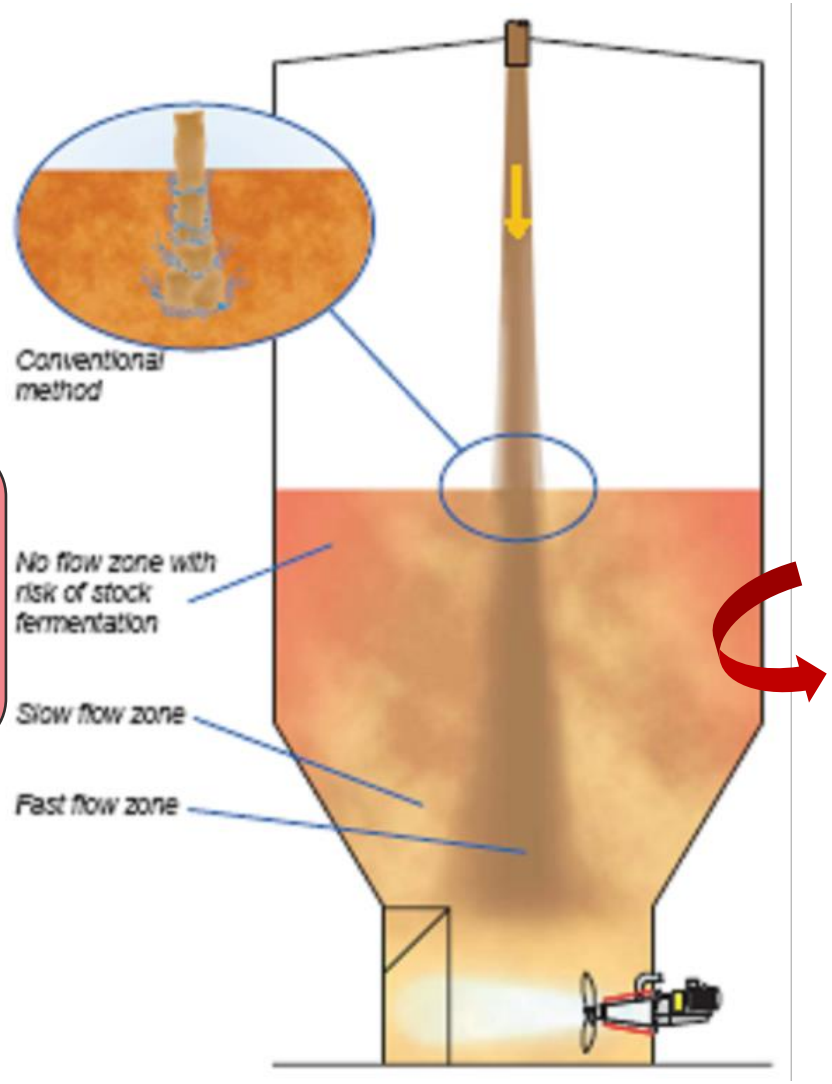


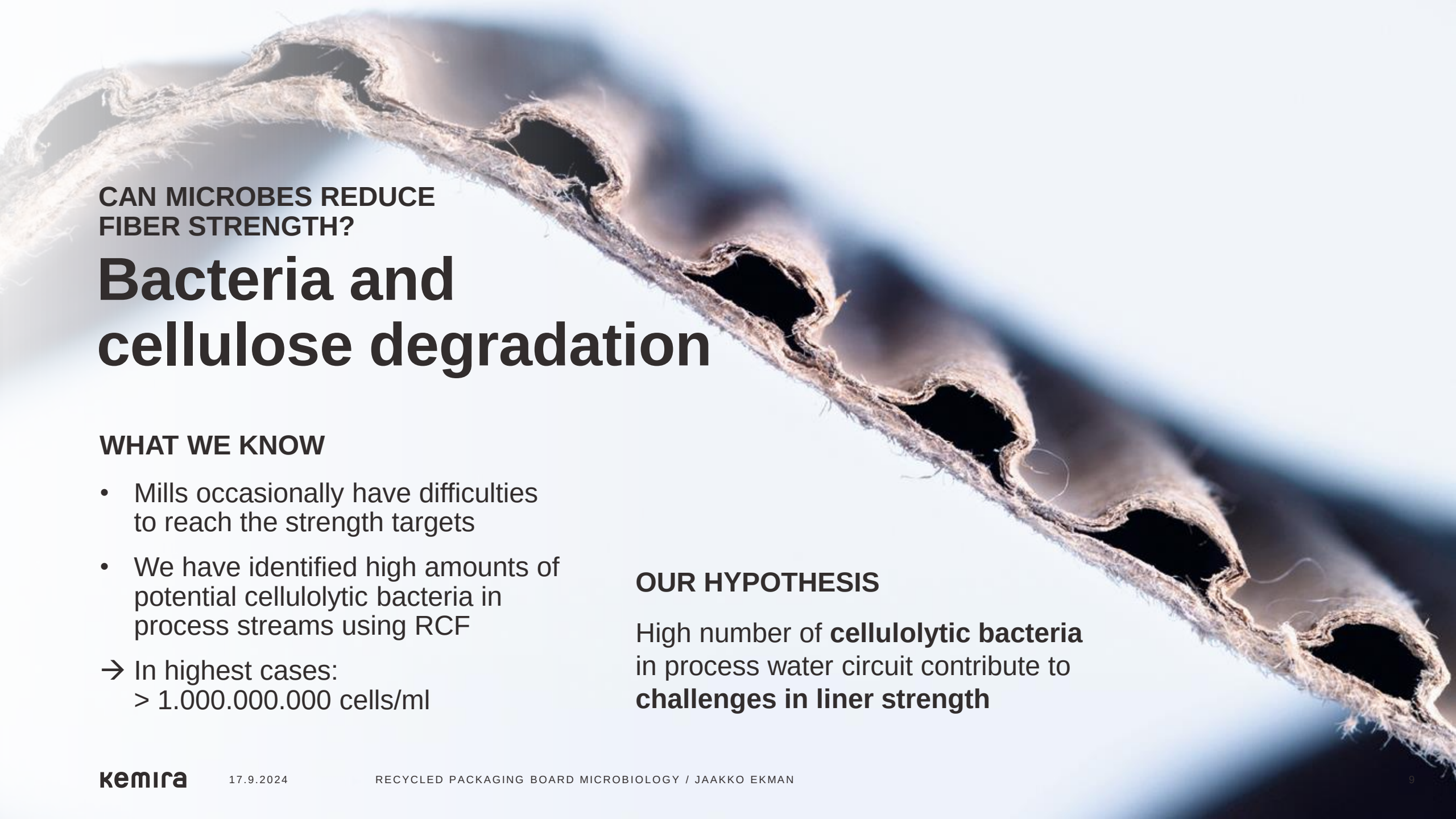
The bigger the volumes and the longer the residence times, the more difficult it is to control bacteria

Mixing and storage time in large towers

- Mixing in a RCF storage tower is never perfect
- Mixing starts to get much worse at levels over 30 %
- Calculated retention time can be short – But a part of the stock can be very old!







CAN MICROBES REDUCE FIBER STRENGTH?

Bacteria and cellulose degradation

WHAT WE KNOW

- Mills occasionally have difficulties to reach the strength targets
- We have identified high amounts of potential cellulolytic bacteria in process streams using RCF

→ In highest cases:
> 1.000.000.000 cells/ml

OUR HYPOTHESIS

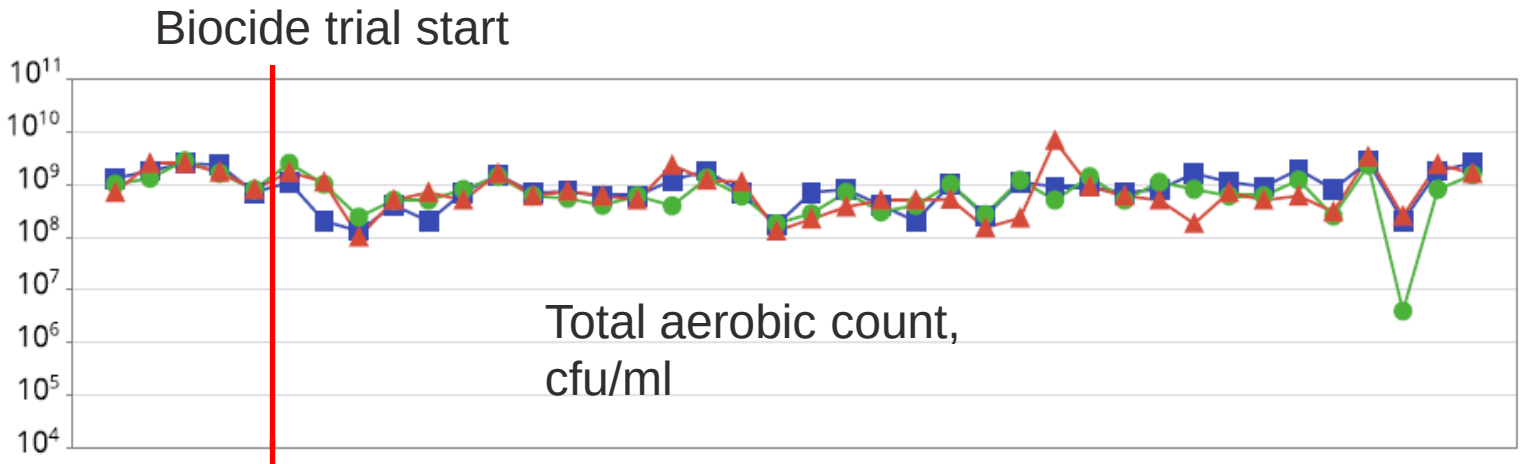
High number of **cellulolytic bacteria** in process water circuit contribute to **challenges in liner strength**

Example 1. DNA tools explain why the situation improved after the microbe control trial started

More stable production with less downtime

Boilout frequency reduced

Savings on starch, other process chemicals, and freshwater quantity



	70 days before treatment start	Just before treatment start	15 days after treatment start	67 days after treatment start	240 days after treatment start
Anaerobic Bacteroidales, %	30.3	11.0	0.4	0.2	0.1
Anaerobic Bacteroidales, cells/ml	7.2E+08	1.4E+08	1.4E+06	1.5E+06	7.8E+05

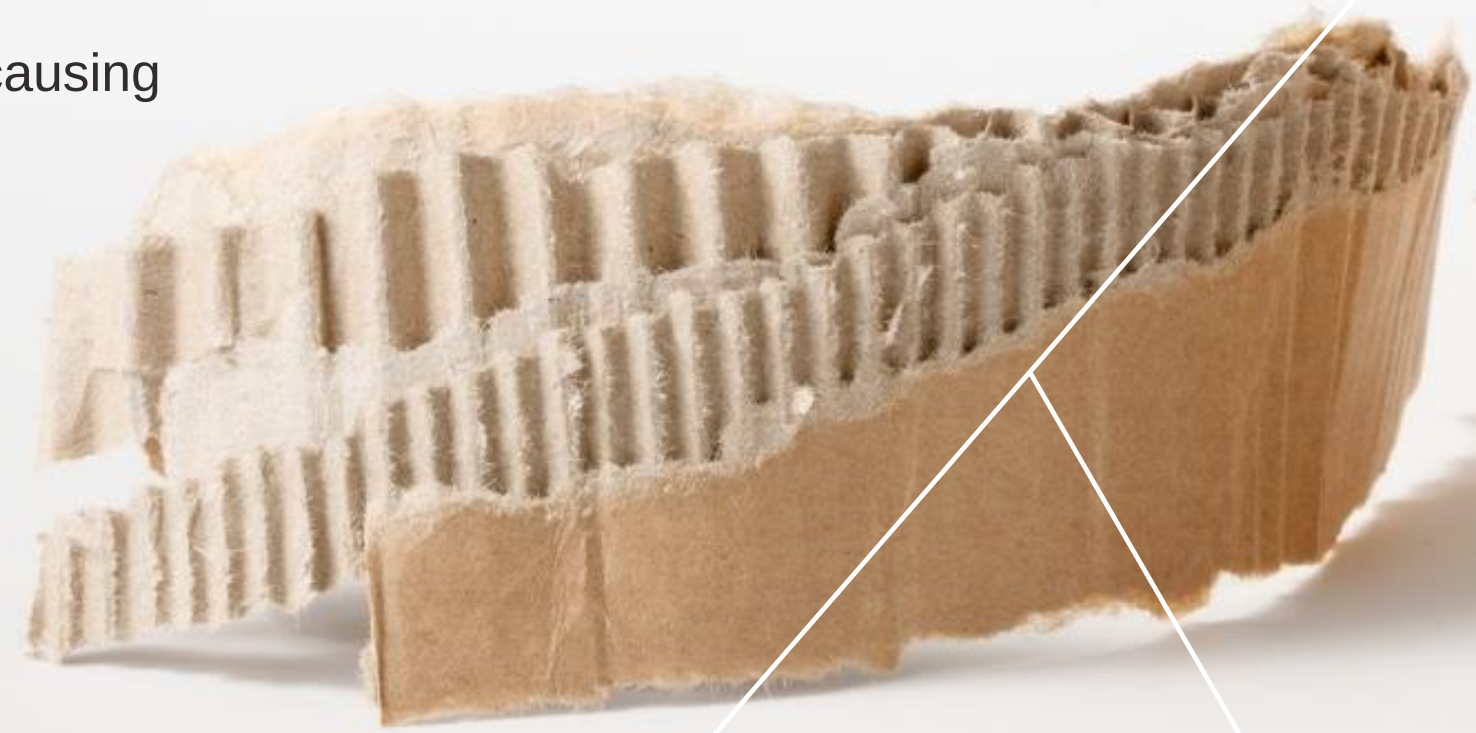
Example 2: Hydrogen producing bacteria were a root cause for a safety hazard

- Bacteria can produce toxic and/or explosive gases and lead to severe accidents
- DNA analysis showed extreme amounts cellulose-degraders
- *Ethanoligenens* and *Clostridiales* can produce hydrogen gas
- Analysis showed the root cause and directed corrective actions

	The proportion of the most common bacteria, %	
	RCF pulp	WW tower
Bifidobacterium	1,2	1,5
Corynebacterium	1,6	2,4
Microbacteriaceae_unclassifiec	7,0	8,6
Micrococcales_unclassified	0,6	1,4
Prevotellaceae_unclassified	6,0	5,5
Weeksellaceae_unclassified	39,1	39,5
Weeksellaceae	9.7	8.5
Clostridiales_unclassified	4,9	5,2
Ethanoligenens	21,4	18,0
Ruminococcaceae_UCG-014	0,0	1,2
Saccharimonadales_unclassifie	2,1	2,2
Xanthomonadaceae_unclassifie	1,4	1,0
Total bacteria, cells/ml	1,9E+09	4,6E+09

Summary

- Special conditions at machines using RCF
- Bacterial activity especially in pulp towers leads to problems
- Starch and cellulose degradation
- DNA tools can reveal the problem-causing bacteria



Thank you!

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