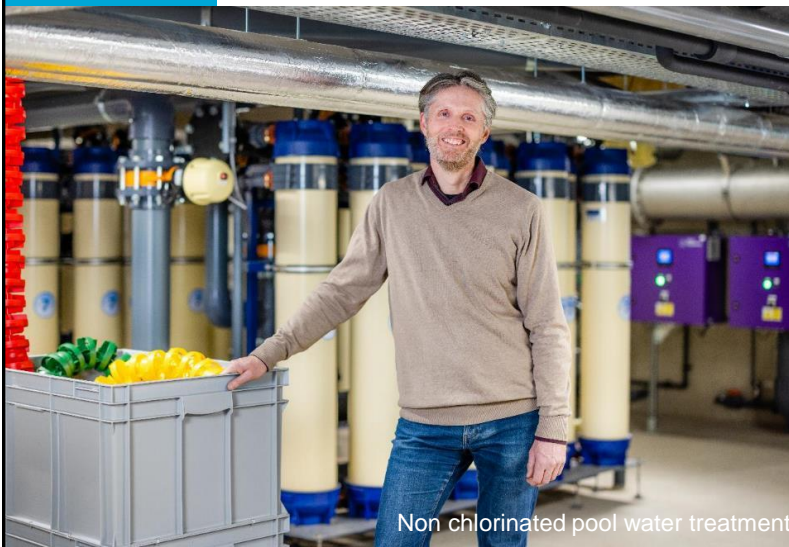


# Non chlorinated pool water treatment with disinfection

dr.ir. Maarten Keuten, TUDelft / Hellebrekers  
PWTAG conference Loughborough November 2024



## Introduction



- Maarten Keuten
- TUDelft / Hellebrekers
- PhD study
- R&D, troubleshooting
- 29 y. in sw.pools
- 19 y. R&D non-chlorinated swimming

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# Non-chlorinated swimming

- Why?
- PhD study; proof of concept
- The full scale concept
- Trail swimming
- 1<sup>st</sup> results



# Why?



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# Why non-chlorinated swimming?

Health complaints from swimmers →

*“We can do better, time for a change”* (Keuten 2005)



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# PhD study

Proof of concept

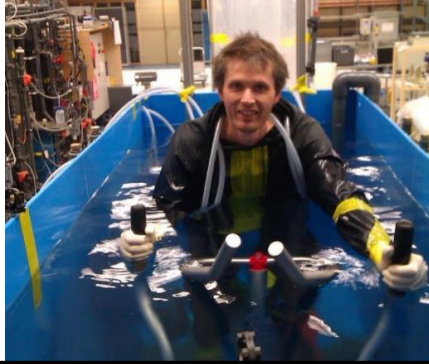
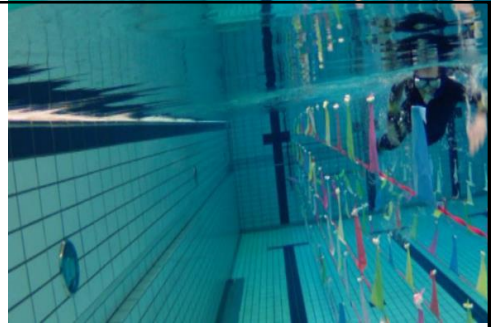
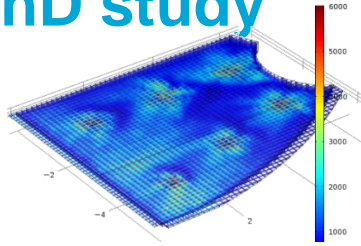
 Hellebrekers  
Water & Leisuretechniek

 TU Delft

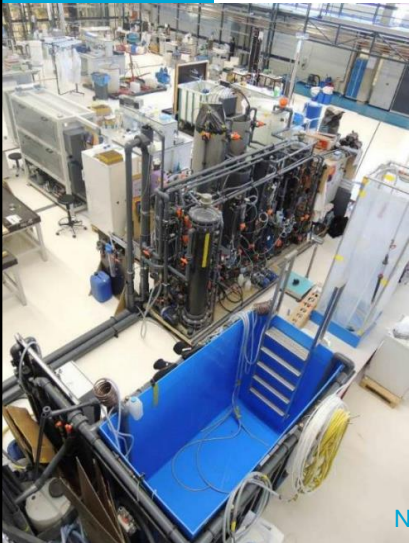
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# PhD study



# Proof of concept

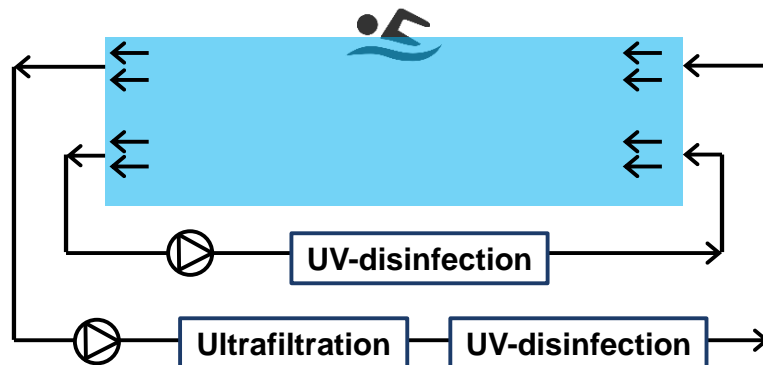


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# Full scale concept

# Full scale concept

Double layer, double barrier



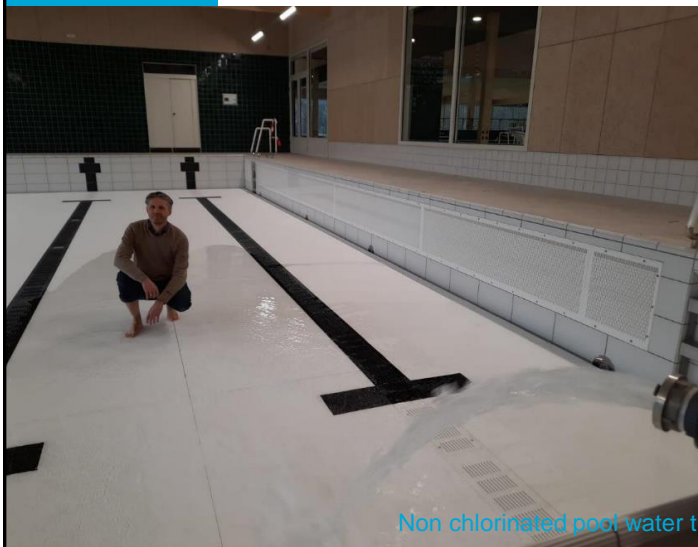
# Full scale concept



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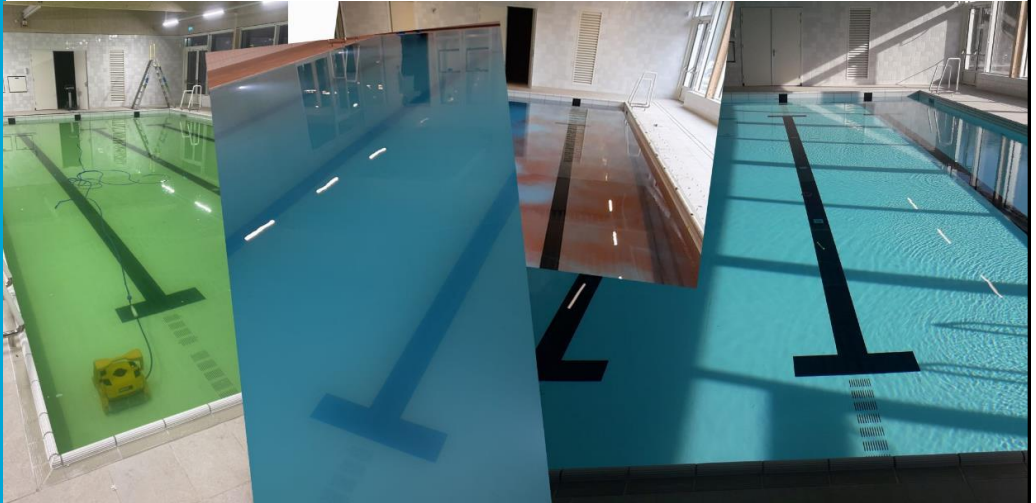
# Full scale concept



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# Full scale concept



# Full scale concept



# Trail swimming

Part of the dispensation

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## Trail swimming

- 2 Sessions (2+9 feb 2023)
- Supervised by outpatient clinic
- Water samples by lab
- Each 10 min. own sampling (cATP, turbidity)
- Questionnaire all participants
- Health-check by physician of outpatient clinic, 7 days after trail swimming
- No health complaints related to non-chlorinated swimming



## Results

During 19 months of operation

# Dispensation

Parameter	Limit	Operator	Lab	Standard
Intestinal enterococci	≤ 50 cfu/100 mL		Weekly	NEN-EN-ISO 7899-2
Pseudomonas aeruginosa	≤ 10 cfu/100 mL		Weekly	NEN-EN-ISO 16266
Spores of sulfite reducing Clostridia	≤ 1 cfu/100 mL		Weekly	NEN-ISO 6461-2
Escherichia coli	≤ 100 cfu/100 mL		Weekly	SOP RIVM
Plate count 37°C	-		Weekly	NEN-EN-ISO 6222
Staphylococcus aureus	-		Weekly	SOP RIVM
Intracellular adenosine triphosphate (cATP)	-	Daily	Weekly	ASTM 4012-81
Acidity	6.0 ≤ pH ≤ 8.5	Daily	Monthly	NEN-EN-ISO 10523
KMnO <sub>4</sub> -consumption	≤ 3.5 mg/L as O <sub>2</sub>		Monthly	NEN-EN-ISO 8467
Urea	≤ 2.0 mg/L		Monthly	NEN 6494
Alkalinity	≥ 40 mg/L HCO <sub>3</sub>		Monthly	NEN 6531
Turbidity	≤ 0.50 ntu		Monthly	NEN-EN-ISO 7027-1
Chlorides	≤ 1000 mg/L		Monthly	NEN-EN-ISO 10301-1
Nitrate	≤ 70 mg/L		Monthly	NEN-ISO 15923-1
Visibility of pool bottom floor	Clear sight	Daily	Monthly	Visual inspection

## Results

- 19 months open; 82 weekly lab-visits
- Online cATP; ≈ 8 pg/ml (comparable with Dutch tap water)
- Online turbidity; ≈ 0.06 ntu
- UV254; 99-100%
- 15 deviations (out of 780 samples ≈ 2%)
  - Pseudomonas
  - Spores of sulfite reducing clostridia
- Health complaints; outpatient clinic
  - No related health complaints
  - 1 under investigation

## Average results

parameters	limit	average	deviations
Intestinal enterococci	≤ 50 cfu/100 mL	2	-
<b>Pseudomonas aeruginosa</b>	<b>≤ 10 cfu/100 mL</b>	<b>7</b>	<b>12</b>
<b>spores of sulf. red. Clostridia</b>	<b>≤ 1 cfu/100 mL</b>	<b>0</b>	<b>3</b>
Escherichia coli	≤ 100 cfu/100 mL	10	-
Plate count 37°C	no limit (cfu/mL)	276	-
staphylococcus aureus	no limit (cfu/100 mL)	16	-
intracellular ATP	no limit (ng/L = pg/mL)	8	-
temperature	no limit (°C)	32	-
		-	-
acidity	6.0 ≤ pH ≤ 8.5	8	-
KMnO <sub>4</sub> -number	≤ 3.5 mg/L O <sub>2</sub>	1	-
urea	≤ 2.0 mg/L	0	-
alkalinity	≥ 40 mg/L	79	-
turbidity	≤ 0.5 ftu	0	-
		-	-
chloride	≤ 1000 mg/L	17	-
nitrate	≤ 70.0 mg/L	18	-
		-	-
clear sight to the bottom	clearly visible	-	-

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## Algae

- Algae on walls and moveable floor
- Periodic mechanical cleaning (3-4 weeks)
- 95% under control without chemicals
- Last 5% still in study

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## What next?

- Evaluation with national health agency and public pool authority
- Optimise sustainability
- Optimise investment costs
- Update dispensation
- Re-evaluate next year

## That's why!

“the experience is very different,  
but the water is just as wet ...” (Keuten 2023)



## Acknowledgements

- Hellebrekers
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## Questions?

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