POLYPLAN

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Hygienic situation in natural swimming pools (NSP)

Unvollständige Inhaltsangabe

1. Analogy disinfected pool versus NSP

2. DANA International Data base for NSP

Evaluation of hygienic data (International)

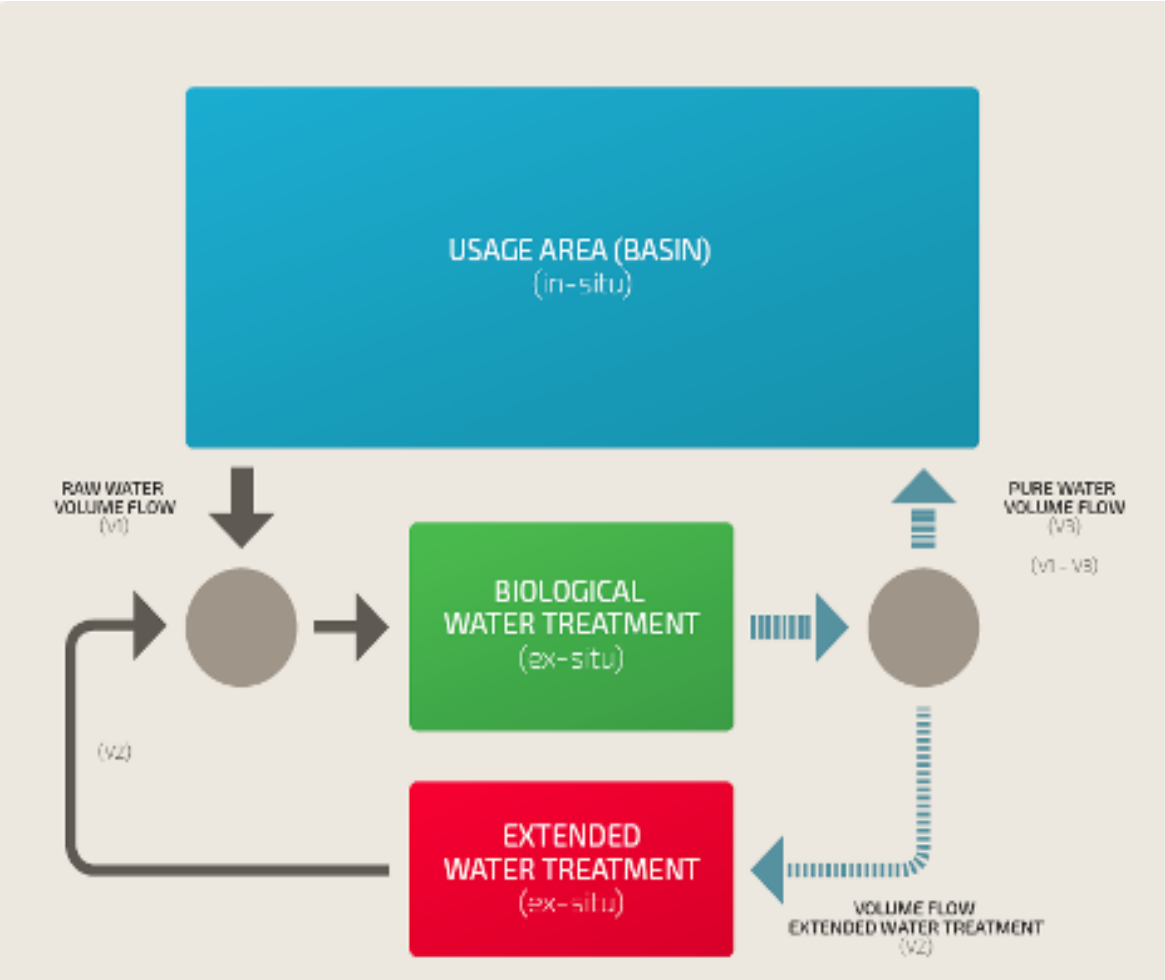
Ecoli, Enterococcus, Pseudomonas aeruginosa, other indicators

Insitu test in order to discover the elimination of E.coli (Germany)

Viruses and Protozoa in a NSP (Ruds Vedby, Denmark)

Flexible measurement periods of hygienic parameters during operation (Herrenberg, Germany)

Internal and external water treatment

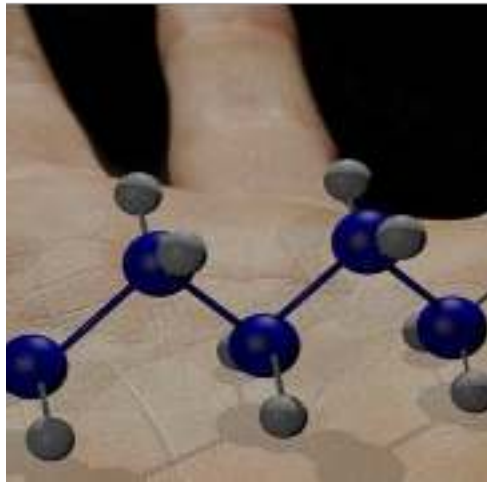


Internal disinfection

A short analogy between chlorinated pools and NSPs

Internal disinfection in NSP

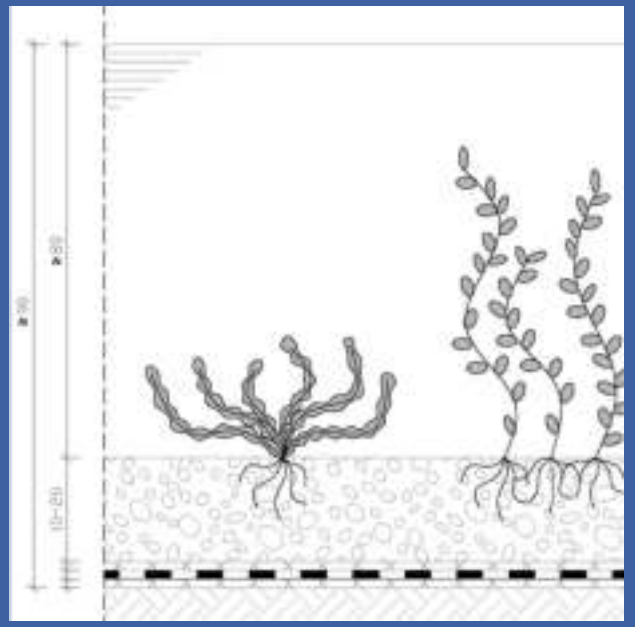
1. Filtration via zooplankter
2. The zooplankter population develops better during higher duty
3. The zooplankter is active searching for food



Internal disinfection in chlorine pool

1. Disinfection via chlorine works in minutes against most of species.
2. No elimination effects against some viruses and Protozoas.
3. Chorine is a stupid oxygenator

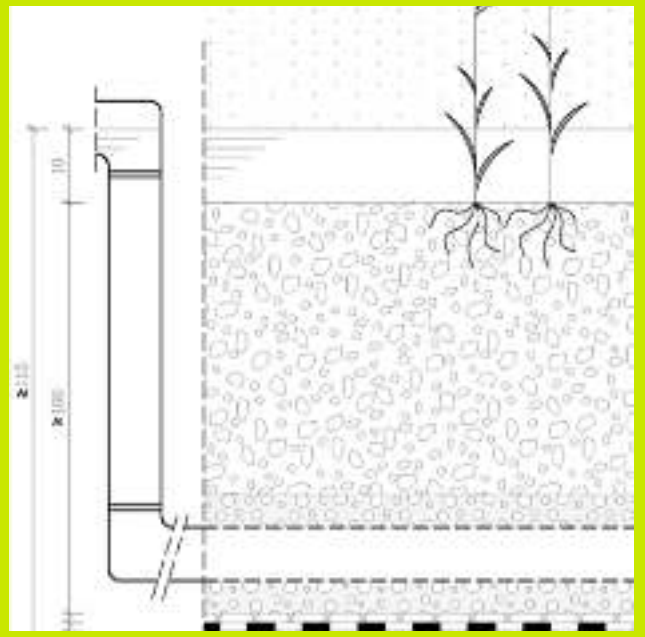
Aquatic systems



Hydrobotanic

1. PT elimination by makropyhts 30-40%
2. E. coli elimination via zooplankton filtration
3. Habitat for zooplankton

Biofilter systems



Constructed Wetlands

1. PT Elimination by biofilm 10-20%
2. E. coli Elimination 1…3 Log steps

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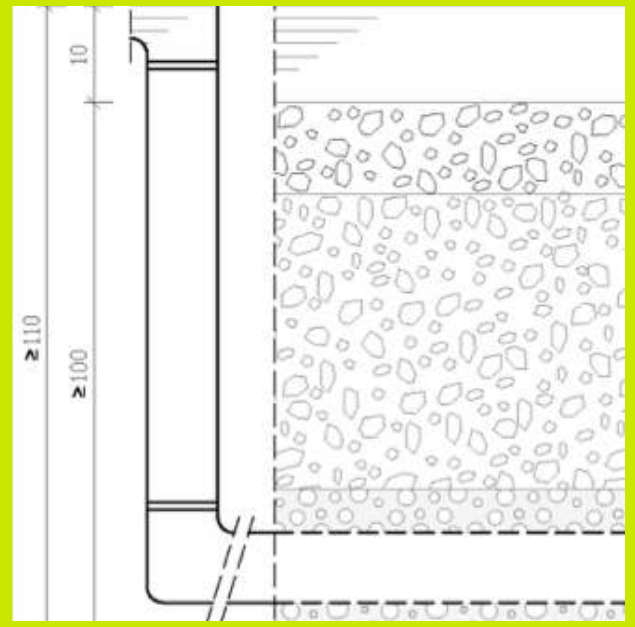


Substrate filter

1. PT Elimination by biofilm 10-20%,
2. E. coli Elimination 1...3 Log steps

Hygienic data in NSPs from 2005 to 2019.


Frihamn Gothenburg

Data base dana

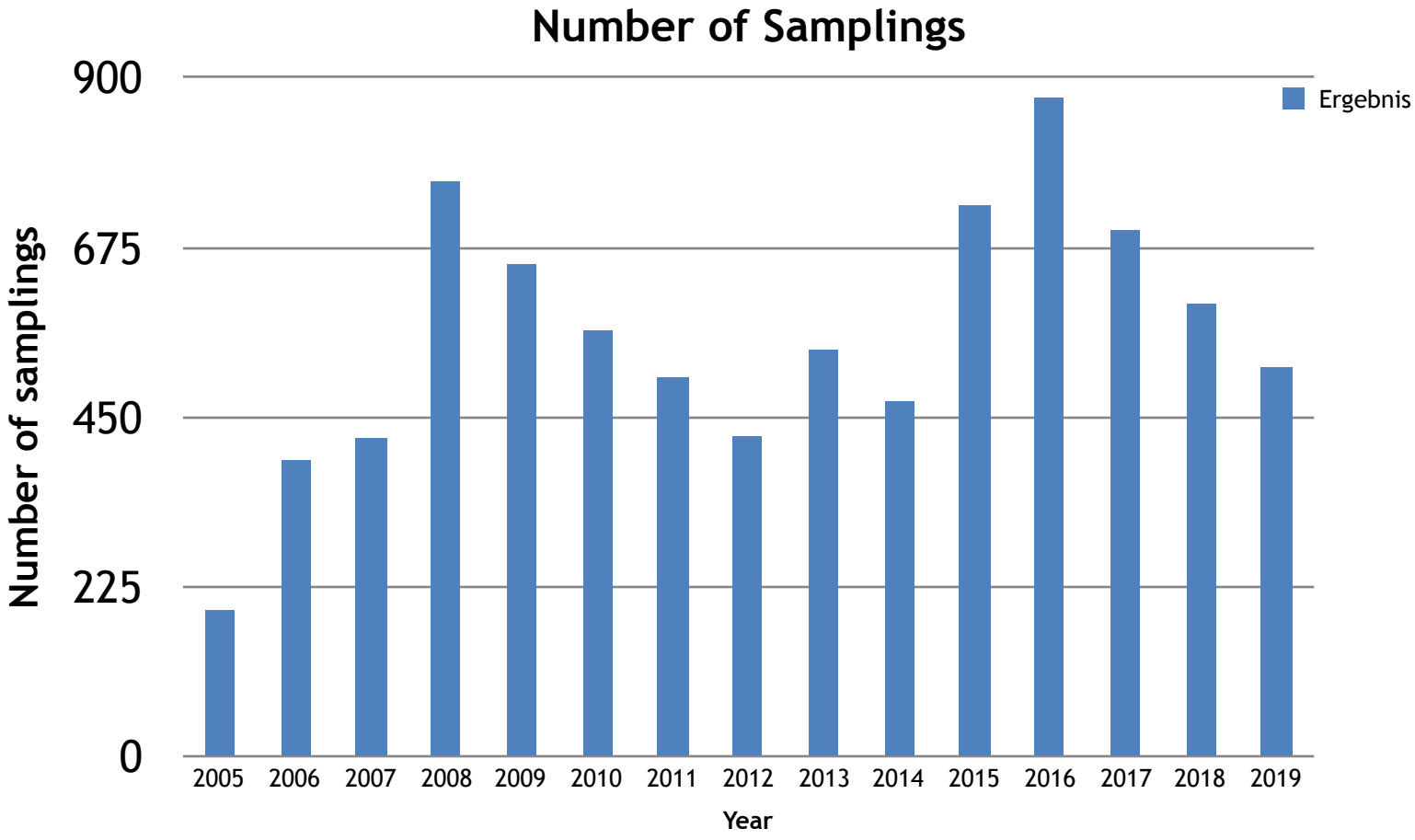
Database for approx. 80 Public NSP world wide 2005 - today

All Parameters are described with regulations like DIN, EN…

All sampling points are described in a scientific way

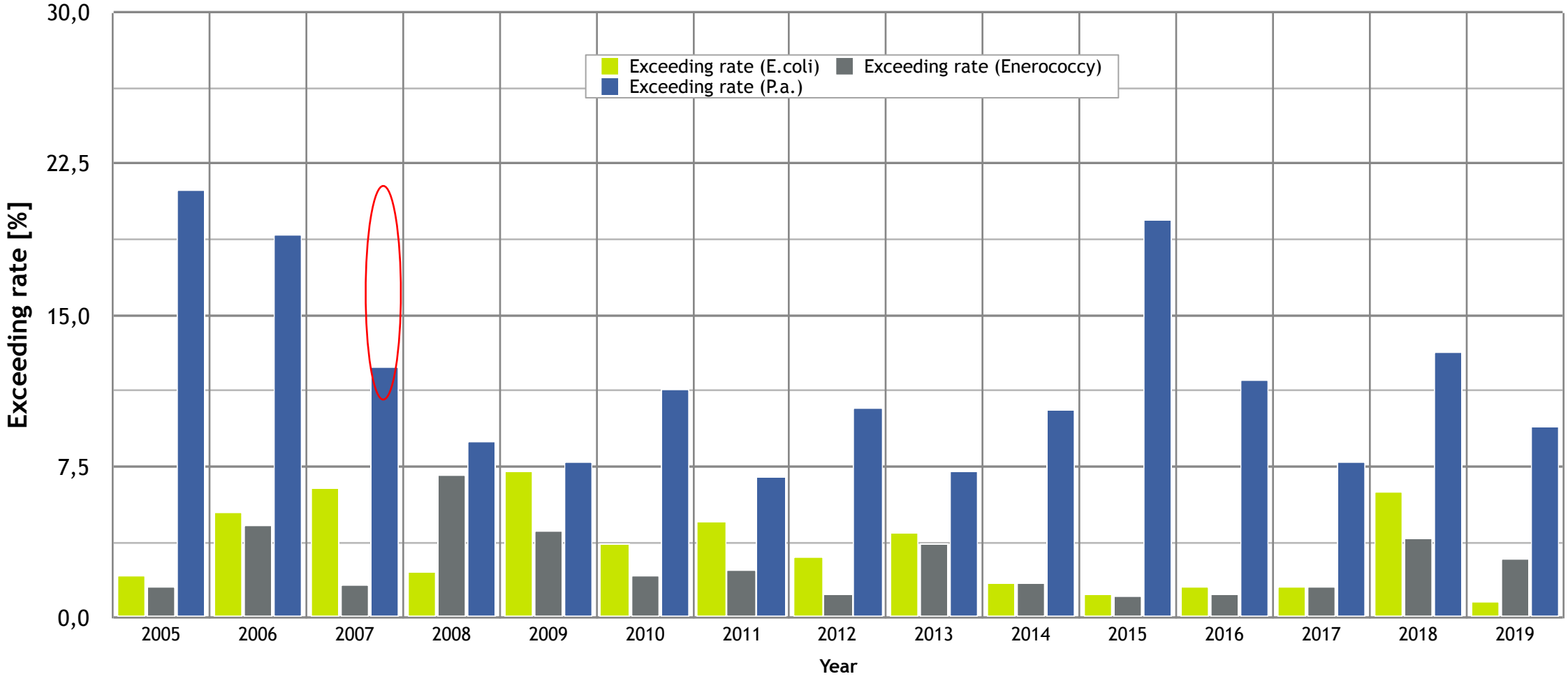
- Operation data
- Hygienic data
- Limnologic data

Evaluation of hygienic data (Quantity)

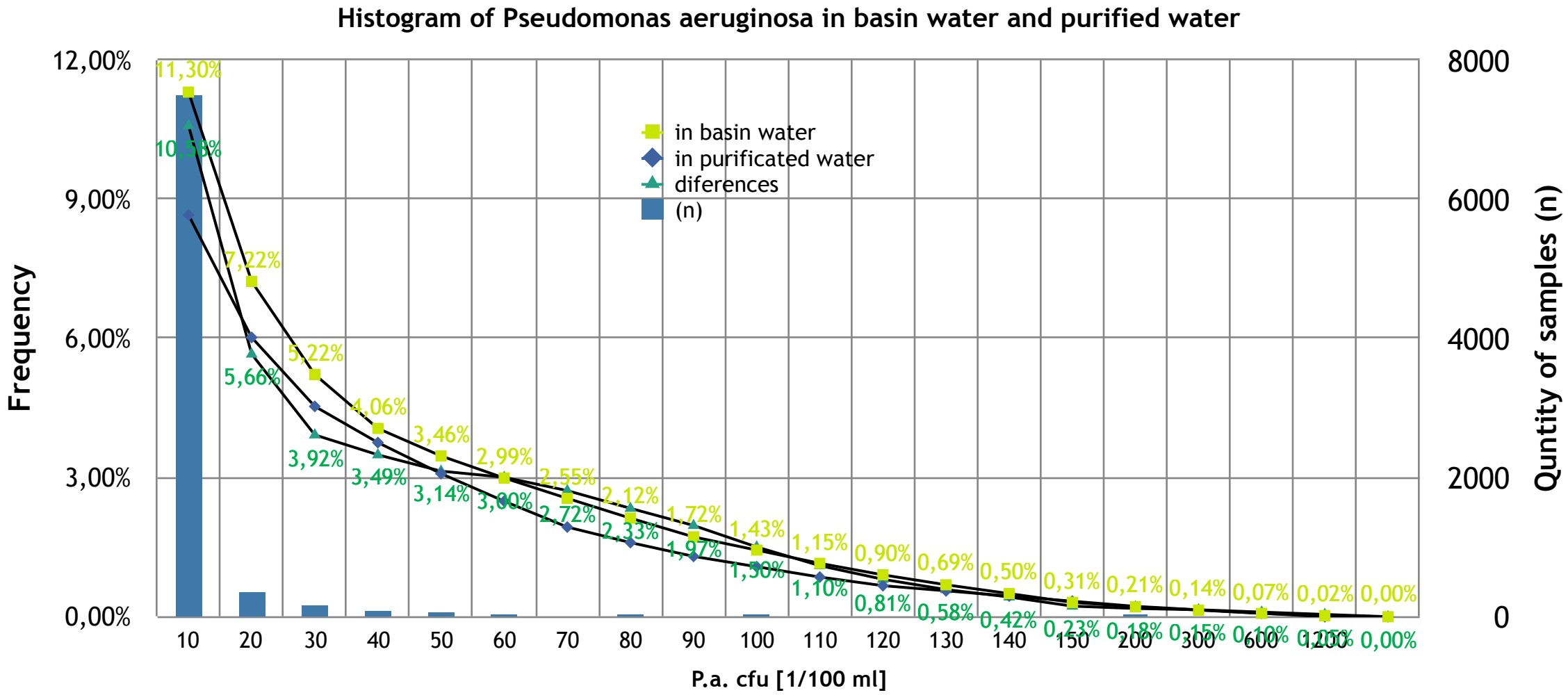


Evaluation of hygienic data (Exceeding rates of guideline parameters)

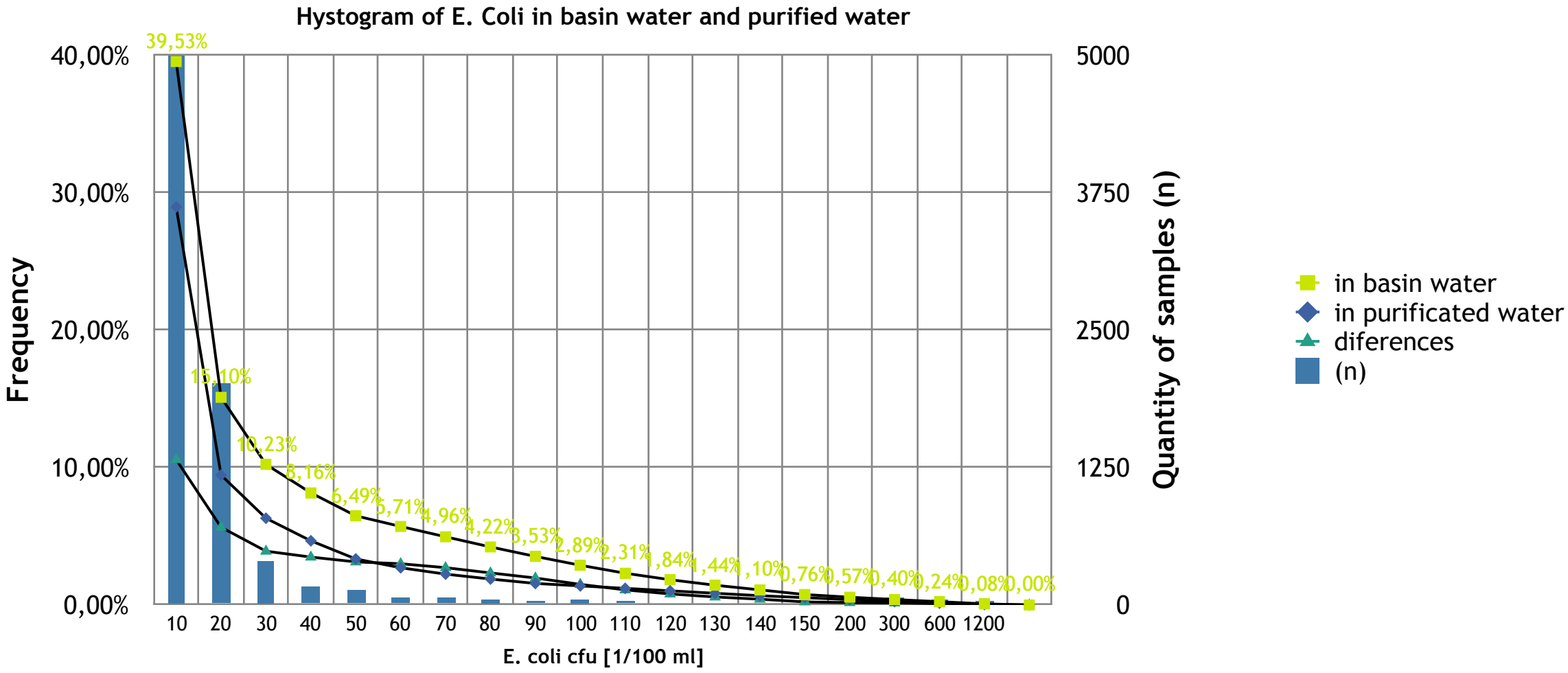
Exceeding rates
E.Coli > 100 Kbe/100 ml; Enterokokken > 50 Kbe/100 ml; Pa > 10 Kbe/100 ml



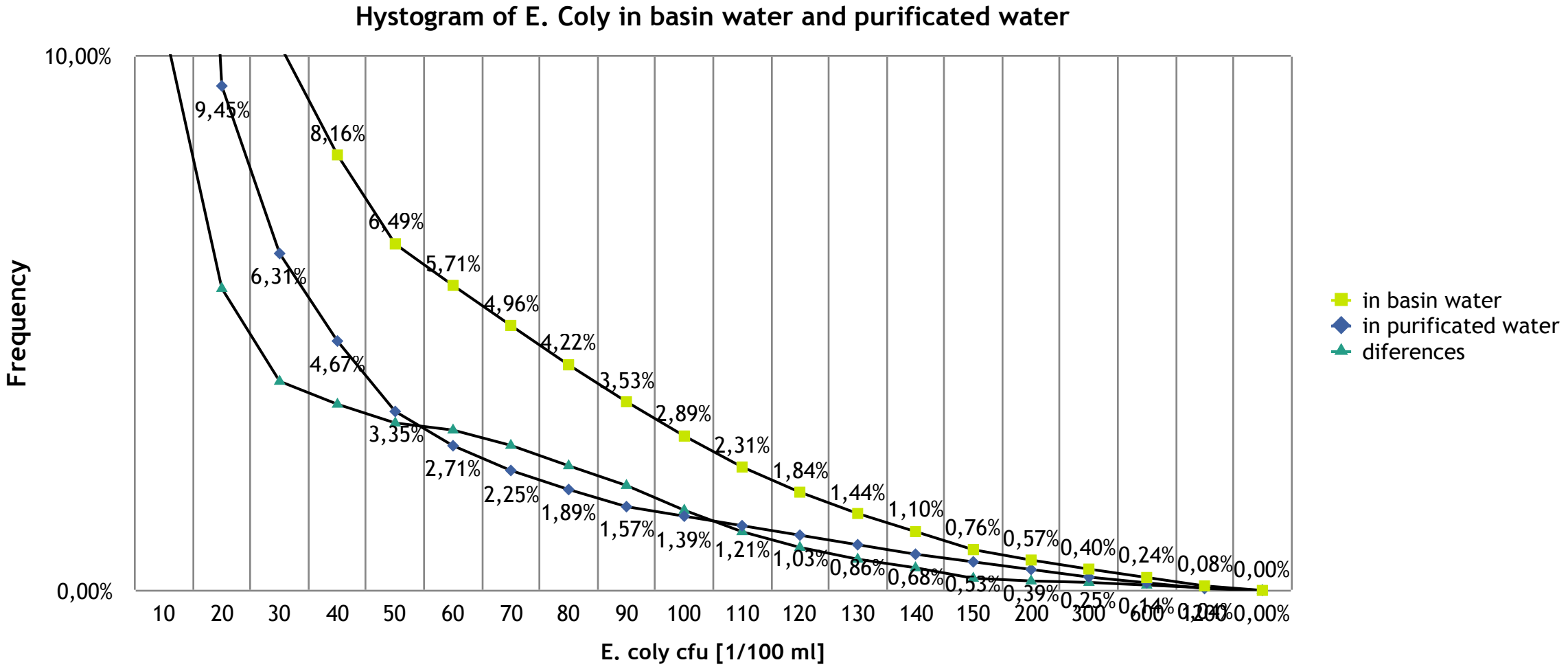
Pseudomonas aeruginosa



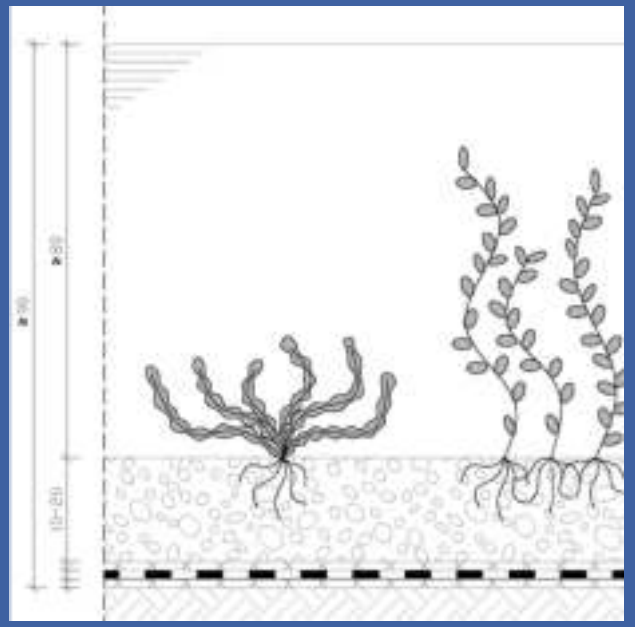
E. coli


Hystogram of E. Coli in basin water and purified water
Frequency
Quantity of samples (n)
40,00%
30,00%
20,00%
10,00%
0,00%
5000
3750
2500
1250
0
39,53%
15,10%
10,23%
8,16%
6,49%
5,71%
4,96%
4,22%
3,53%
2,89%
2,31%
1,84%
1,44%
1,10%
0,76%
0,57%
0,40%
0,24%
0,08%
0,00%
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 200 300 600 1200
E. coli cfu [1/100 ml]
in basin water
in purificated water
diferences
(n)

E.coli


Hystogram of E. Coly in basin water and purificated water
10,00%
0,00%
Frequency
9,45%
8,16%
6,49%
5,71%
6,31%
4,96%
4,22%
4,67%
3,53%
3,35%
2,89%
2,71%
2,31%
2,25%
1,84%
1,89%
1,44%
1,57%
1,10%
1,39%
0,76%
1,21%
1,03%
0,57%
0,86%
0,68%
0,40%
0,53%
0,39%
0,24%
0,25%
0,08%
0,14%
0,00%
0,04%
0,00%
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
200
300
600
1200
E. coly cfu [1/100 ml]
in basin water
in purificated water
diferences

Aquatic systems



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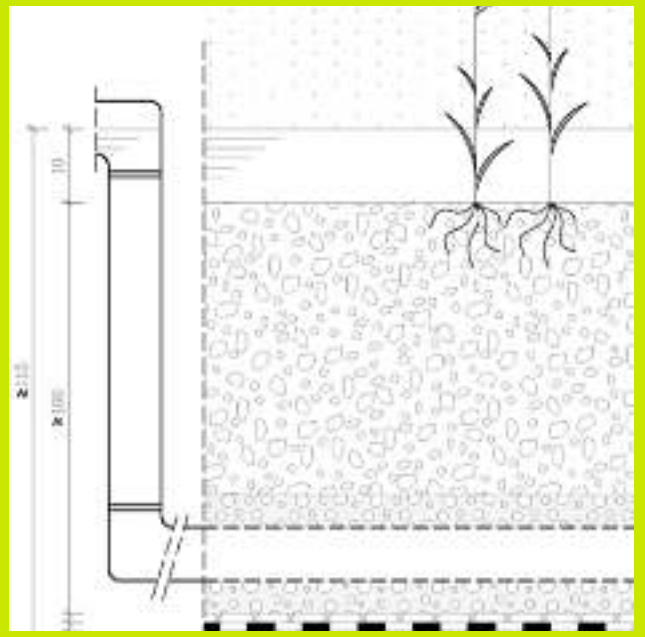

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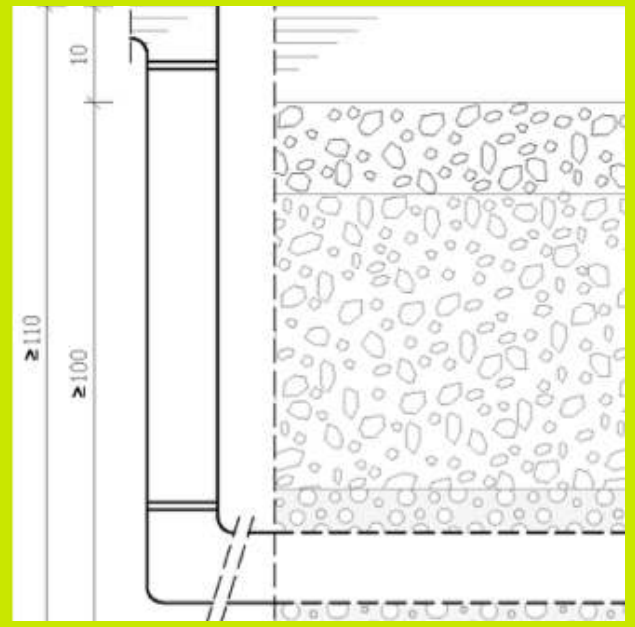

Substrate filter

1. PT Elimination by biofilm 10-20%,
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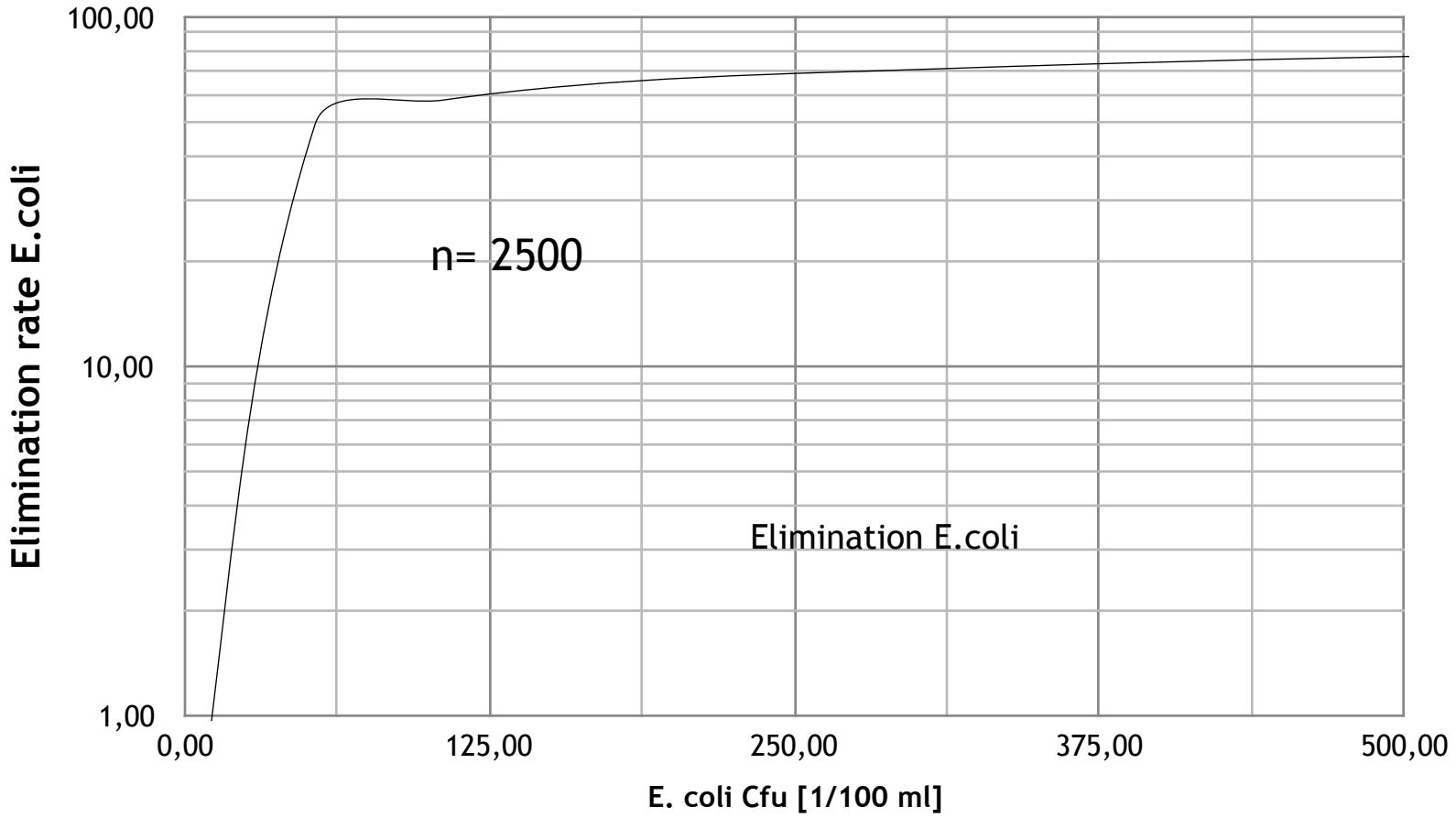
Elimination rates of E. Coli in the ex-situ water treatment plants (substrate filter and constructed wetland)



Some major findings of our new new publication

Hygienic quality of public natural swimming pools (NSP); Stefan Bruns and Christina Peppler,

IWA Publishing 2019 Water Supply | 19.2 | 2019

Major findings of in-situ and ex situ elimination rates in NSP versus Chlorinated pools

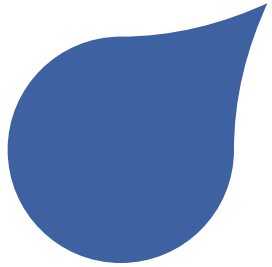
Elimination by 1 log step in the pool water	Percentile	In-situ *E.coli* [min]	In-situ Protozoans [min]	Elimination rates	Ex situ Protozoans [min]	Specific elimination rates (water treatment ex-situ)
Chlorinated pool, 0,6 mg/l, 3 Filtration rates/d		**3**	**12000**	Protozoans (200 h one Log step)	**1230**	Protozoans (1.0 Log)
NSP (group 2); 0.04 m³/m³ Zooplankton filtration, 3 filtration rates/d	10%	83800	92000	Protozoans (1 .0 Log/ zooplankton filtration)	1110	Protozoans (2 .5 Log)
NSP (group 2); 0.11 m³/m³ Zooplankton filtration, 3 Filtration rates/d	30%	30500	33500	Protozoans (1 .0 Log/ zooplankton filtration)	1110	Protozoans (2 .5 Log)
NSP (group 2); 1.066 m³/m³ Zooplankton filtration, 3 filtration rates/d	50%	3150	3450	Protozoans (1 .0 Log/ zooplankton filtration)	1110	Protozoans (2 .5 Log)

Figure 2 | Elimination time [min] required to achieve a reduction of *Giardia* and *E. coli* by 1 log step in the pool water, both for in-situ disinfection and ex-situ disinfection of a chlorinated pool compared to an NSP of group 2 (10%,30%,50%) percentile.

Can we talk about biological disinfection ?

What do we need to discover?

For the further development of NSP for the best possible hygienic and health status, these elementary questions will have to be solved in the next years or decades.



Is the elimination rate for Giardia and Cryptosporidium as determined by Connelly et al. (2007) for one species of zooplankton **(Daphnia)** applicable to all occurring zooplankton species, as required to be determined by the FLL (2011), **or are there species-specific elimination rates?**

Will zooplankton predominantly filter water in regions of higher feed density (a realistic scenario)? This fact would improve the actual, real elimination rate

What will be the best way to achieve a constantly high population of zooplankton

Is the population of the plankton distributed more or less homogeneously, so that we can assume the same feeding rate all over the water column?

Are there other aspects of the internal water treatment of NSPs which may cause pathogen reduction, besides the grazing rate via zooplankton?

Here you can get the whole publication

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DANA goes cloud

That makes things easier

Easy Installation of new pools all over the world

IOT technology makes by-directional communication easier

Floating Pool Aarhus

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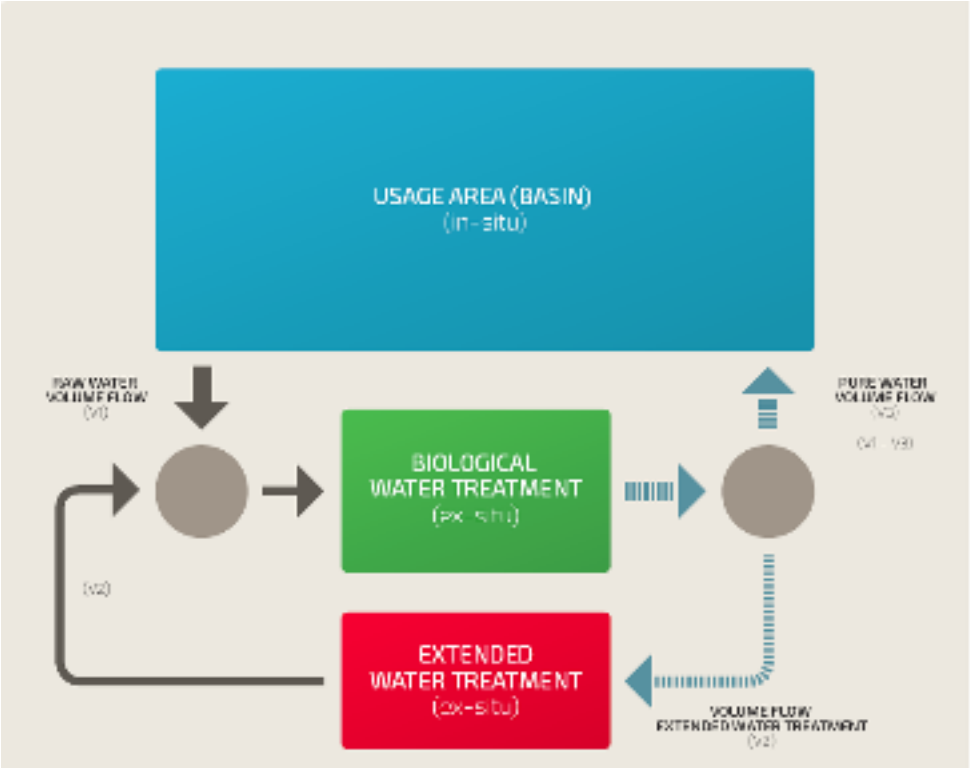
Thanks for attention

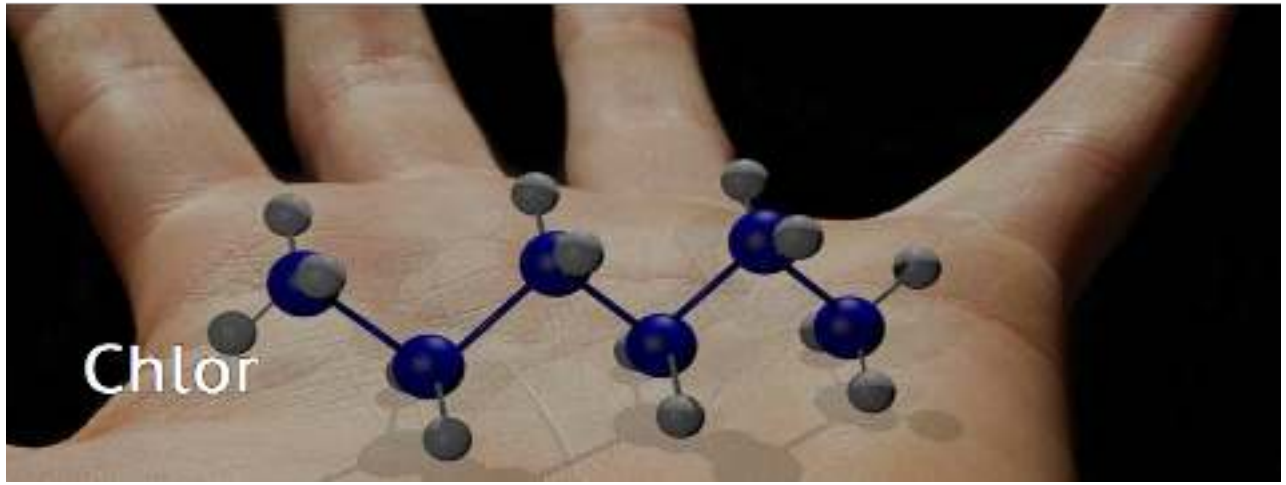
Publications about hygienic situations in NSP

What are the responsible actors for disinfection in NSP versus chlorinated pools?

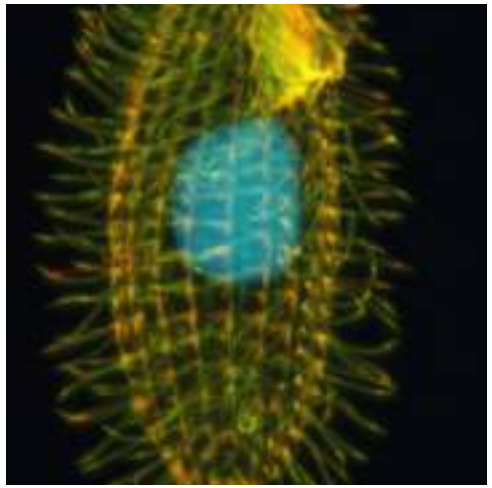
Elimination rates of water treatment plants (substrate filter and constructed wetland)



Zooplankton population is visible



Chlorine is been measured



Ciliata

Wimperntierchen, **Bakteriovore**

Size of Individium: **10-300 µm**

Eatable particle size: **0.5-3 µm**

Rotatoria

Rädertierchen, **Omnivore**

Size of Individium: **100-500 µm**

Eatable particle size: **0.5-50 µm**

Copepoda

Ruderfußkrebse, **omnivore**

Size of Individium: **100-2000 µm**

Eatable particle size: **0.5-100 µm**

Cladocera

Hüpferlinge

Size of Individium: **100-2000 µm**

Eatable particle size: **0.5-100 µm**

How is Zooplankton measured?

	Minimum	Maximum	Average
	Fmin	Fmax	Fav
	ml/Ind./d	ml/Ind./d	ml/Ind./d
Ciliata	0.012	0.163	0.0875
Rotatoria	0.007	16.992	8.5
Copepoda	0.048	129.6	64.824
Cladocera	0.096	66.48	33.288

Method of the FFL

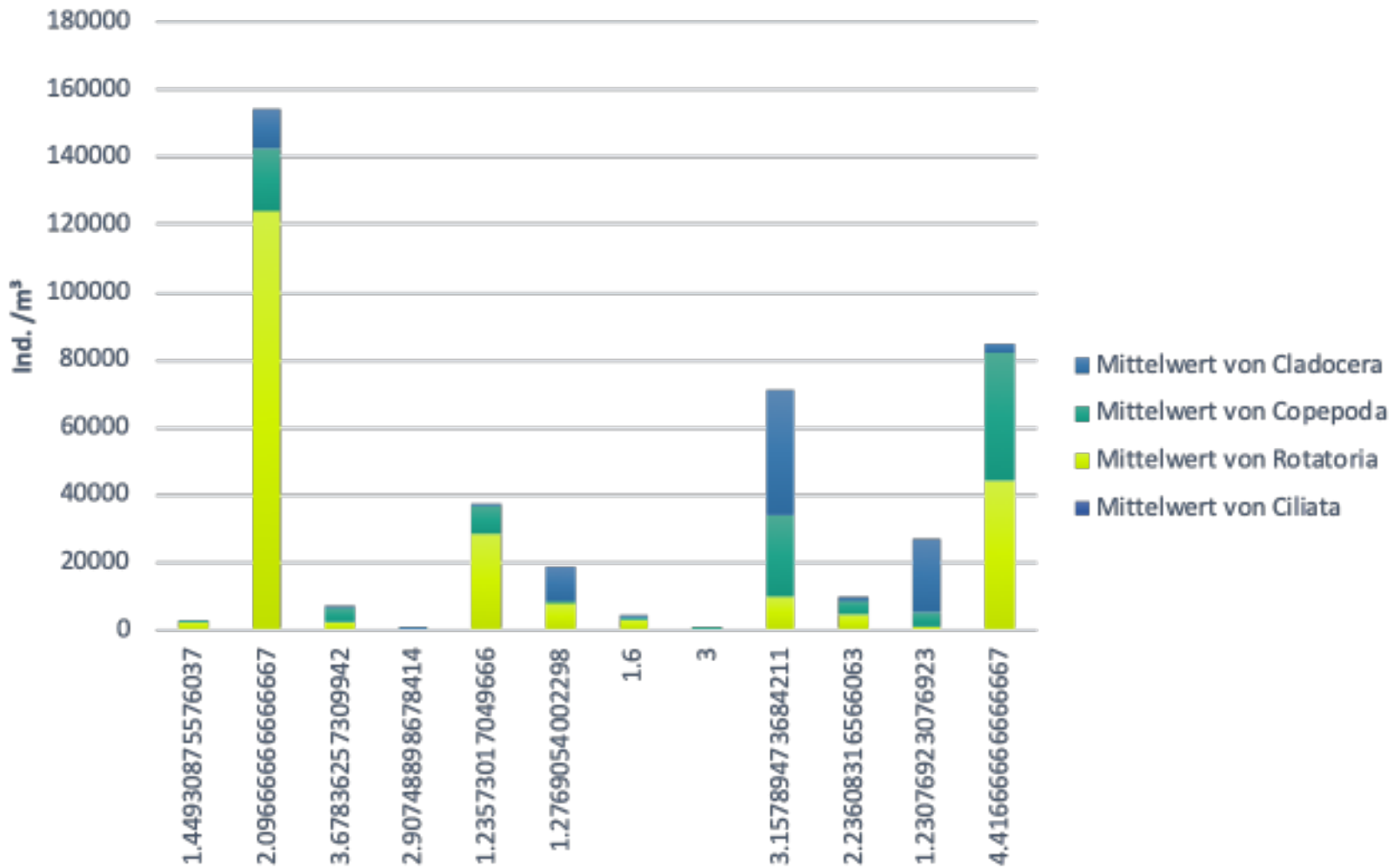
1. Determination of the population of zooplankton, selected to following groups: Ciliata, Rotatoria, Copepoda, Cladocera
2. Multiply the population in number/m^3 with the specific mean filtration rate / Ind. / day species wise.
3. Add the 3 different species selected filtration rates to achieve the total filtration rate via zooplankton

What are the populations of the different species for different Pools ?

Group 1	Rotatoria Ind/m³	Copepoda Ind/m³	Cladocera Ind/m³	Filtration m³/m³/d	Umwälzrate 1/d
n	n	n			1.1925
5%Quantil	21.0000	164.5000	0.0000	0.0321	
10%Quantil	85.0000	212.0000	0.0000	0.0416	
20%Quantil	149.0000	340.0000	0.0000	0.0647	
30%Quantil	223.0000	488.0000	57.0000	0.0947	
Median	1203.0000	1635.0000	5308.0000	1.0666	
Mittelwert	27165.0196	9273.4902	13618.8235	2.5688	

Group 2	Rotatoria Ind/m³	Copepoda Ind/m³	Cladocera Ind/m³	Filtration m³/m³/d	Umwälzrate 1/d
n	n	n			4.7855
5%Quantil	64.0000	76.4000	0.0000	0.0183	
10%Quantil	83.4000	105.2000	43.2000	0.0497	
20%Quantil	127.8000	189.6000	85.0000	0.0626	
30%Quantil	311.8000	358.8000	122.8000	0.1183	
Median	1868.0000	637.0000	510.0000	0.3347	
Average	14099.8919	7198.7838	3442.6757	1.4014	

Zooplanktondichten in Abhängigkeit der Umwälzrate (Nennwert)



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What are the filtration rates according to the found numbers

The NSPs were assigned to two different groups

Group 1: a low filtration rate was identified if turnover values were between 0 and 2.5 times per day.

Group 2: a high filtration rate was defined for turnover values between 2.6 and 10 times per day

The ex-situ elimination of Cryptosporidium in the NSP is approximately 10% faster than in the chlorinated pool

The in-situ elimination of Cryptosporidium is dependent on the population of zooplankton. In the 50% percentile (Median) the elimination rate is four times quicker than in the chlorinated pool.

The results show that it will take approximately 2.3 water exchanges in a NSP and 2.55 water exchanges in a chlorinated pool to reduce the internal concentration of Giardia or Cryptosporidium to 10% by external water treatment

In ex-situ treatment of NSP the elimination rate reached 2 log-steps versus 1 log-step in chlorinated pools.

In this case the necessary water exchanges by water treatment will be reduced to 1.3 in the NSP in comparison to approximately 2.4 in the chlorinated pool.

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For the further development of NSP for the best possible hygienic and health status, these elementary questions will have to be solved in the next years or decades.

Is the elimination rate for Giardia and Cryptosporidium as determined by Connelly et al. (2007) for one species of zooplankton **(Daphnia)** applicable to all occurring zooplankton species, as required to be determined by the FLL (2011), **or are there species-specific elimination rates?**

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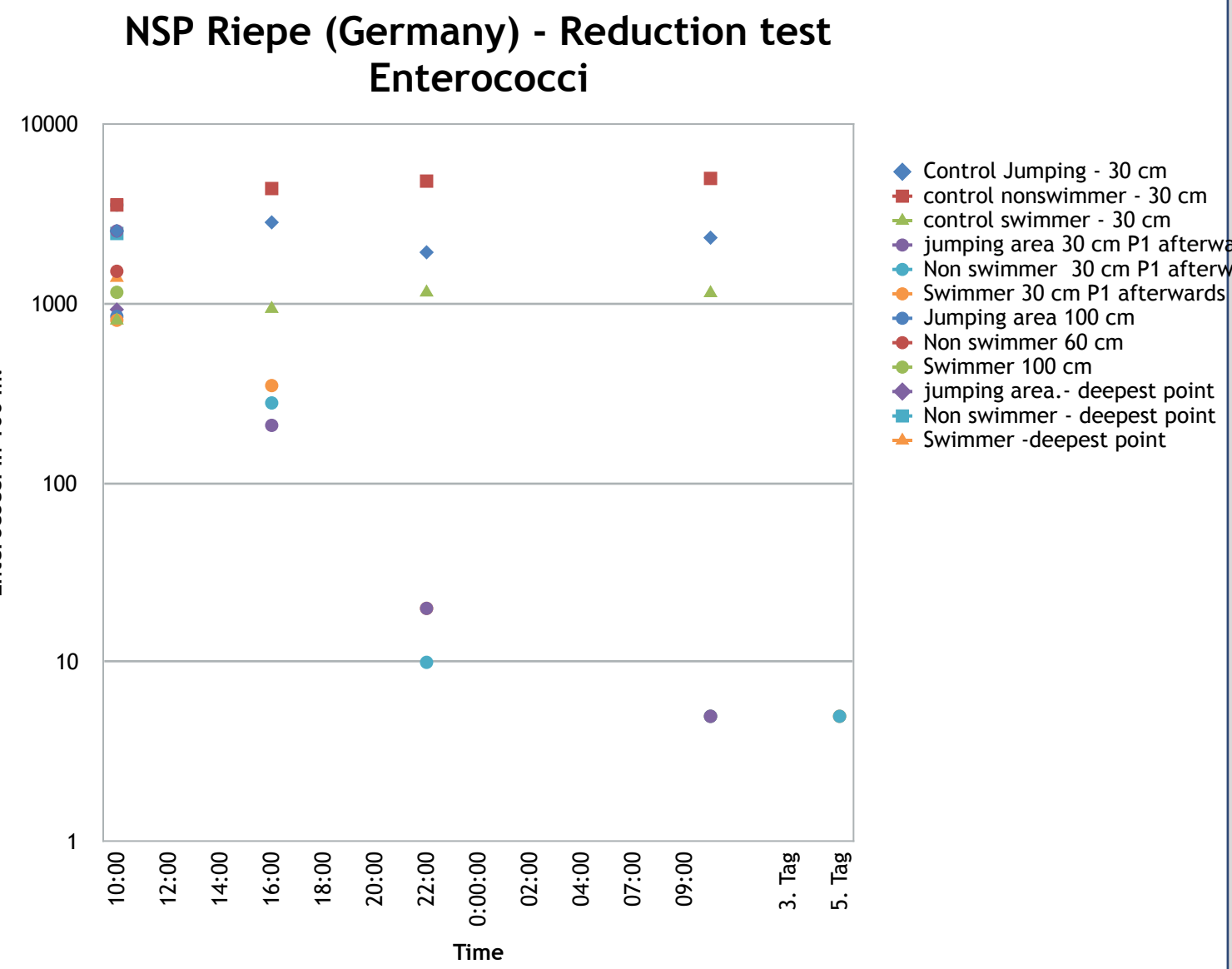
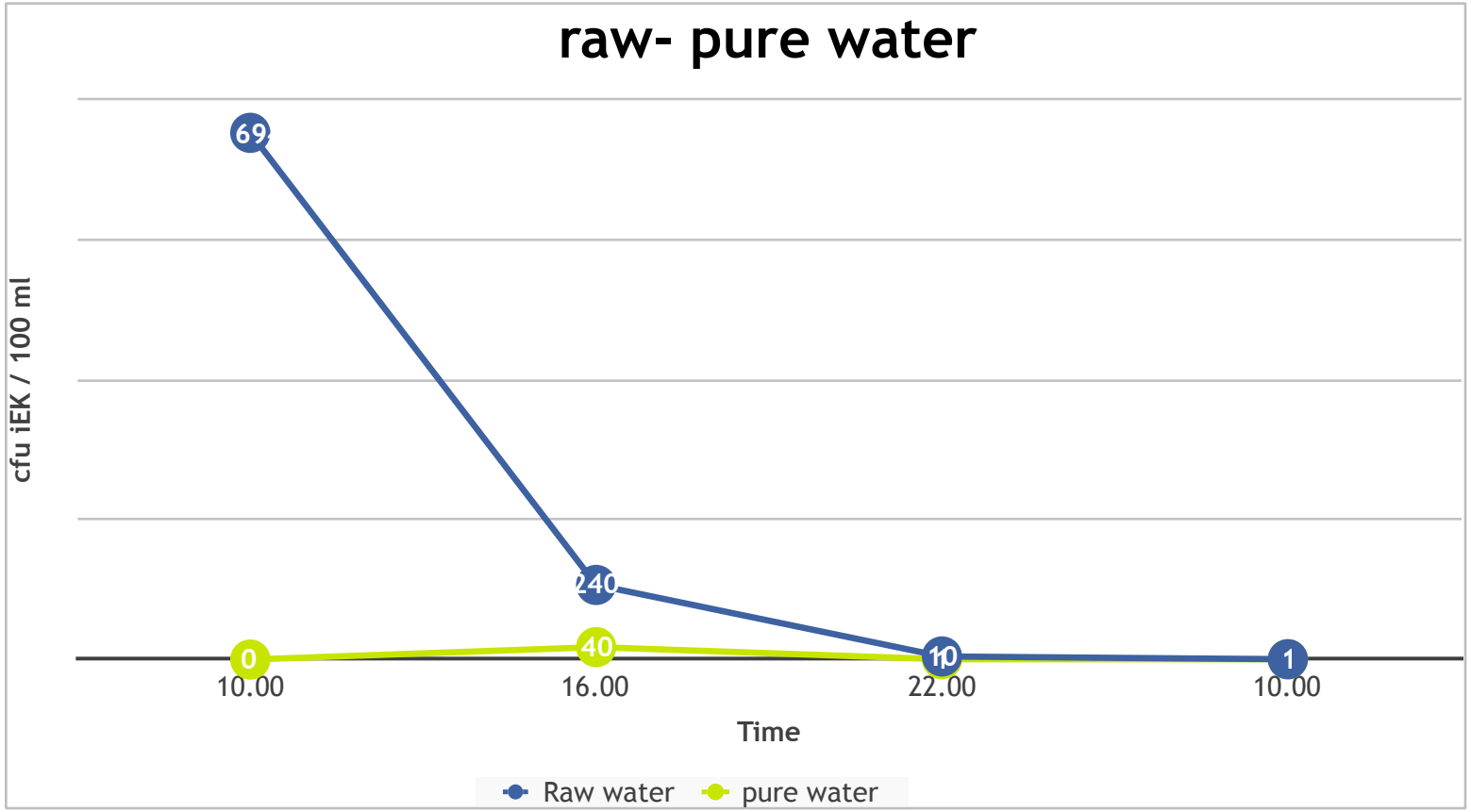
In-situ study about Enterococci elimination rates, Germany, Riepe



In-situ test in order to discover the elimination of Enterococci (Germany)

This test has been done with Dr. Heinemeyer, (health department of Lower Saxony Germany). The results have been published in „Performance of Public Swimming Ponds"; an Overview of the hygienic situation in Pools with biological water purification". The brochure can be ordered at http://www.iob-ev.eu

In-situ test in order to discover the elimination of Enterococci (Germany)



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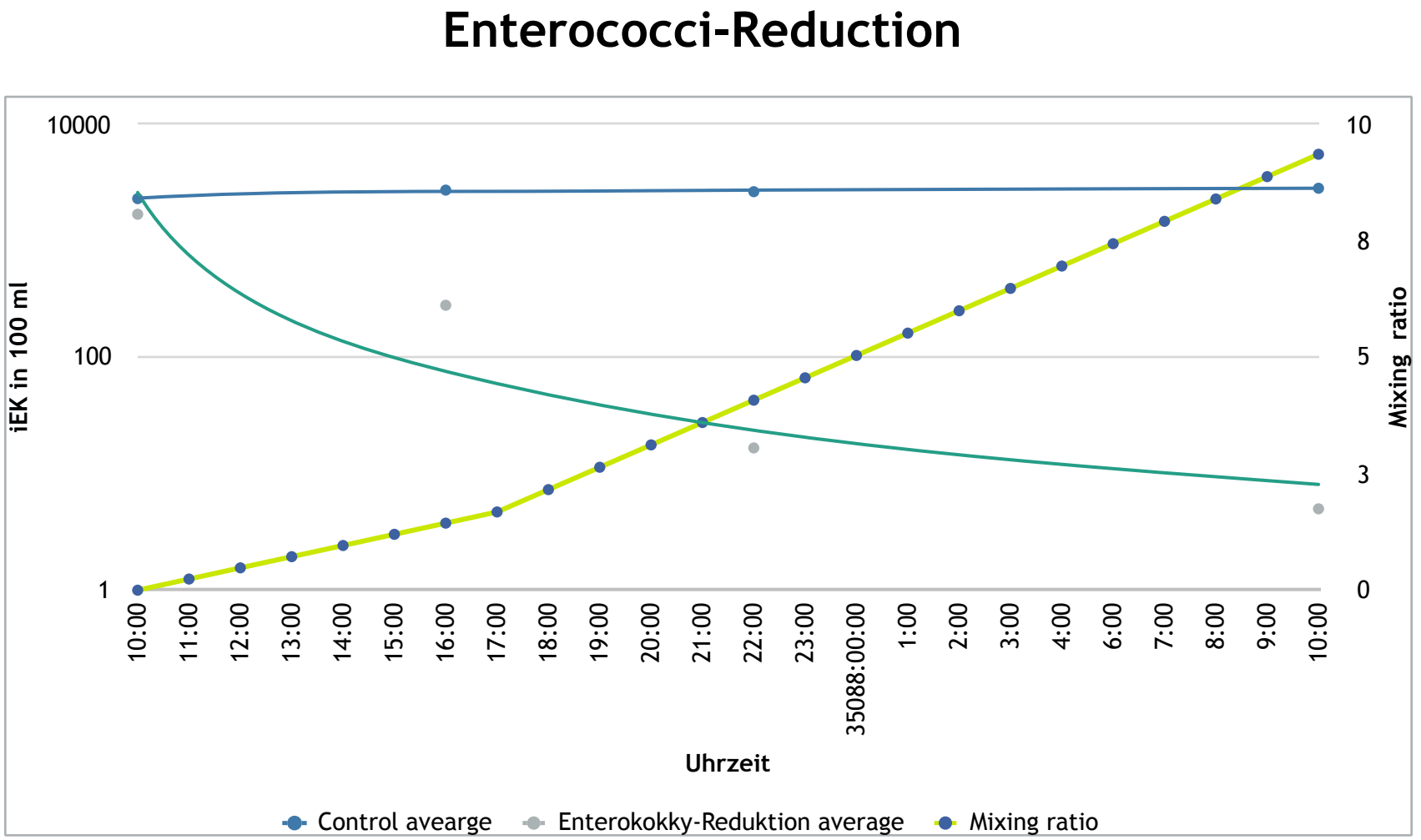

Research of other hygienic aspects in NSPs
Denmark Ruds vedby

2015

Parametre	25 m bassin	Børne bassin	Aquakultur	Neptunfilter	Samlet
Iltmætning	11	13	3	4	31
Fosfor	15	17	7	8	47
Enterokokker	15	17	7	8	47
E. Coli	15	17	7	8	47
Pseudomonas aeringiosa	15	17	7	8	47
Salmonella	0	0	0	0	0
Vira	19	21	4	4	48
Sapovirus	0	4	0	0	4
Protozoer	19	20	4	4	47

2016

Fosfor	21	24	22	23	90
Enterokokker	21	24	22	23	90
E. Coli	21	24	22	23	90
Pseudomonas aeringiosa	21	24	22	23	90
Salmonella	0	0	0	0	0
Vira	13	17	0	0	30
Sapovirus	0	1	0	0	1
Protozoer	13	17	0	0	30

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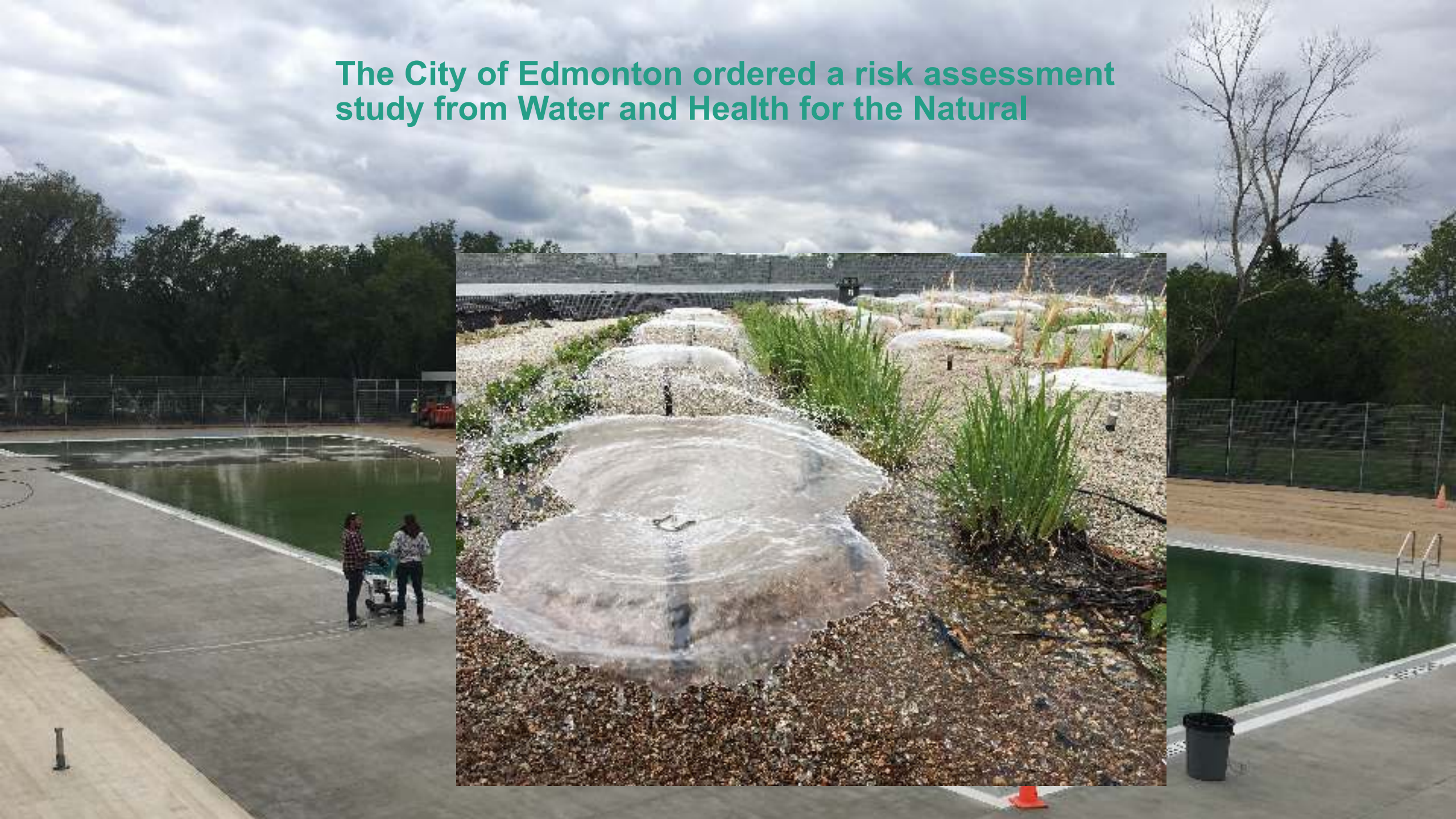
Resultat

The analyzes have been done during the seasons 2015 and 2016 in different times of the day. In no cases viruses and protozoa have been detected.

That results corresponds to a research program of 2005 from the University of Bremerhaven TTZ in behalf of Polyplan. In 52 samples of different NSP just two small signals of Noro viruses appeared.

The City of Edmonton ordered a risk assessment study from Water and Health for the Natural



What are the NSP pathogen risks?

- Regulation for recreational water quality
- What is the benchmark?
  - *35 illnesses per 1000 swimming episodes* (U.S. EPA 2012)
- What about NSPs?
  - More akin to a somewhat higher risk scenario?

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