Patrick Smeets, 1 Oktober 2007

kiwa
Partner for progress

Microbiologische risico's van drinkwater

TU Delft

Drinkwater is toch veilig?

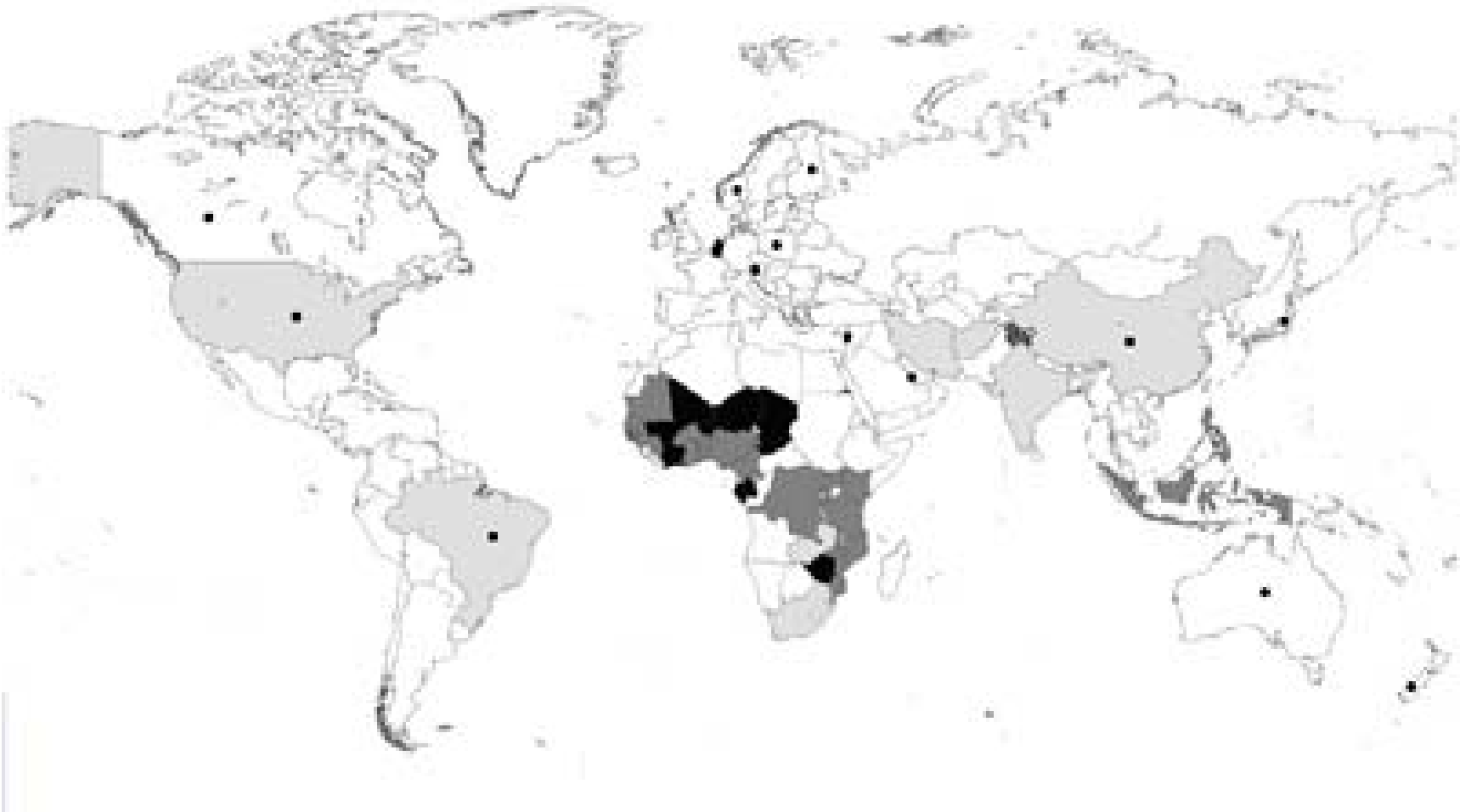
Microbiologische risico's in ontwikkelde landen door 'Ongelukken'

1993	Milwaukee, USA	Change in treatment plant operation resulted in Cryptosporidium in water	**403,000** people ill **4,400** hospitalised **100** people died
2000	Walkerton, Canada	*E.coli 0157H7* and *Campylobacter* in water due to operational errors	**2,300** people ill **65** hospitalised **7** people died
2001	Belfast, Northern Ireland	9 potential sources of contamination comprised the supply; sewage backflow was considered the main cause.	**191** cases of cryptosporidiosis, **41** hospitalisations.
2002	Northeast Italy	Broken sewer pipe in football field irrigation system allowed water from Bacchiglione River to enter city aqueduct.	**670** reported gastrointestinal illness (GI). **32** cases were referred to hospital, **6**/32 were admitted.
2002	Ski resort, Sweden	Unchlorinated groundwater (GW) source. Crack in sewage pipe located 10m from a well supplying system.	9/12 stool samples positive for NLV. Estimated **500** cases in the population.
2003	Divonne-les-Bains, Ain district, France	Cross-connection between STP effluent network and distribution system; chronic contamination of water source and inadequate treatment	**786** suffered GI. Multiple enteropathogens identified, **2** people were hospitalised,
2007	Galway, Ireland	Contamination with cryptosporidium	**60** people hospitalised
2007	Spencer, USA	Human error put lye in water	**100** people medical attention at least **1** hospitalised

Microbiologische risico's in ontwikkelde landen
'Terrorisme' (nog niet microbiologisch)

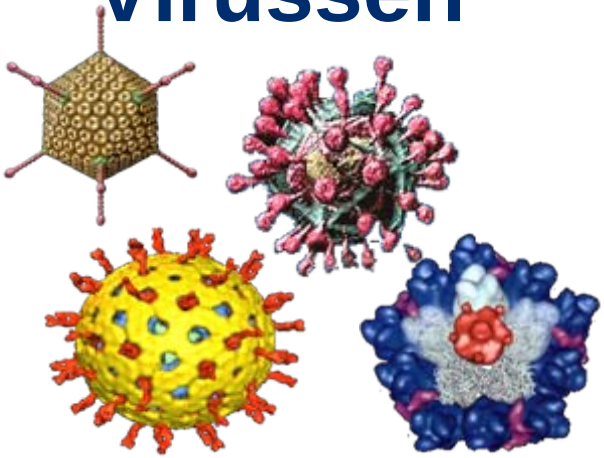
year	location	Incident	public health effect
		Intentional threats and contamination incidents	
2002	Rome, Italy	Plot to break in through water pipes into American Embassy	no, offenders arrested
2003	China	Poisoning of water reservoir with pesticides	42 people hospitalised
2003	Prague, Czech Republic	Threat of poisoning with mercury and cyanide	no, blackmailer arrested
2004	Carpentersville, USA	Vandals spray fire extinguishers in filtration unit	no, filtration unit was not in use
2005	Lake Constance, Germany	10 litres of atrazin dropped near water intake	no, because of low solubility and low toxicity of atrazin
2006	Blackstone, USA	Vandals break into a water storage tank	no, drinking water ban proclaimed

Cholera in ontwikkelingslanden neemt weer toe!



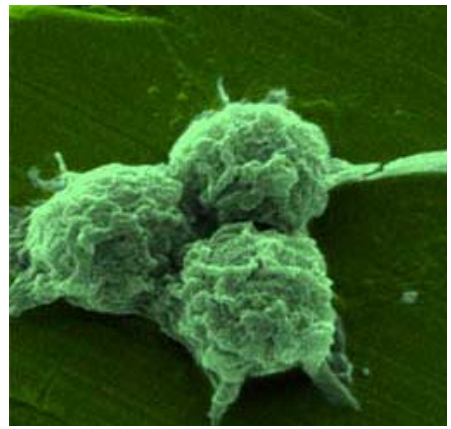
Wat zijn de risico's en waar komen ze vandaan

Virussen



Bacteriën

Protozoa



Overige microbiologische risico's: prionen, wormen, toxines …

Oorsprong:

- **Uit fecaliën van mens en dier (E. coli O157, norovirus, Cryptosporidium ….)**
- **Groeien in het milieu of in drinkwater (legionella)**

Verontreinigingsbronnen oppervlaktewater

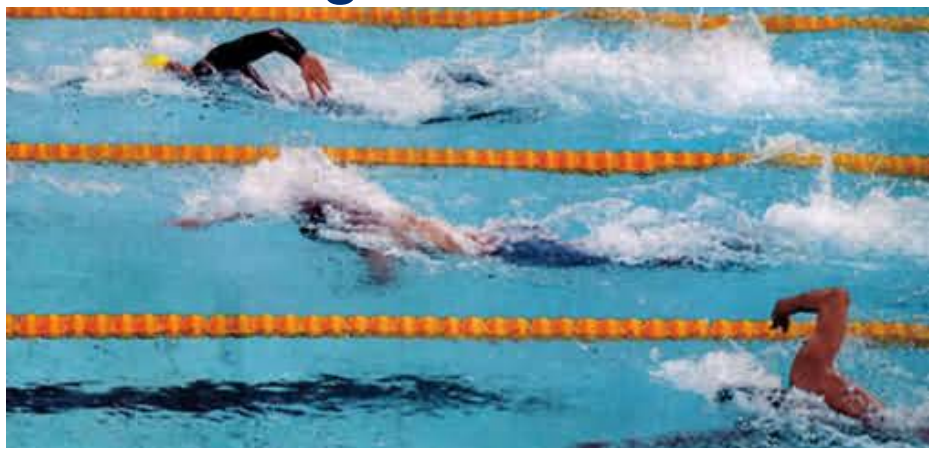
Wastewater **Recreation** **Wildlife**

Wat zijn de gevolgen

- Darmklachten, diaree, overgeven, misselijk…
- Ernstig bij gevoelige groepen (onderdrukt imuumsysteem)
- Soms ook ernstige effecten, bijvoorbeeld Guillain-Barré syndrome (verlamming door Campylobacter)
- Dood

Hoe veilig moet drinkwater zijn?

- Géén indicatorbacteriën (E. coli) in 100 ml monster
- Kans op infectie <1/10.000 per jaar
- Hoe toon je aan dat het water veilig is?
- Analyse onmogelijk



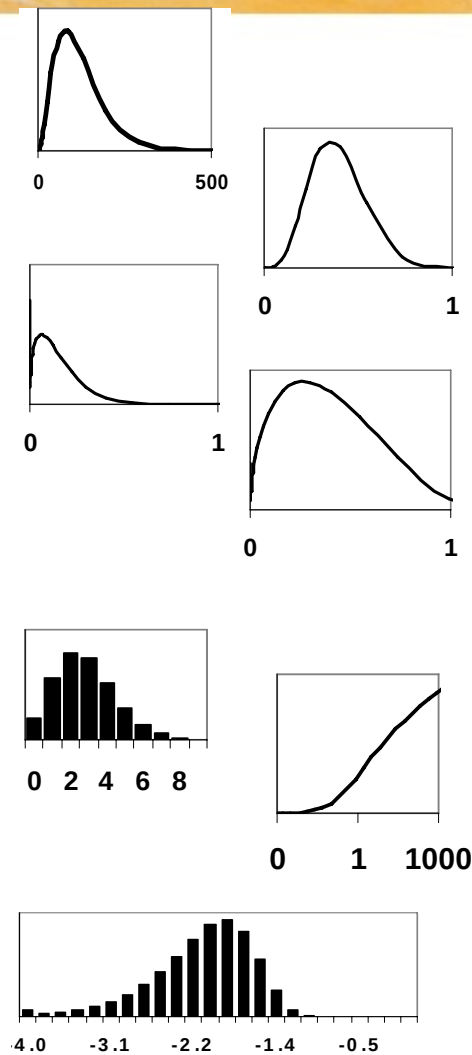
Pathogens in source → Removal by treatment → Pathogens in drinking water → Risk of infection

Internationaal project over risico-analyse MicroRisk

2002-2006
11 Partijen
7 landen

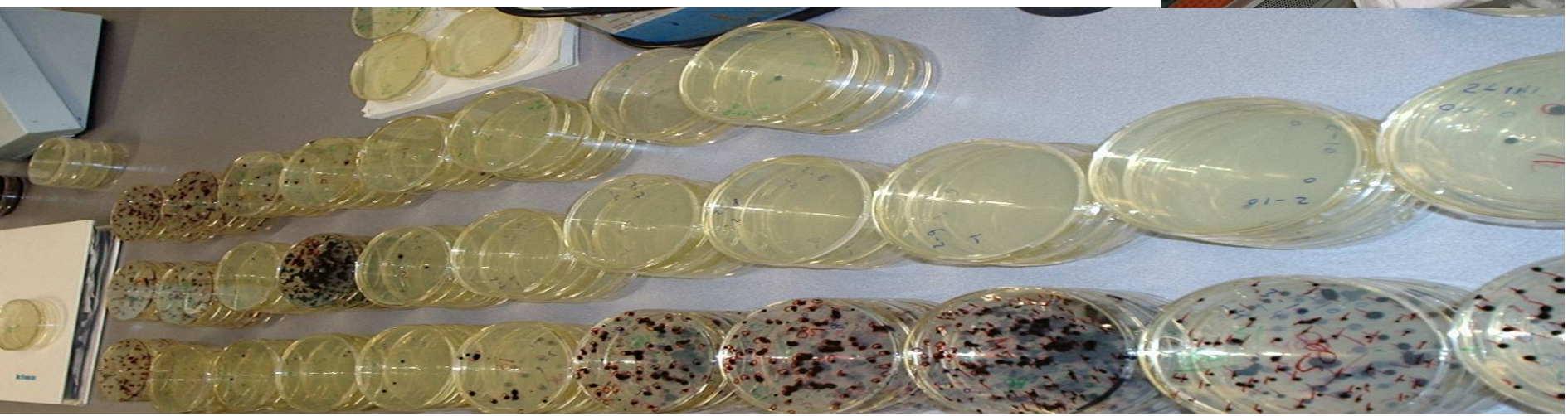
QMRA for drinking water
Quantitative Microbiological Risk Assessment

Source	Monitor	100 /L
Sedimentation	1 log	10 /L
Filtration	2 log	0.1 /L
Disinfection	2 log	0.001 /L
Distribution	No cont.	0.001 /L
Consumption	1 L	0.001 /d
Dose-Response	10%	*0.1
Risk of infection		0.0001 inf/d

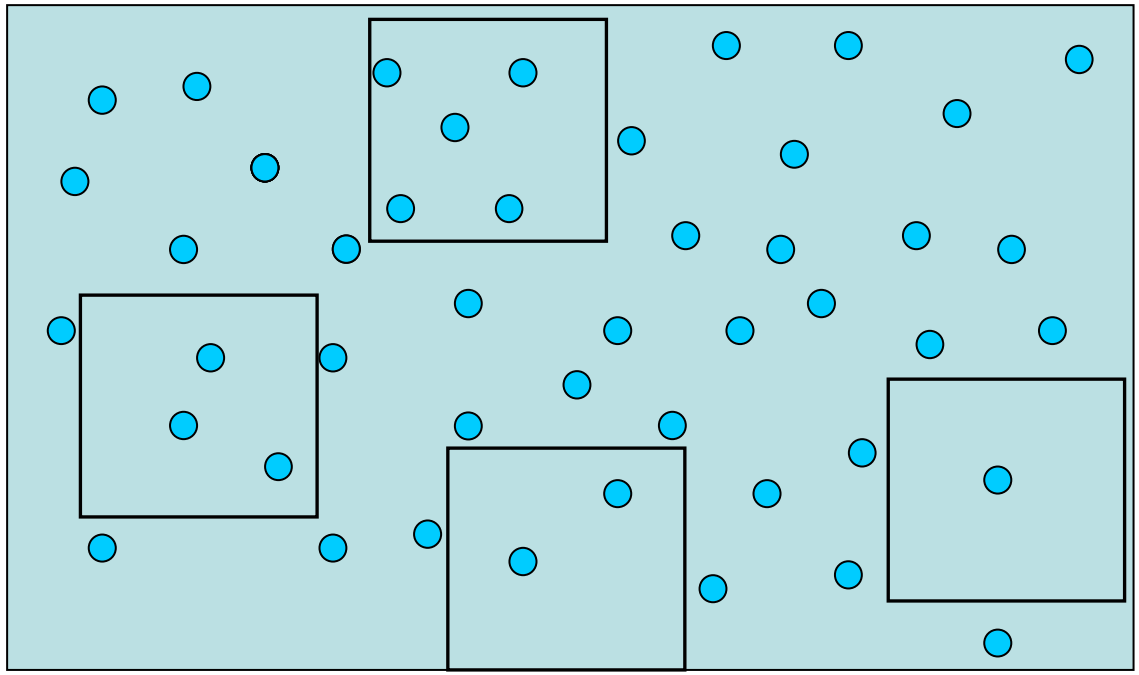


Meten in de bron

- Véél verschillende pathogene micro-organismen
- Analysemethoden moeilijk en duur
- Onzekerheden:
  - Variatie: hoe hoog zijn piek concentraties?
  - Recovery: welk percentage toon je aan?
  - Type: is deze variant gevaarlijk voor de mens?

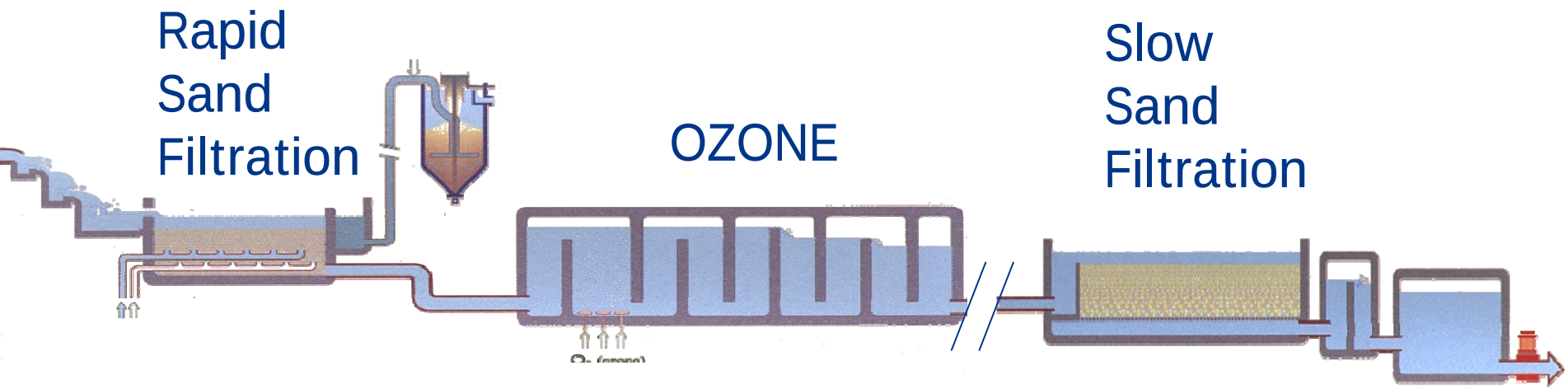


Hoeveel micro-organismen zitten in het monster?



Gemiddeld 3 organismen in een monstervolume
Waarneming varieert echter van 0 tot 7

Drinkwaterzuivering

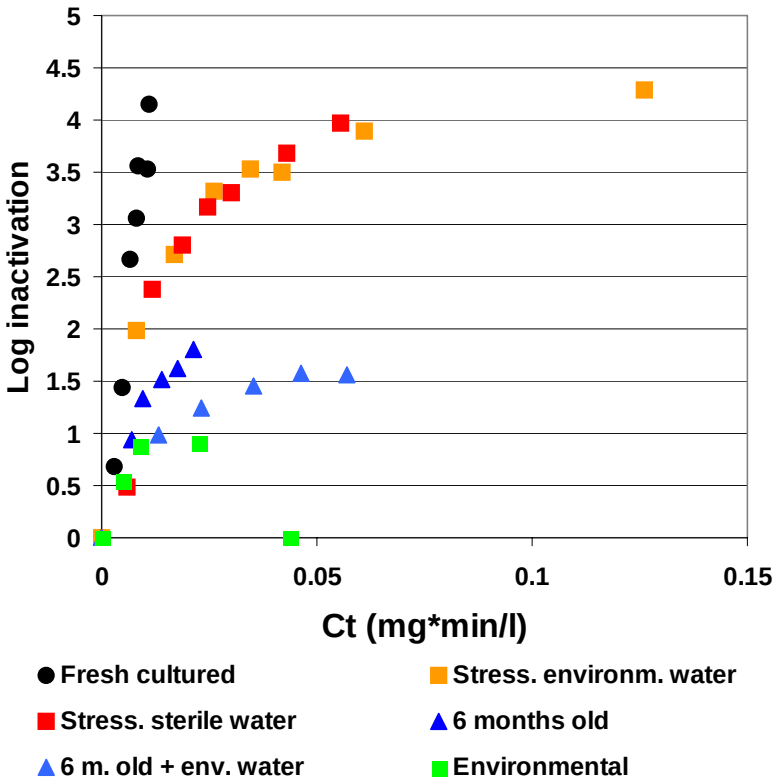


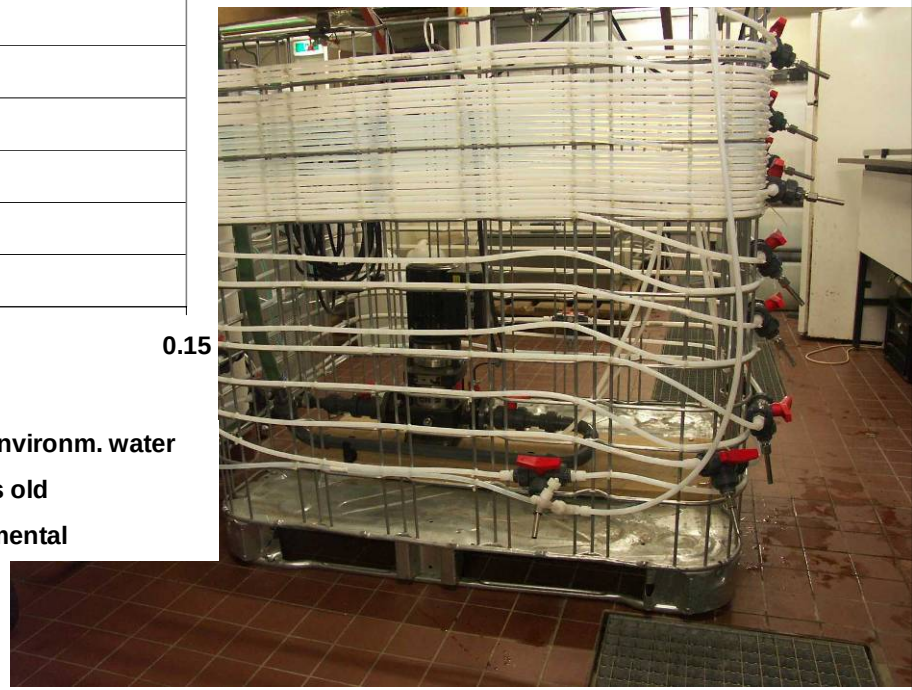
Meervoudige barrières tegen micro-organismen

Verwijdering door de zuivering
Hoe kwantificeer je dat?

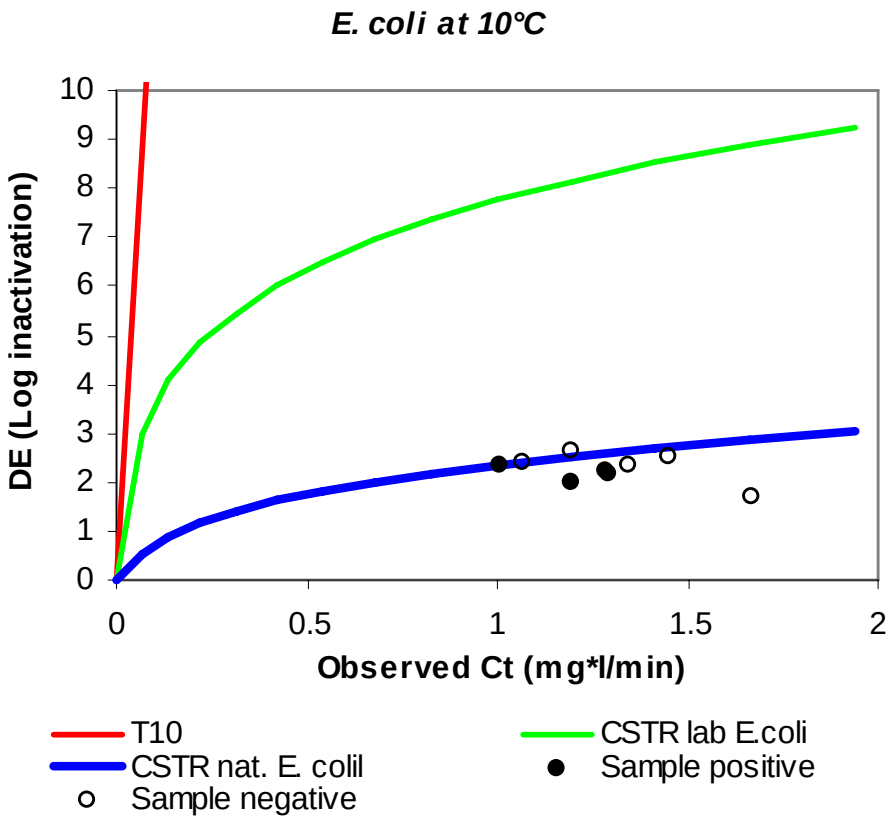
- Literatuuronderzoek
- Processen experimenteren
- Processen modelleren
- Metingen in de praktijk

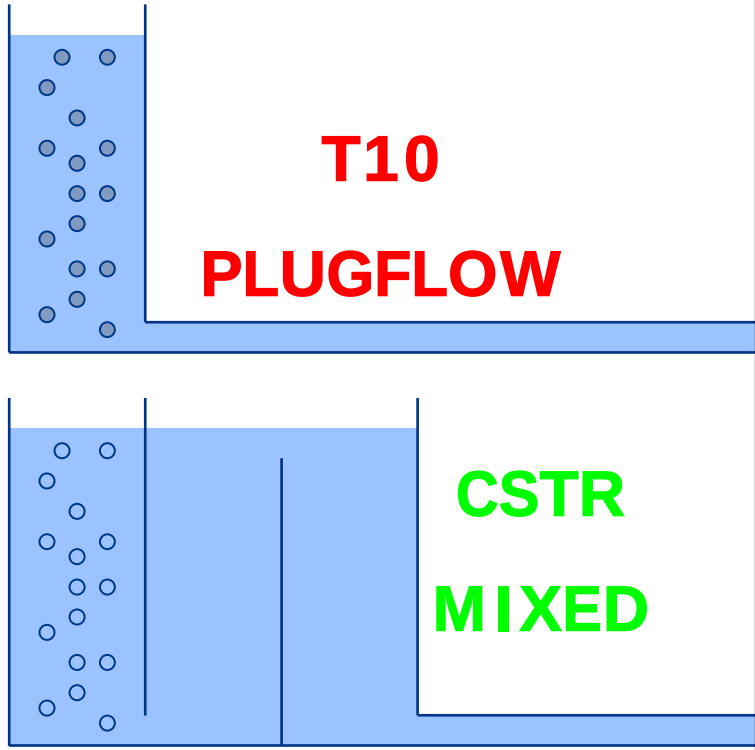
Experimenteren
Inactivatie door ozonisatie





Modelleren
Model wel verifiëren met de werkelijkheid!

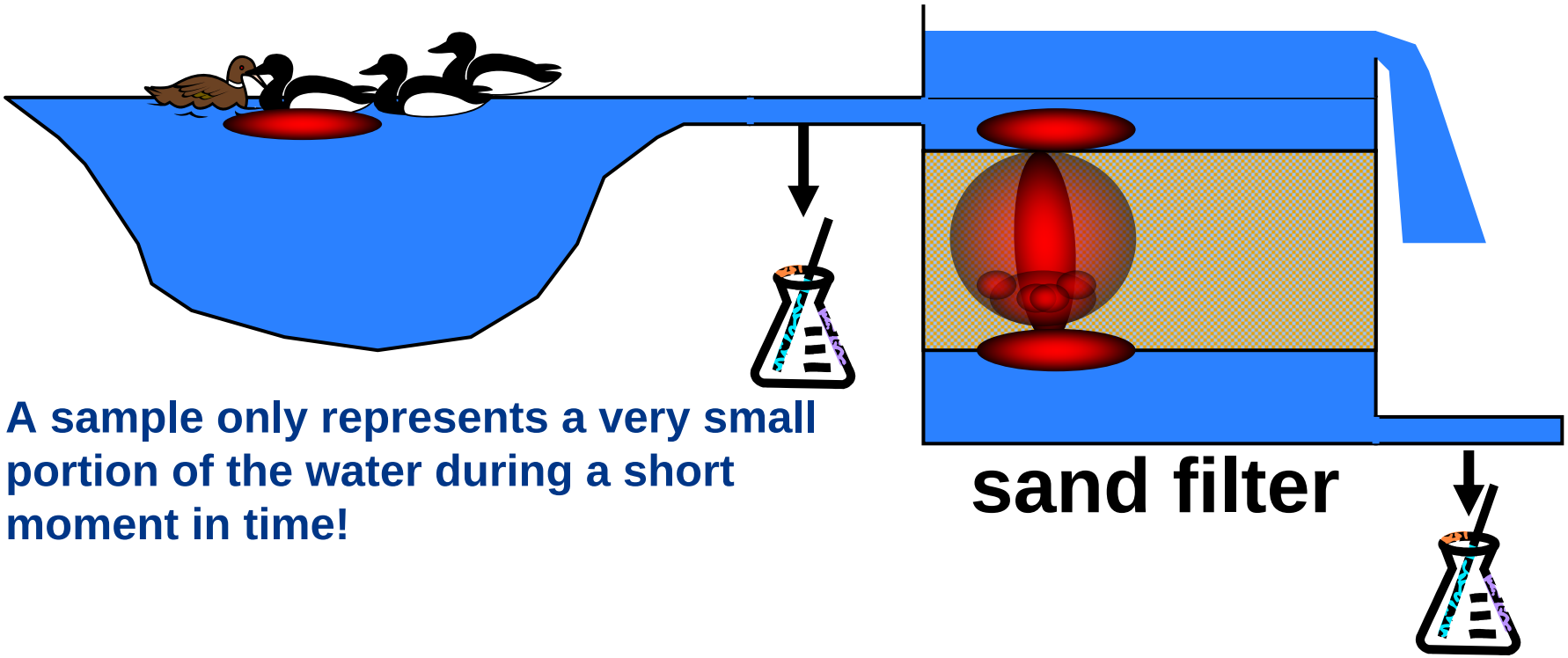




Verified at full-scale

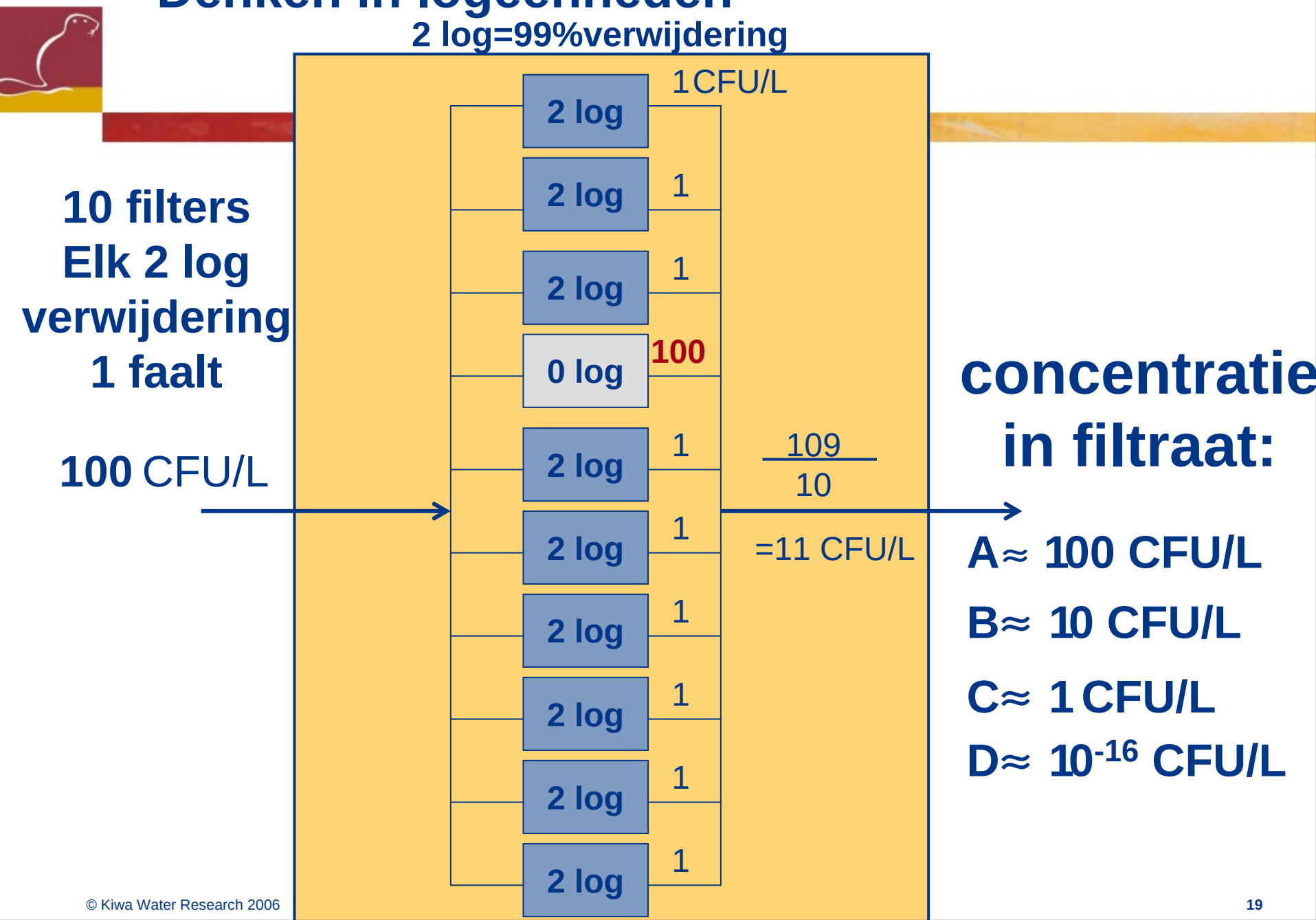
Meten in de praktijk
Invloed van variaties en metingen

Treatment processes can retain and release organisms over time!

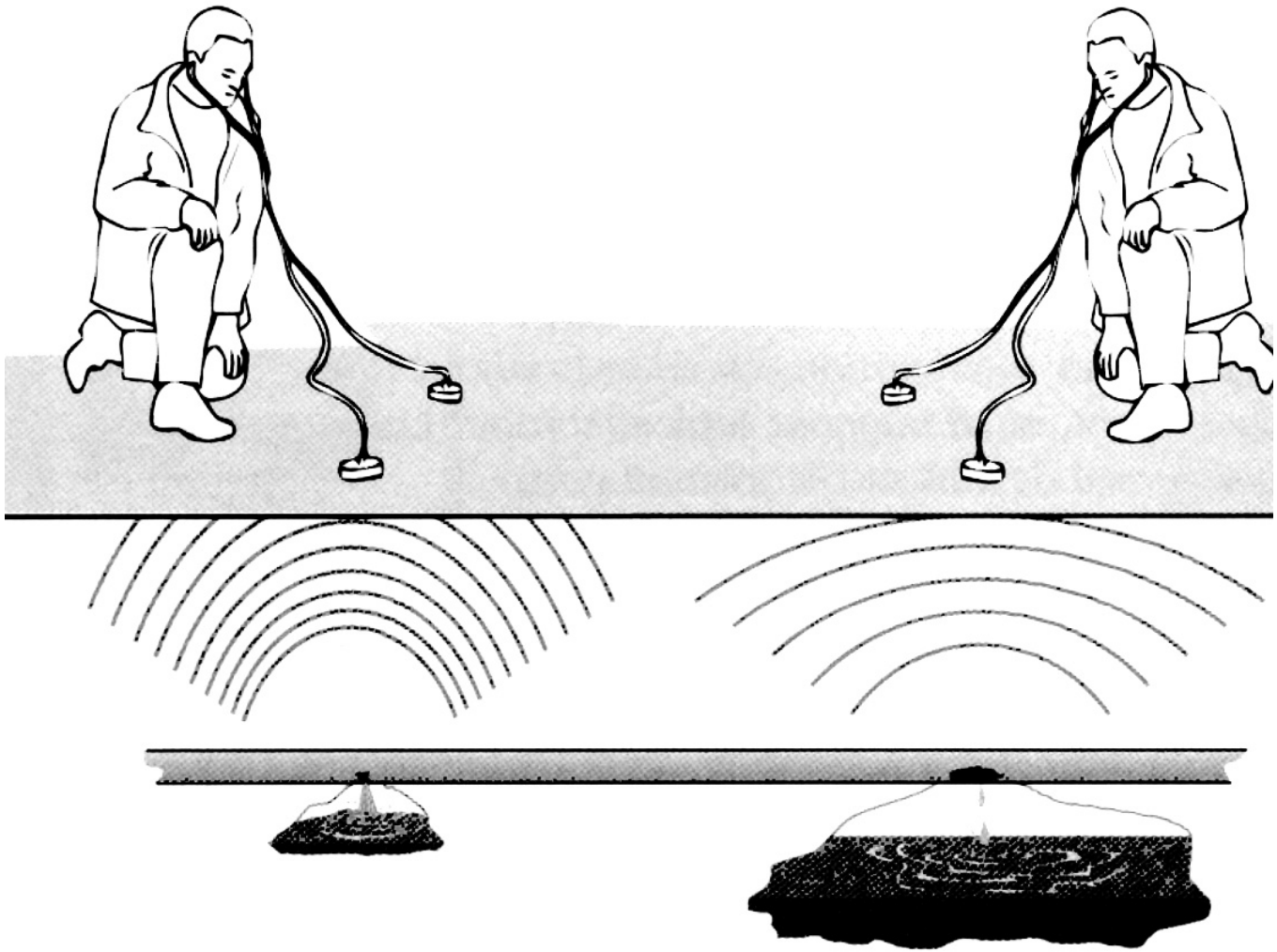


A sample only represents a very small portion of the water during a short moment in time!

Denken in logeenheden



Lekkage bij distributie
E. coli in 0.1% van de monsters



Drinkwaterconsumptie

- Telefonisch interview (‘recall’)
- Dagboek

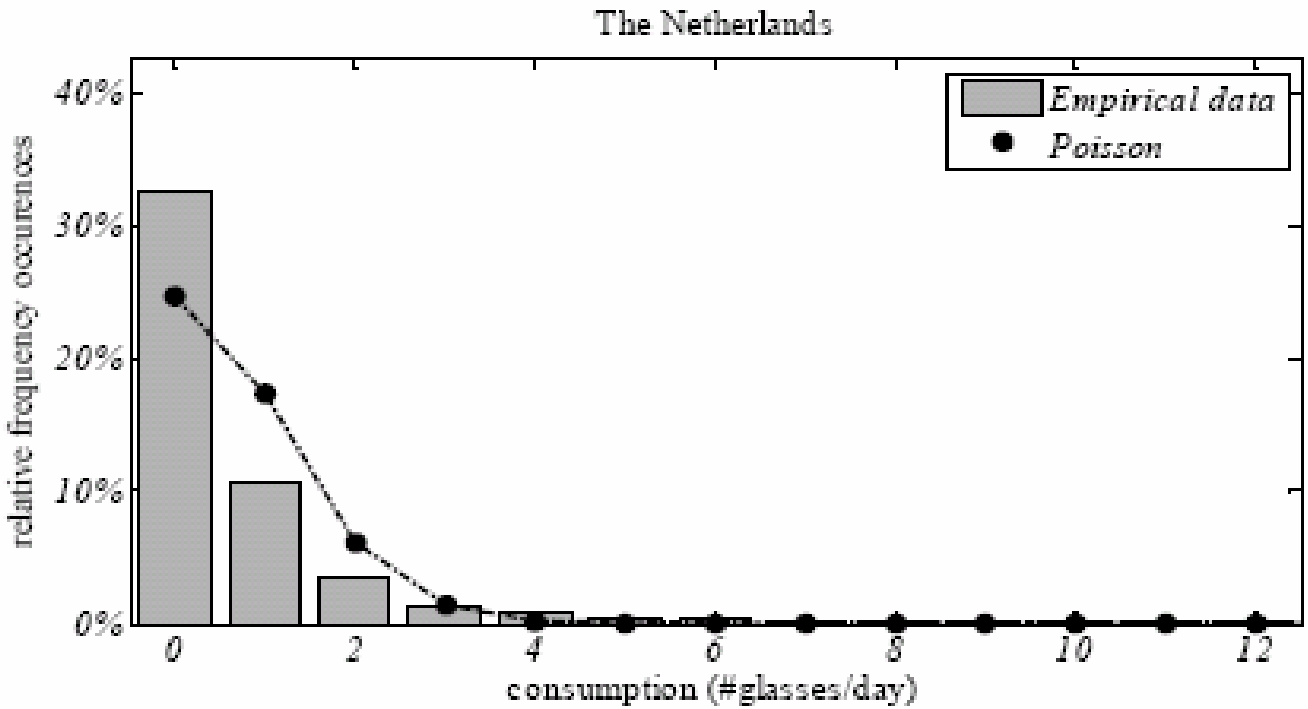
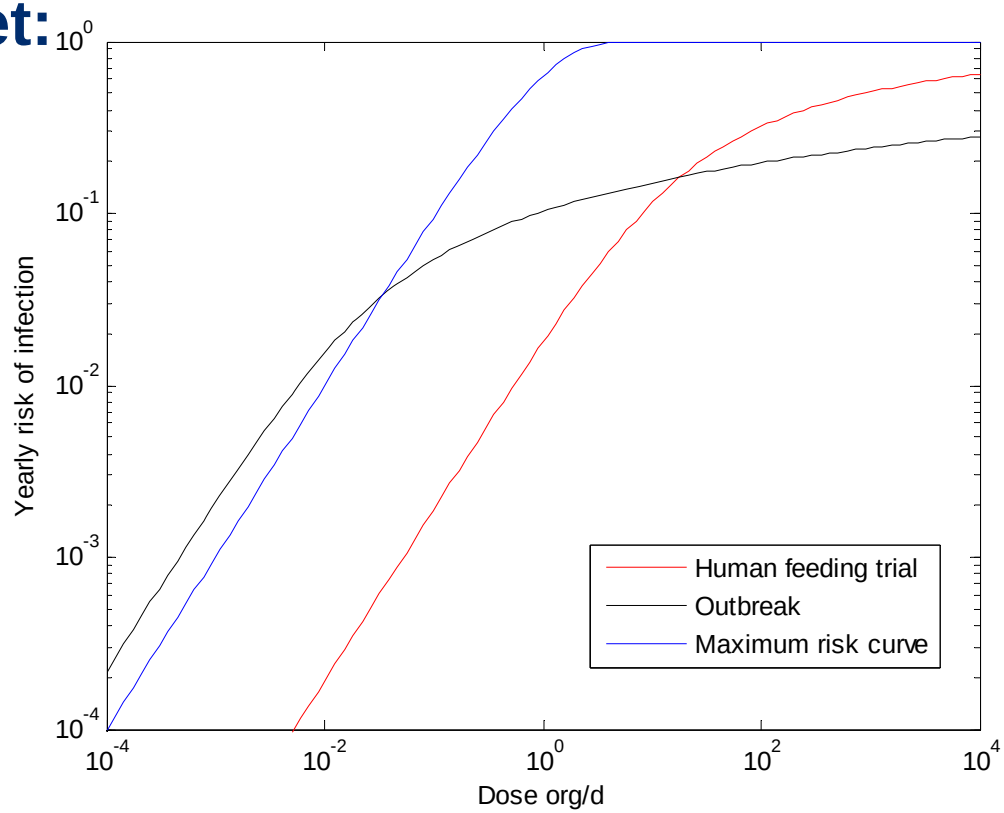


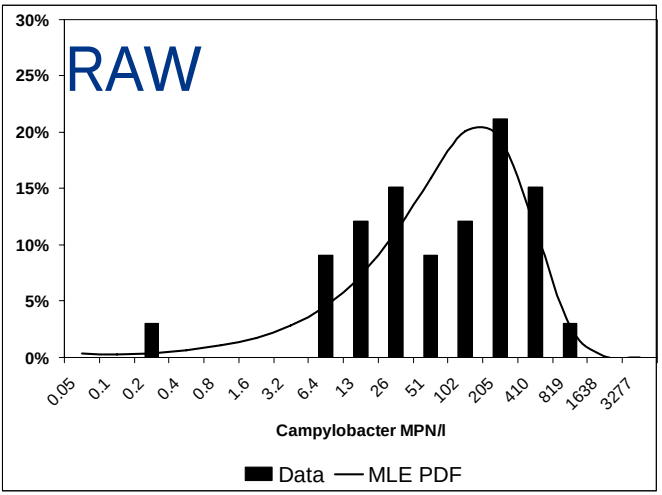
Figure 6.8. Statistical probability distributions for discrete tap water consumption

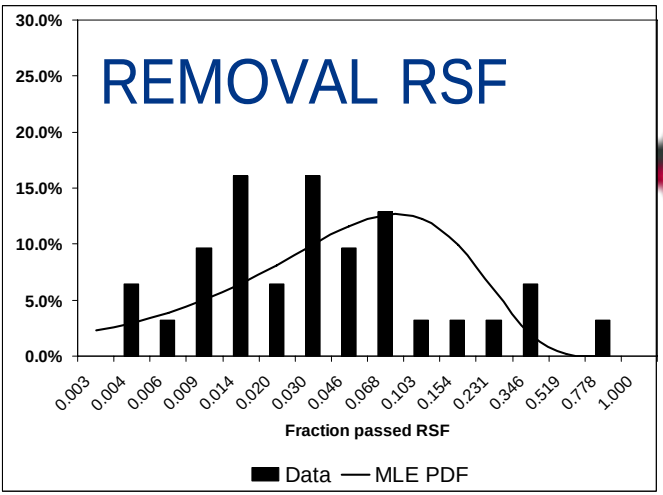
Kans op infectie
Dosis-respons

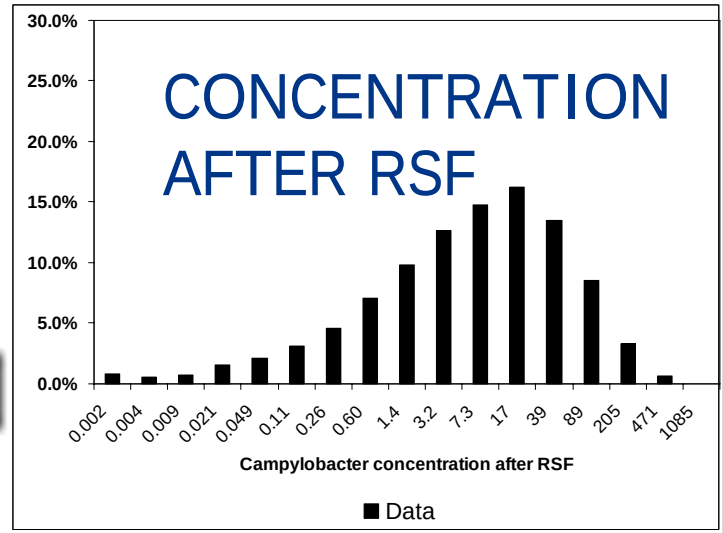
- **Wat is de kans dat je een infectie ontwikkelt wanneer je één of meer micro-organismen binnen krijgt?**
- **Relatie vaststellen met:**
  - **Vrijwilligers (studenten)**
  - **Uitbraken**
- **Maximum=100%**



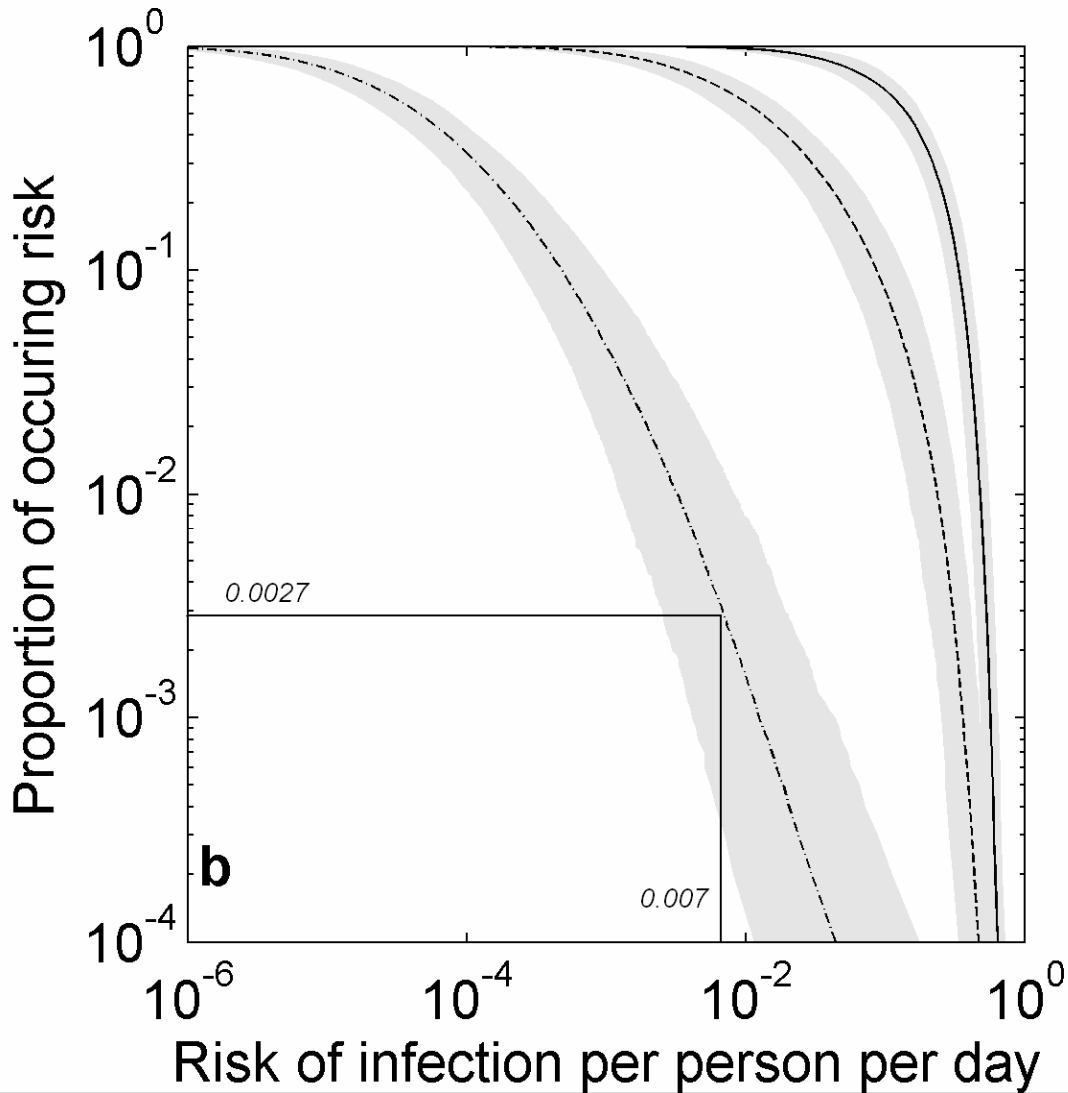
Monte Carlo analyse







Resultaat: FN-curve



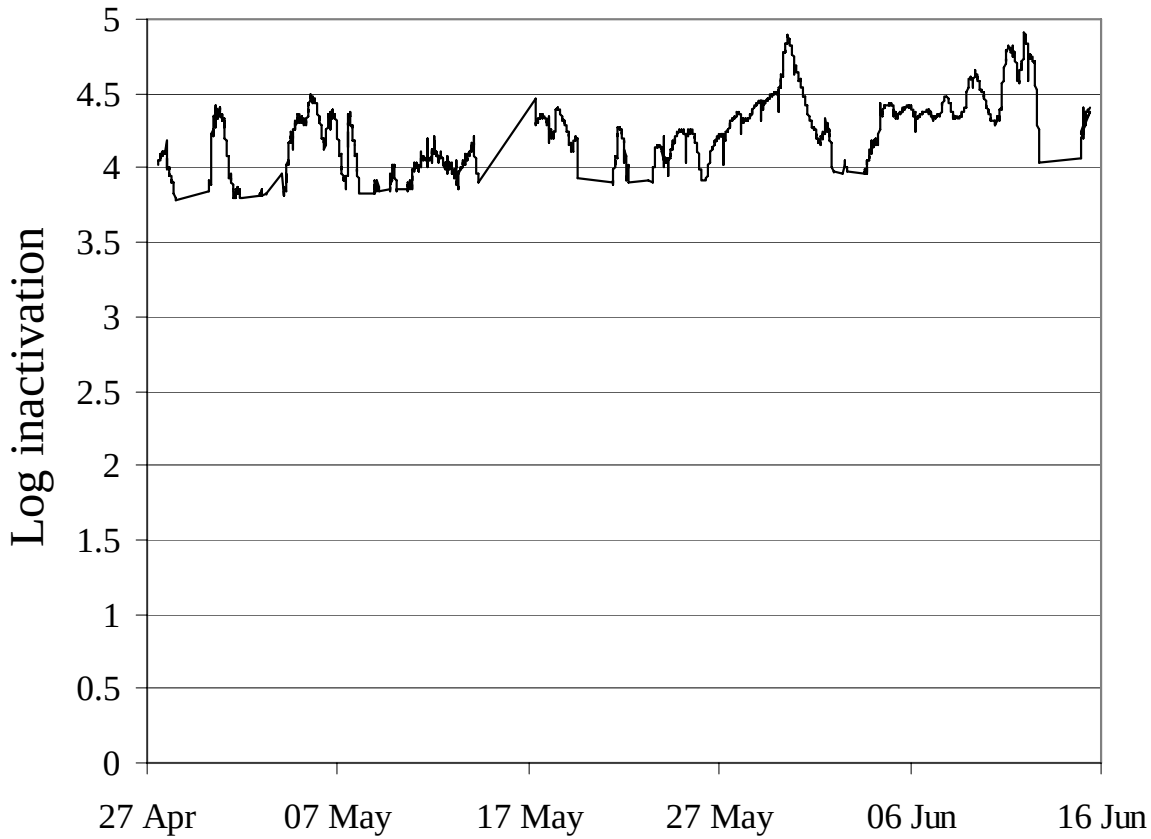
Ruwwater
Na filtratie
Na ozonisatie

Wat doe je met het resultaat?

- Zuiveringsstappen toevoegen?
- Bedrijfsvoering veranderen
  - Meer ozon of chloor doseren
  - Sturing verbeteren
  - Filtratieprocessen optimaliseren
  - .....
- Meer meten?
- Huidige situatie handhaven en borgen

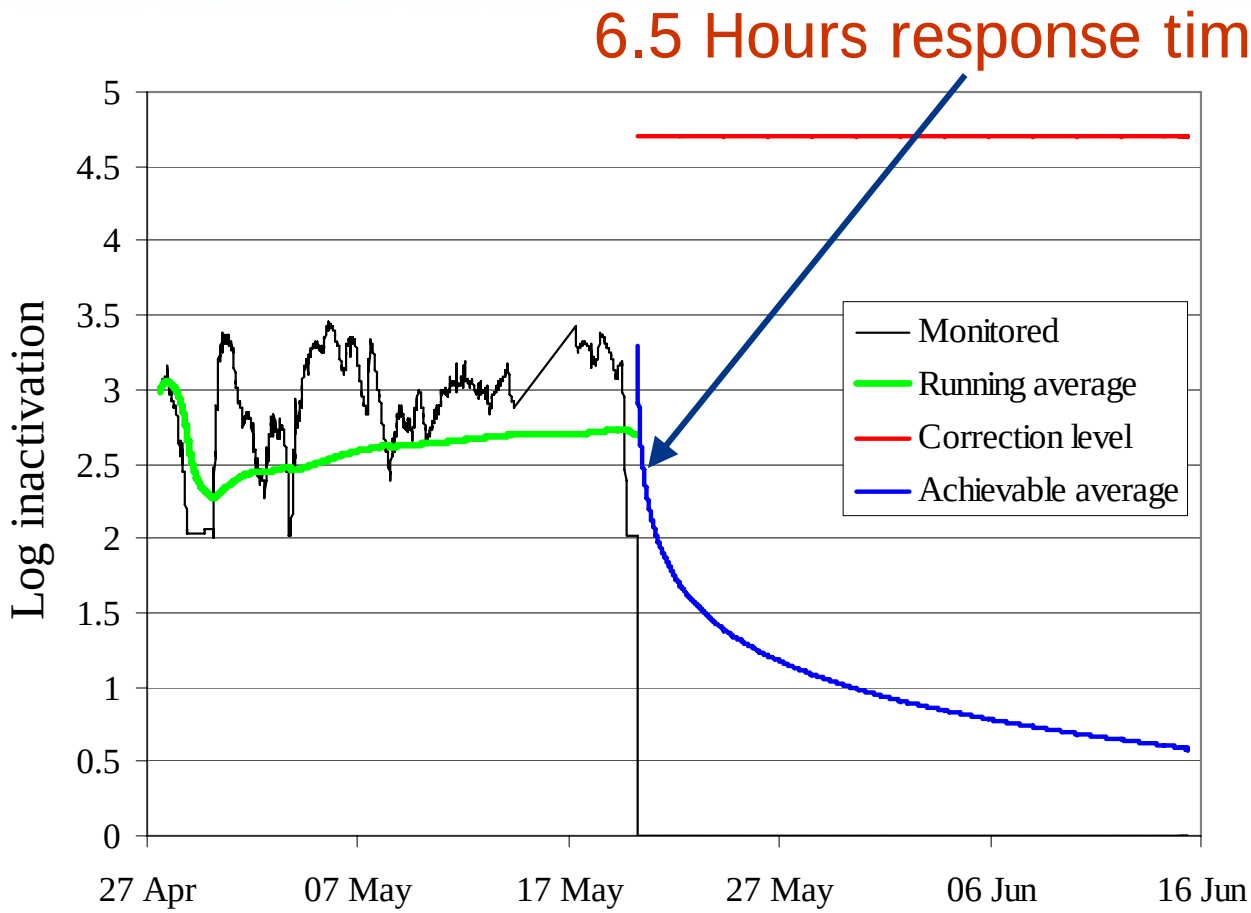
Proces en/of bedrijfsvoering verbeteren
Voorbeeld chloordesinfectie

- Total reduction
- Current 2.1
- Double dose 2.3
- No events 2.5
- Hydraulics 2.6
- Hydr.+events 4.0



Goal: 2.5 log to meet health target

Procesbewaking is essentieel!



Goal: achieve 2.5 log average inactivation over period

Procesbewaking: hoe vaak moet je meten?

Risk from event < nominal risk (95% certainty)

nominal log reduction	Interval / year
1	1 week
2	1 day
3	3 hours
4	15 min
5	2 min

Verschillende landen, verschillende prioriteiten

- Westers ontwikkeld: verwaarloosbaar risico, hoe verifieer je dat?
- Beperkt ontwikkeld: hoe zorg je voor constante goede bedrijfsvoering?
- Primitief: hoe maak je mensen bewust van risico's (latrines boven visvijver)

Source: F. Wieneke