



Water, Heat and Health

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Health effects of climate change (CC) Loss of DALY's in 2004

World (X 1.000.000) 5.4

- Unintentional injury 0.2
- Malnutrition 0.5
- Respiratory infections 0.6
- Malaria 1.0
- **Diarrhoeal diseases 2.2**

EU (X 1.000) 25.9

- Unintentional injury 4.2
- **Diarrhoeal diseases 21.4**



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Climate change effects on water

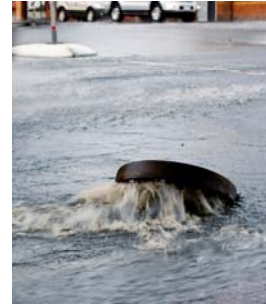


Heat



<http://growingourwn.files.wordpress.com>

Drought

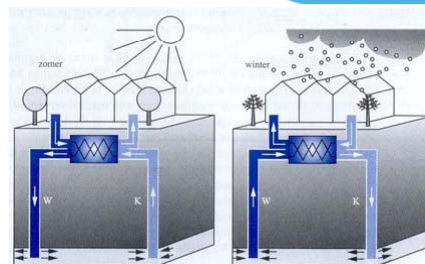


<http://www.waterland.net>

Extreme Rainfall

Changed human water use

- Air conditioning and cooling
- Water storage and infiltration
- Energy storage (heat, cold)
- Waste water reuse
- Increased irrigation
- Water recreation
- Water in the city to prevent heat islands



<http://www.degroenemug.nl>



Microbial risks

Growth of pathogenic or toxic micro-organisms

- *Legionella pneumophila*
- Cyanobacteria
- *Mycobacterium avium*
- *Pseudomonas aeruginosa*
- *Naegleria fowleri*

Exposure to faecal pathogenic micro-organisms

- *Cryptosporidium*
- *Giardia*
- *Campylobacter*
- *Escherichia Coli O157:H7*
- Enteric viruses
- Noroviruses



<http://www.cmse.ie>



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Growing micro organisms

Temperature >25°C, water and nutrients

Exposure through aerosols in the city:

- Air conditioning and cooling towers
- Fountains



<http://www.stadsfontein.nl>

Exposure through (warmer) water contact:

- Surface water recreation (industrial cooling and heat)
- Drinking water from surface water
- Drinking water warmed in in-house systems

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Growth in surface water



Increased surface water temperature from:

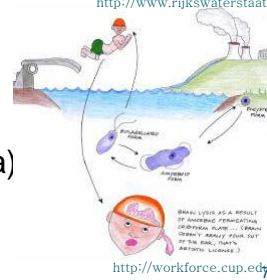
- Climate change
- Industrial cooling
- Drought



<http://www.rijkswaterstaat.nl>

Growth or blooms in surface water:

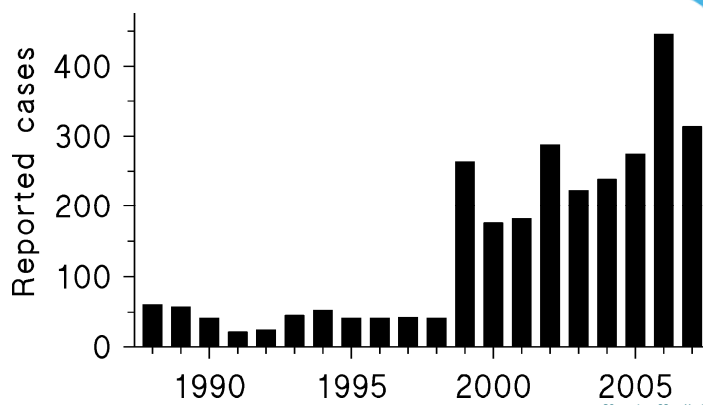
- Cyanobacteria (blue-green algae)
- *Naegleria fowleri* (brain eating amoeba)



<http://workforce.cup.edu>

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Legionair's disease in the Netherlands



Van der Kooij, 2008

Peak of legionellosis during hot and humid summer (2006)

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Increased cooling, increased risk?



de Volkskrant

Tweede persoon overleden na legionella-uitbraak

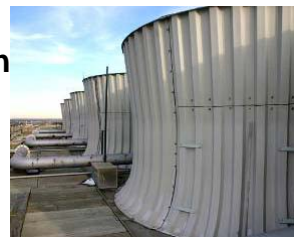
ANP op 03 augustus '06, 10:35, bijgewerkt 03 augustus '06, 10:43

Legionella infection through cooling tower near Amsterdam train station in 2006:

31 people infected
3 died



<http://www.micraairconditioning.co.uk>



<http://www.me.umn.edu>

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Growth risks in drinking water?



- No chlorine or disinfectant in (Dutch) drinking water
- Surface water temperature increases at intake
- In-house installation can heat up quickly
- Distribution systems designed for fire fighting, long residence times allow warming (underground)
- Impact of higher temperatures on microbial stability?
- Is there a “tipping point” for pathogenic risks?

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Research needs Growth of microorganisms



- How to control risks from cooling towers?
- What about water features (fountains)?
- Which pathogens are able to grow?
- Can we control *Legionella* through low nutrient levels in drinking water?
- Will climate change promote toxine producing Cyanobacteria and increase algeal blooms?



Faecal pathogenic bacteria

- Grow in infected humans and animals
- Can be transported through water
- Have low infectious doses
- Cause diarrhea....
and more severe outcomes



<http://calgaryisawesome.com>

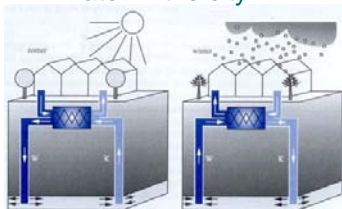
Exposure routes related to climate change



Water in the city



Water recreation



Groundwater uses (contamination)



Water reuse

Impact of drought on surface water quality



- (Treated) sewage in surface water during drought 2003:
 - Rhine 11%
 - Meuse 45%
- Impact on:
 - Recreation
 - Irrigation
 - Shellfish
 - Drinking water
 - Water stress



<http://scienceblogs.com>

Excessive rainfall



Increased contamination:
Faecal material from CSO's,
WWTP overload or bypass
Agricultural runoff

Exposure:
Water storage in the city
Flooding of sewers (streets)
Flooding of rivers
Infiltration into soil (groundwater)



<http://www.wldelft.nl/>



<http://www.waterencyclopedia.com>

Extreme rainfall: a risk for drinking water



Rainfall is associated with many outbreaks (Hrudey 2004)
51% of outbreak in USA followed rain events (Curriero 2001)
Milwaukee: contaminated water and treatment failure
>400.000 ill, >100 died
Haarlem: Contamination of reservoir through construction
E. coli detected, no cases



<http://erikpentenga.web-log.nl>

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<http://www.dag.nl>

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Contamination of wells and springs



- Walkerton contamination of wells: 1000 ill, 68 hospitalized, 6 died (Anon, 2000)
- Wells at risk after dry period due to cracking of the soil (Rutter 2000)
- Small and private supplies are at risk (already 54% in UK non-compliant) (Hunter 2003, Yip-Richardson 2009)
- Affects 40-50 mln people in EU (Hulsmann 2005)
- Rapid transport through (karstic) soils (Stadler 2008)



<http://www.campin.me.uk>

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Water in living environment Risk of illness



Screening level studies

Flooding of streets with (waste) water,
>10% (G. Sterk 2008)

Playing in Wadi (storage)

>11% (Stowa 2009)

Recreational waters

1.1-5.5% (Stowa 2009)

Playing fountains

2.8-5.5% (Stowa 2009)



<http://www.refdag.nl>

Risks from Climate Change mitigation + adaptation

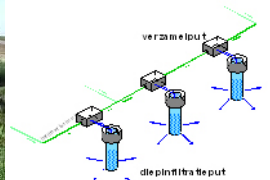


Contamination of groundwater aquifers:

- Energy storage (heat and cold) in groundwater
- Private and agricultural irrigation wells
- Infiltration of excess (rain)water



<http://co.water.usgs.gov/nawqa/hpgw/photos/irrigwell.jpg>



<http://www.iftechnology.nl>



<http://www.dlploodgieters.nl>

Risks from Climate Change mitigation and adaptation

Waste water reuse to

- Decrease water demand
- Recover energy and
- Recover nutrients

Risks through:

- Malfunctioning and errors (household water outbreak)
- Irrigation of food crops (Falloon 2009)



Research needs for faecal organisms

What will be the risk from surface water?

Risk assessment of mitigation and adaptation

Effect of extreme situations (rainfall and flooding) on groundwater safety

Resilience of surface water treatment systems to high variations in quality and quantity

How can we guarantee safety of small systems?

Risk of irrigation with contaminated surface water

EU 7th framework project

Prepared enabling change



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PREPARED results

- Water Cycle Safety Plan
- Climate Hazard Database
- Risk assessment models for the water cycle
- Risk Reduction Database
- GIS toolbox

Where is the optimal intervention point in the water cycle?
Sanitation? Wastewater treatment? Drinking water treatment?

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Research at KWR

- Risk from new urban water concepts
- Water Safety Planning (drinking water)
- Fresh water availability in Rhine and Meuse delta
- Safe setback of groundwater wells for drinking water
- Risk for groundwater wells under extreme conditions
- Hotspot (GIS tool to locate warming locations in distribution)
- Legionella research

Policy needs

- (Drinking) water companies
- Waterboards
- Municipalities
- Business
- Provincial and central government
- End users



All stakeholders need to be aware of the interactions and risks in the water cycle

Take home message

- Risks will increase if we take no action, especially for small water supplies
- Climate change mitigation and adaptation need to be planned carefully and not lead to increase of microbial risks
- Stakeholders need to prepare for exceptional situations of water stress and floodings

The end, happy future!

