# MBA versus QMRA:

## Både og eller enten eller?

Michael B. Waak, SINTEF

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# Drikkevannsforskriften (2017)

- ✓ Vannbehandling skal gi tilstrekkelige hygieniske barrierer

- ✓ Behandlingen skal være tilpasset:
  - Råvannskvaliteten
  - Identifiserte farer (virus, bakterier og parasitter)
  - Mengde produsert vann per døgn

- ✓ Hygieniske barrierer er et **funksjonskrav** – ikke et teknologikrav

# Hva er mikrobiell barriere analyse (MBA)?

- ✓ Praktisk verktøy for vannverkseiere, planleggere og saksbehandlere

- ✓ **MBA hjelper oss å svare på:**
  - Hvor mye reduksjon er nødvendig?
  - Hvor mye reduksjon har vi i dag?
  - Hvor er eventuelle gap?

- ✓ MBA **operasjonaliserer** barrierekravet i forskriften

# $\text{Log}_{10}$–reduksjon

$$R = -\log_{10}\frac{N_t}{N_0}$$

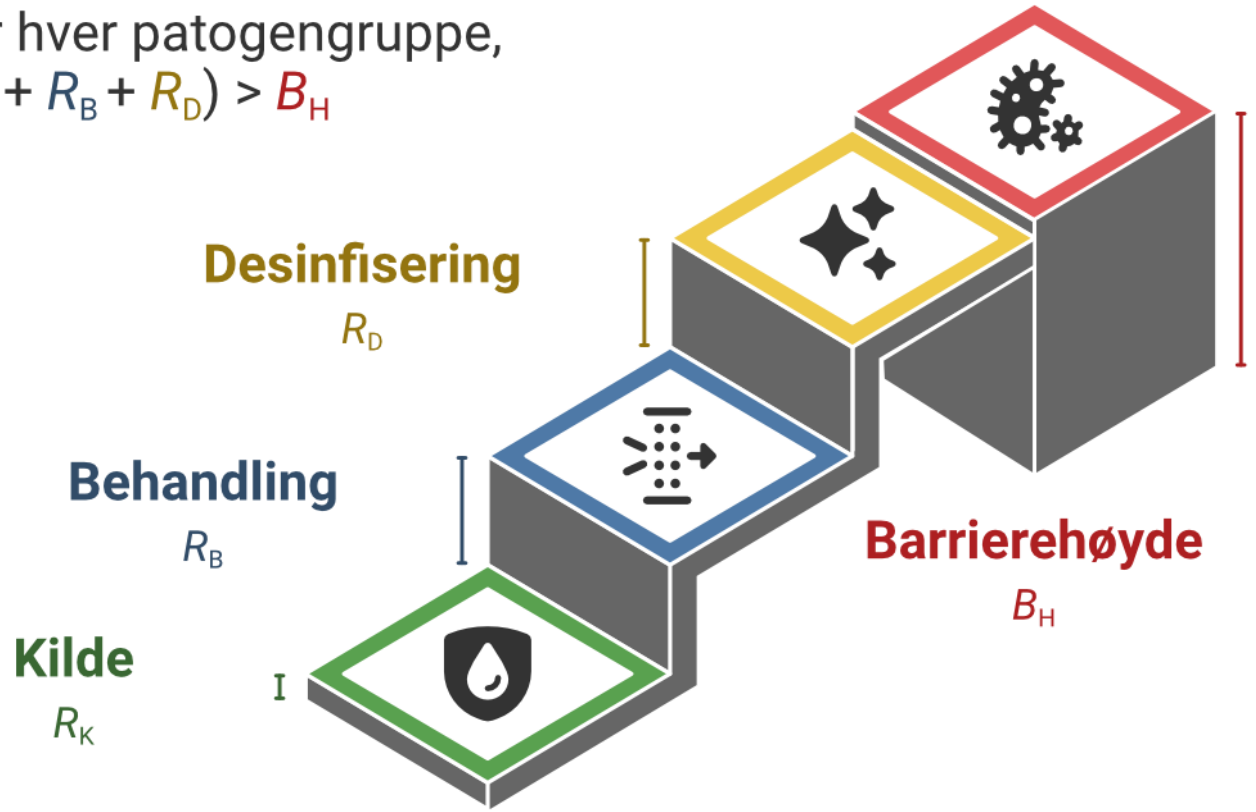
| Log–reduksjon (*R*) | Reduksjon | Gjenværende |
|---|---|---|
| 0.0 | 0% | 100% |
| 1.0 | 90% | 10% |
| 2.0 | 99% | 1% |
| 3.0 | 99.9% | 0.1% |
| 4.0 | 99.99% | 0.01% |

# MBA: Kort oppsummert

**Patogengrupper**

- Bakterier
- Virus
- Parasitter

For hver patogengruppe,
$(R_K + R_B + R_D) > B_H$



# Vannforsyningen: fra kilde til sluttbruker

Vannkilde | Vannbehandling | Distribusjon | Forbruk | Risiko

# MBA: Styrker og svakheter

## Styrker

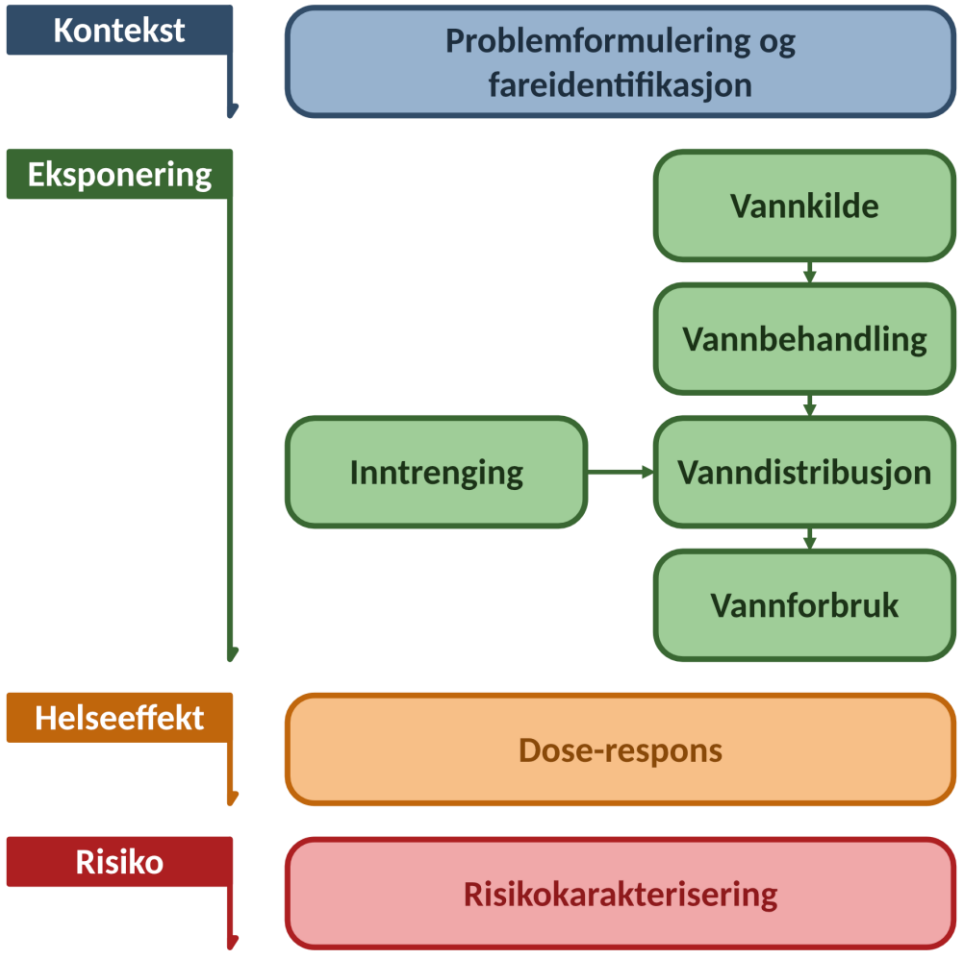
- ✓ Tydelig og standardisert rammeverk
- ✓ Praktisk og operasjonelt
- ✓ Design- og barrierefokusert
- ✓ Robust som minimumssikring

## Svakheter

- ✗ Statisk og designorientert
- ✗ Begrenset systemperspektiv
- ✗ Lite eksplisitt kobling til helserisiko
- ✗ Utfordrende ved ekstreme eller sammensatte scenarier

# Hva er quantitative microbial risk assessment (QMRA)?

- ✓ Systematisk rammeverk for å evaluere mikrobiell sikkerhet
- ✓ Involvere vanligvis mange Monte Carlo-simuleringer
  - — Utforsker variasjon og usikkerhet



# Vannforsyningen: fra kilde til sluttbruker


Quantitative Microbial Risk Assessment (QMRA)

# QMRA: Hva tilfører det utover MBA?

- ✓ Oversetter barrierer (log-reduksjon) til faktisk helseutfall
- ✓ Tester om sikkerhetsnivået er tilstrekkelig – også i ekstreme scenarier
- ✓ Kvantifiserer usikkerhet og variasjon i risikoestimatet
- ✓ Støtter prioritering og beslutninger på tvers av hele systemet

INNLEGG FRA MØTER I FORENINGEN

# Norwegian drinking water supply systems and risk management: guidelines, directives and microbial risk assessment

*Av Razak Seidu*

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## Evaluation of the microbial risk reduction due to selective closure of the raw water intake before drinking water treatment

J. Åström, S. Petterson, O. Bergstedt, T. J. R. Pettersson and T. A. Stenström

ABSTRACT

Short-term peaks in pathogen concentrations may increase the risks for waterborne diseases considerably. In this study the occurrence of indicator organisms and pathogens in the river Göta älv at the raw water intake to Göteborg was evaluated and related to risk for drinking water consumption. About half of the 24 pathogen samples, taken during event and non-event conditions, were positive for at least one of the following: *Cryptosporidium*, *Giardia*, norovirus, enterovirus, *Campylobacter* and *E. coli* O157. Positive pathogen detects were often associated with heavy rainfalls and viruses with a sewage emergency discharge. The annualised probability of infection from this type of event was calculated from pathogen concentrations in a QMRA model. Given that the water intake is not closed, the risk given present water treatment seems to be acceptable for *Giardia*; however, it is at a borderline for *Cryptosporidium* and insufficient for noro- and enteroviruses. Present results emphasise the need for an appropriate intake regulation with respect to high pathogen loads, as the risk increases with time of exposure to pathogen contaminants. Rather than a threshold level on *E. coli*, reports on upstream microbial discharges are valuable for quick pathogen indications.

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## Quantitative microbial risk assessment combined with hydrodynamic modelling to estimate the public health risk associated with bathing after rainfall events

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[b] Norwegian Institute for Water Research (NIVA), Gaustadalléen 21, 0349 Oslo, Norway

HIGHLIGHTS

- River flooding and overflow from combined sewer system after rainfall event contaminate the recreational beaches
- Hydrodynamic modelling was used to identify the sp
- of microbial pa
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- sponse relation
- work

GRAPHICAL ABSTRACT


Science of the Total Environment 660 (2019) 306–320

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## Climate-driven QMRA model for selected water supply systems in Norway accounting for raw water sources and treatment processes

Hadi Mohammed *, Razak Seidu

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HIGHLIGHTS

- The effect of precipitation on pathogen infection risks in drinking water is assessed.
- Risks of infection in small water treatment plants in Norway may be high in the future.
- Extreme precipitation events may pose considerable treatment challenges in

GRAPHICAL ABSTRACT

# Integrating Quantitative Microbial Risk Assessment into Health Risk Management of Water Supply Systems in Norway

Av Razak Seidu[1a], Arve Heistad[1], Oddvar Lindholm[1], Lasse Vrale[1], Petter D. Jenssen[2], Thor Axel Stenstrøm[1]

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## Some aspects of deep-bed filtration dynamics in QMRA for drinking water

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ABSTRACT

Unlike most unit processes in drinking water treatment, the performance of deep-bed filtration processes vary *systematically* on short time-scales; the particle removal capacity changes with time since the previous backwash, even when the influent water quality is stable. For microorganisms, the removal efficiency may vary by orders of magnitude. In this note, the potential impact of such dynamics on microbial risk estimates is studied, using representative experimental filtration data for viruses and bacteria in conjunction with single-hit dose-response models for microbial infection.

Assuming that filtration is the only source of variation in pathogen concentrations on the time-scale of a single filter cycle, it is concluded that such variations are unlikely to substantially affect risk estimates, except possibly in an outbreak situation with extremely high pathogen concentrations; it is generally sufficient to know the *mean* pathogen concentrations. Future studies should include concurrent variation in the performance of other unit processes and raw water pathogen concentrations. Experimental work should focus on capturing the variation in filtration performance in order to correctly estimate *mean*

Water Research 91 (2016) 31–37

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## A theoretical approach to using faecal indicator data to model norovirus concentration in surface water for QMRA: Glomma River, Norway

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ABSTRACT

Monitoring of faecal indicator organisms, such as *Escherichia coli*, in environmental and drinking waters

Norges miljø- og biovitenskapelige universitet

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Fakultet for realfag og teknologi

# Nasjonalt estimat over sykdom fra drikkevann i Norge basert på Kvantitativ Mikrobiell Risikoanalyse (QMRA)

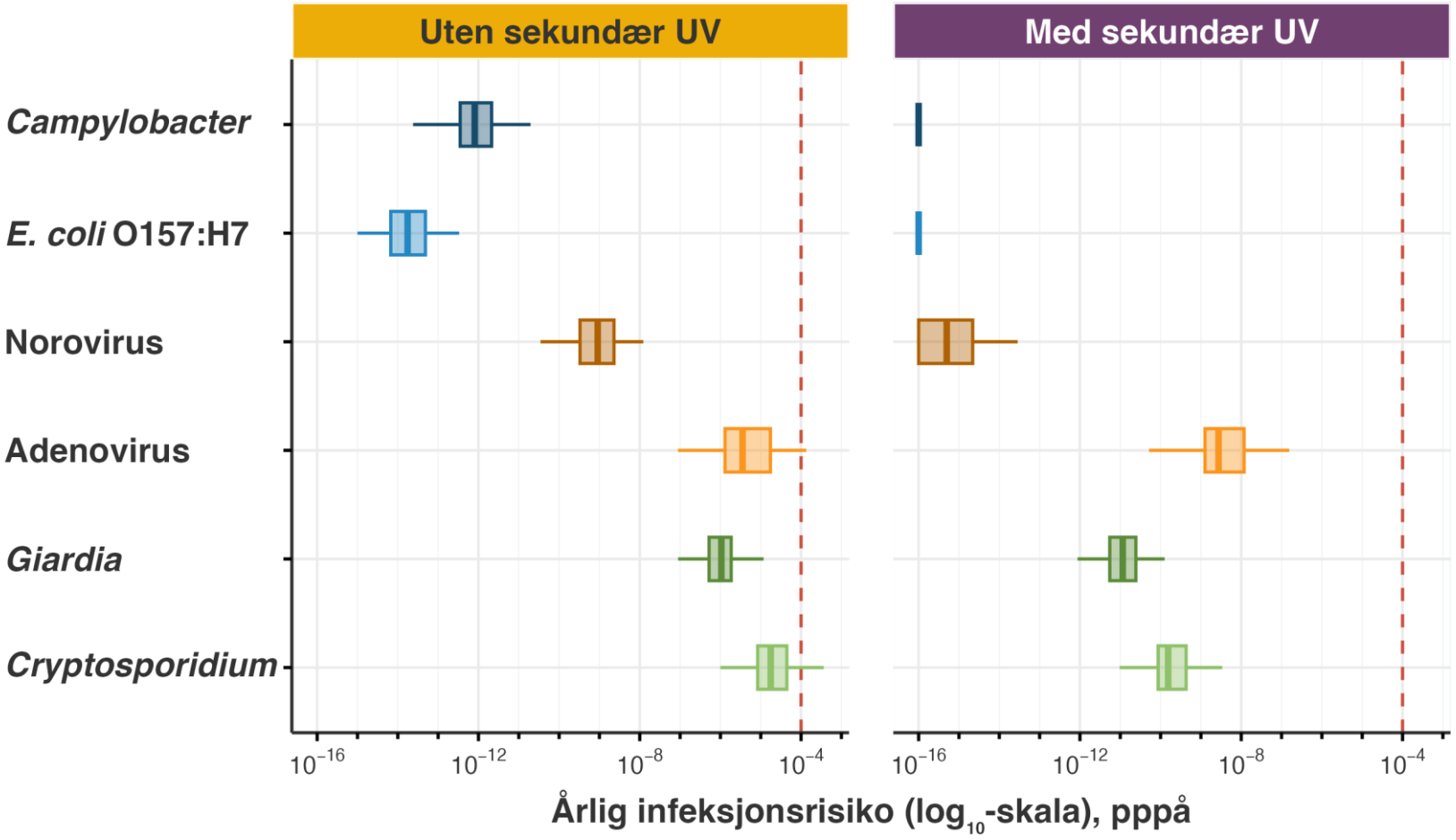
National Estimate of Waterborne Diseases in Norway based on Quantitative Microbial Risk Assessment (QMRA)

Frieda Trones Lieungh
Vann- og miljøteknikk

# Case-studie: Innlekking til fjellanlegg

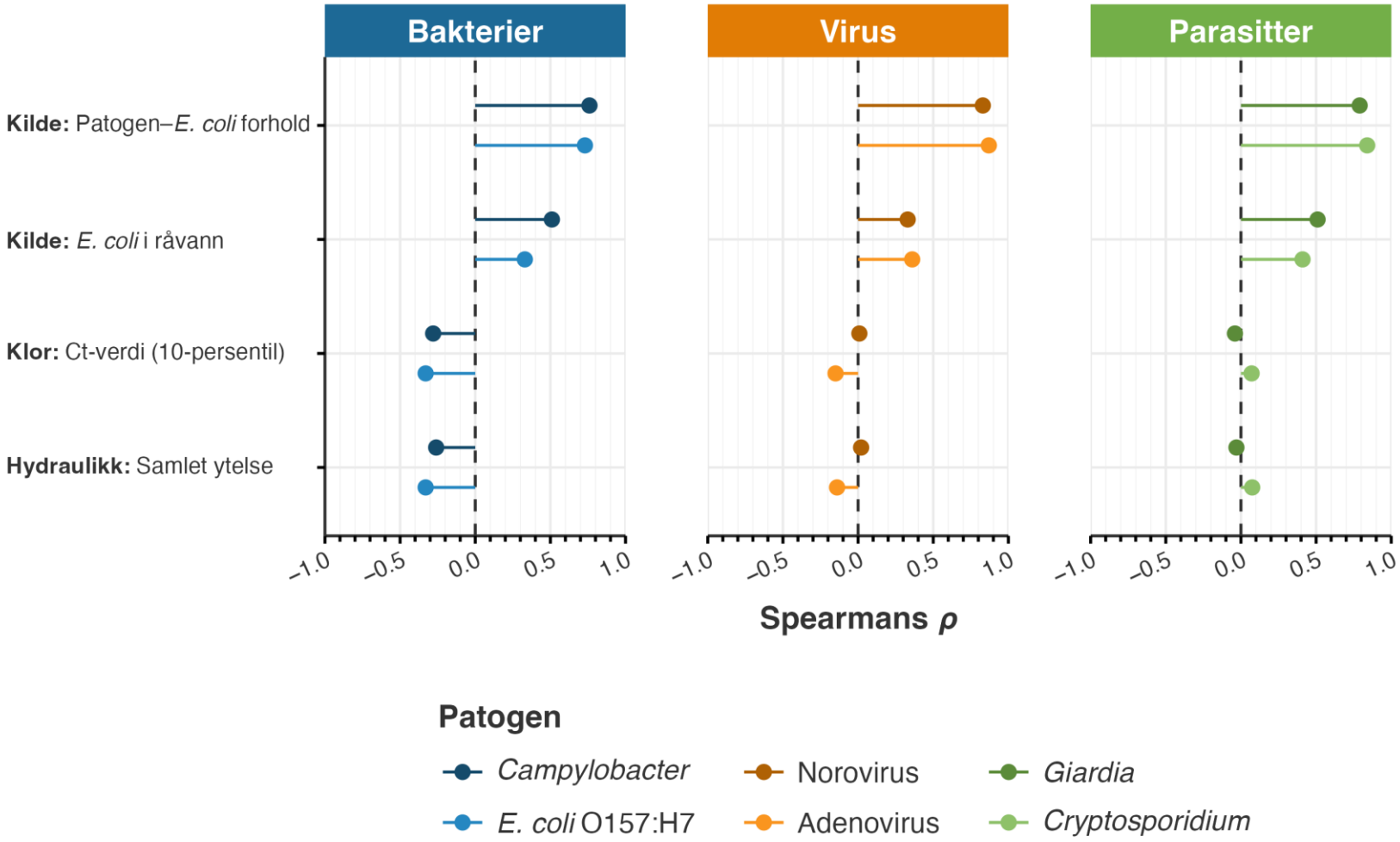
- ✓ Samarbeid med Trondheim kommune
- ✓ Medfinansiert med tilskudd fra Folkehelseinstituttet (FHI)
- ✓ **Støtte beslutningstaking og ressursprioritering**
  - Tetting av lekkasjer
  - Bruk av sekundær UV-desinfeksjon

# Eksempel av QMRA



# Sensitivitetsanalyse

Risiko påvirkes av antagelser!



# Eksempler: relevans for Norge

- ✓ Utforsk virkningene av fremtidige klimascenarier på kildevannskvaliteten
- ✓ Støtt utviklingen av kommunale vannsikkerhetsplaner
- ✓ Forberede seg på ekstreme hendelser
- ✓ Valg av ny primær- eller reservevannkilde

# QMRA: Styrker og svakheter

## Styrker

- ✓ Kvantifiserer faktisk helserisiko
- ✓ System- og eksponeringsfokusert
- ✓ Håndterer variabilitet og usikkerhet eksplisitt
- ✓ Egnet for scenario- og hendelsesanalyse

## Svakheter

- ✗ Datakrevende og modellavhengig
- ✗ Mer kompleks og mindre operasjonell
- ✗ Resultater kan være følsomme for antakelser
- ✗ Krever fagkompetanse og tolkning

# Kort oppsummert

Der MBA svarer på:

«Har vi tilstrekkelige barrierer?»

kan QMRA svare på:

« Hva betyr dette for faktisk helserisiko – under normale og ekstreme forhold?»

# MBA og QMRA: bedre sammen

- MBA = strukturell og regulatorisk ryggrad
- QMRA = kvantifiserer risiko og håndterer dynamikk, usikkerhet og scenarier
- MBA og QMRA sammen → sterkere beslutningsgrunnlag
- Hvis man måtte velge en metode: **start med MBA**

# Teknologi for et bedre samfunn