



Contaminants in reclaimed water: What are the emerging risks?

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المؤسسة العامة للمياه
Saudi Water Conservation Program (SWCP)



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STC EXICON

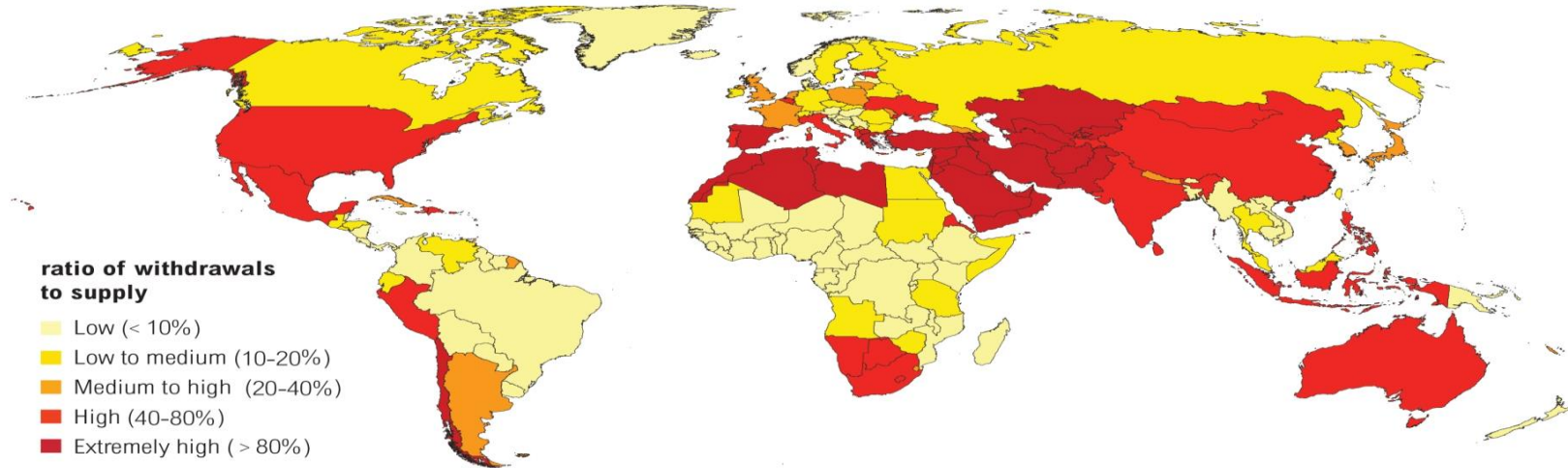
TECHNICAL ADVISOR

QWi

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Saudi Arabia is located in a water scarce region

Water Stress by Country: 2040



NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

Goal: Safe use of reclaimed water to alleviate water scarcity

Q1. What emerging microbial contaminants are present in wastewater?

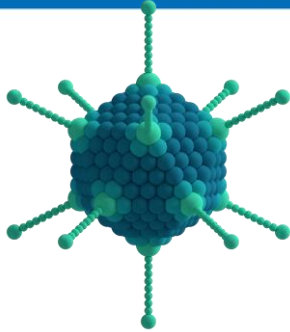
- Human enteric viruses and extracellular DNA

Q2. How can we redesign our wastewater treatment plant to remove these contaminants?

- Conventional activated sludge vs. Membrane bioreactor
- Chlorine vs. UV

Case study 1: Human enteric viruses

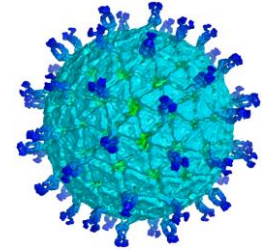
**dsDNA or
dsRNA**



Adenovirus

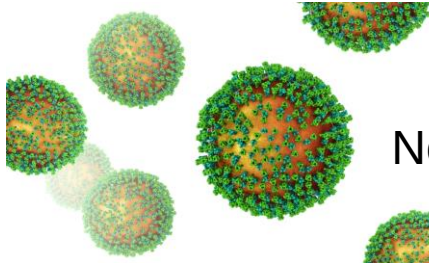


Polyma BK

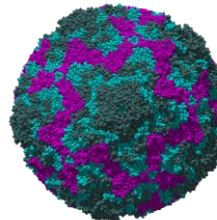


Rotavirus

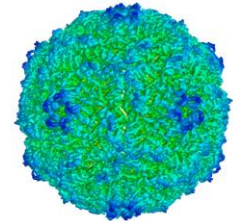
ssRNA



Norovirus

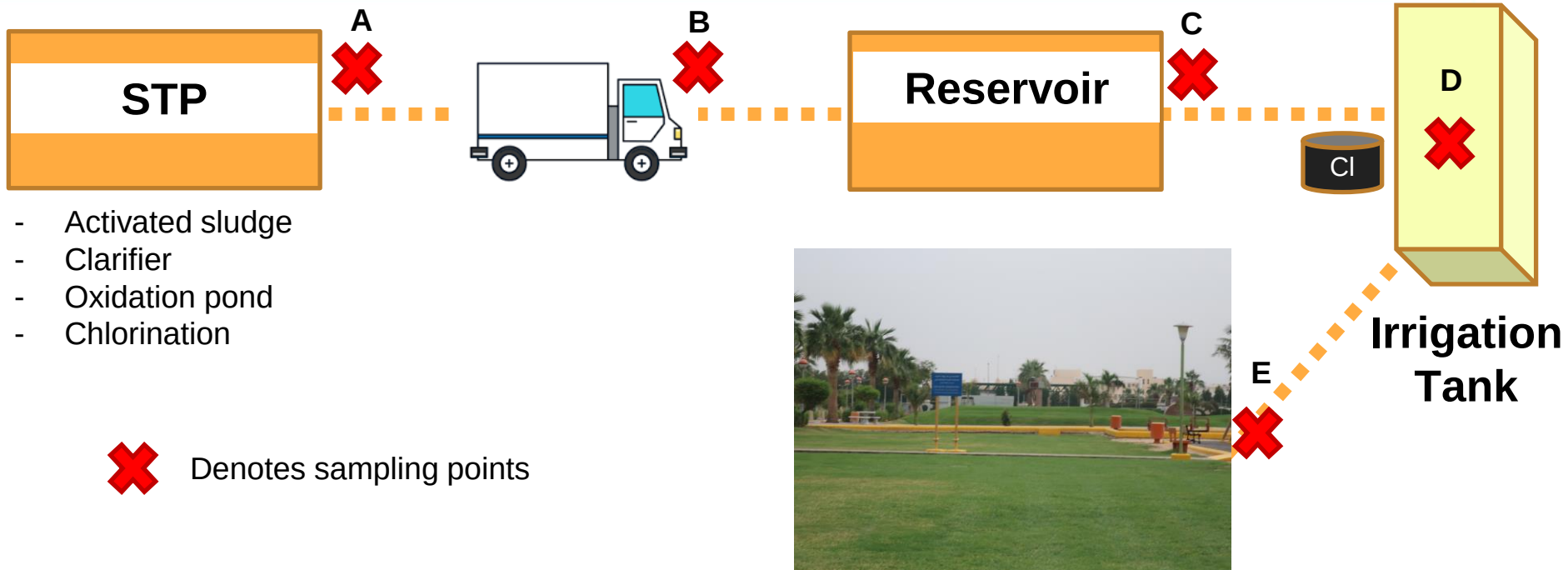


Enterovirus



Aichi

Case study 1a: A private compound in Jeddah, KSA

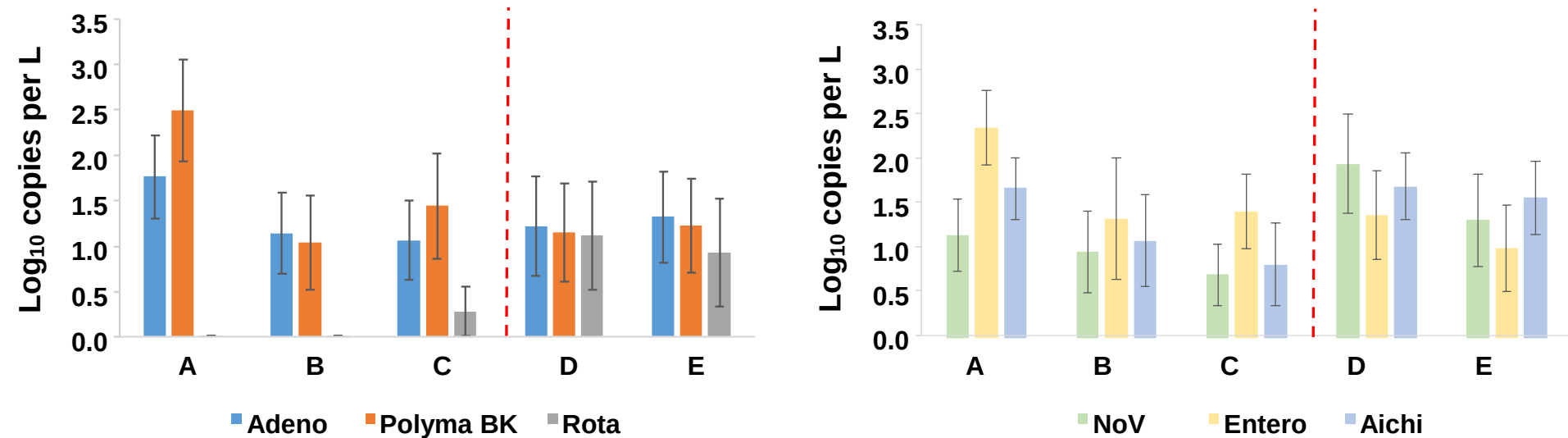


Case study 1a: Comparison against local guidelines

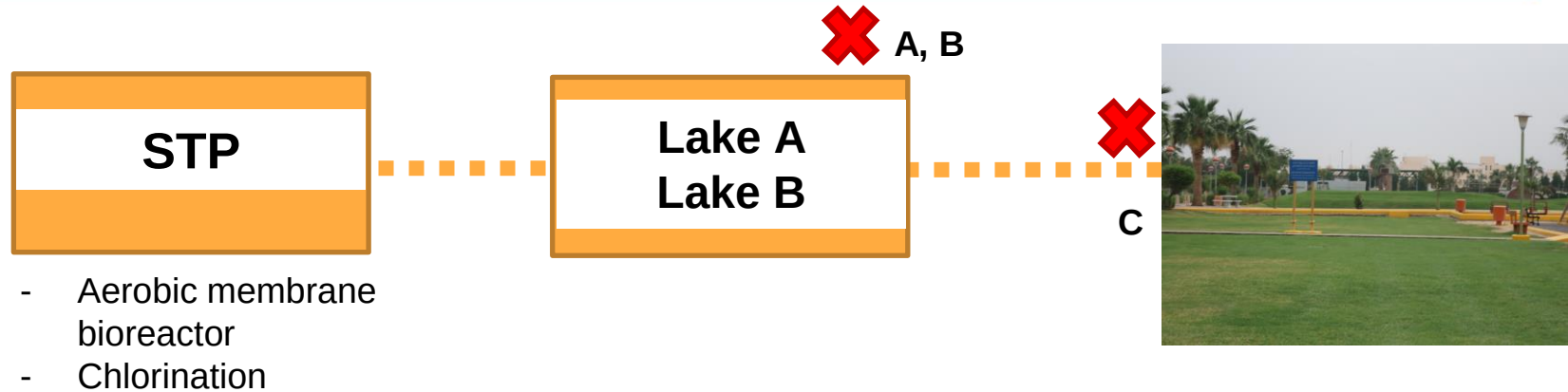
Parameter	Reclaimed water at point of use	Unrestricted irrigation	Restricted irrigation
pH	7.2	6 to 8.4	6 to 8.4
Total organic carbon (TOC), mg/L	4.0	40	Not specified
Total dissolved solids (TDS), mg/L	1344	2000	2000
Free residual chlorine	0.10 (total chlorine)	0.2	Not specified



Case study 1a: Occurrences and abundances



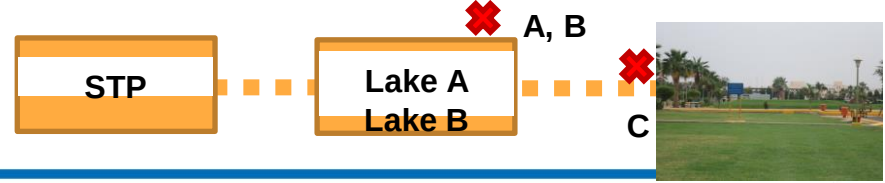
Case study 1b: KAUST compound



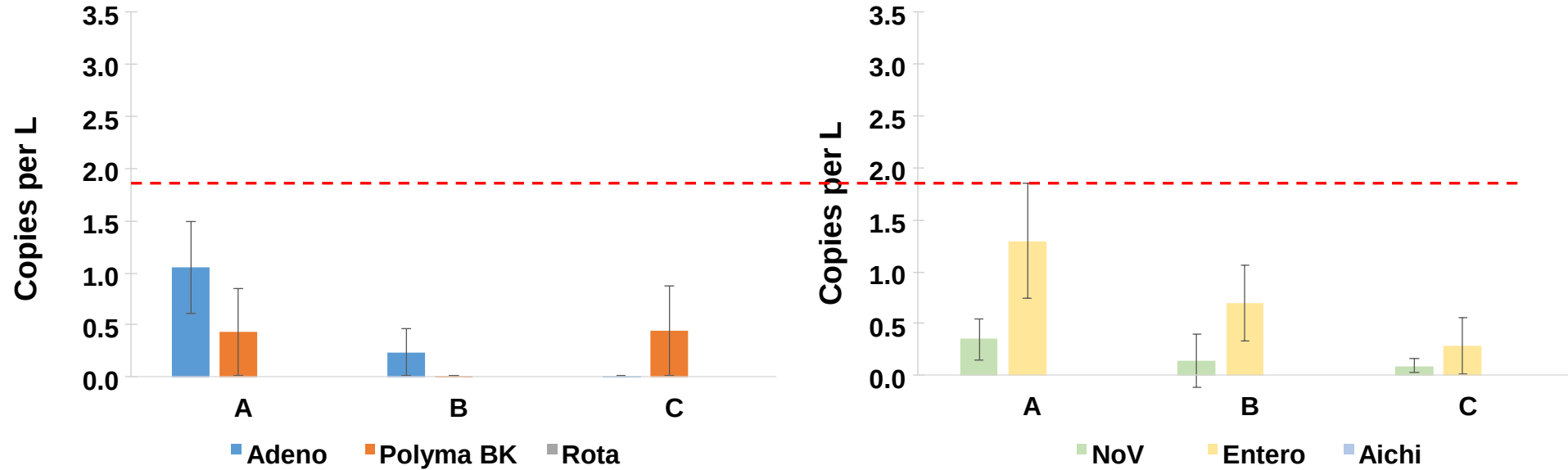
X Denotes sampling points

Case study 1b: Comparison against local guidelines

Parameter	Reclaimed water	Unrestricted irrigation	Restricted irrigation
pH	7.9	6 to 8.4	6 to 8.4
Total organic carbon (TOC), mg/L	2.4	40	Not specified
Total dissolved solids (TDS), mg/L	2.6	2000	2000
Free residual chlorine	0.02 (total chlorine)	0.2	Not specified



Case study 1b: Occurrences and abundances



Take-home messages

- Occurrence and abundance of human enteric viruses higher in reclaimed water produced by non-membrane based treatment
- Chlorination has limited efficacy in reducing viral particle counts
- Produce disinfection byproducts that are toxic, mutagenic and carcinogenic

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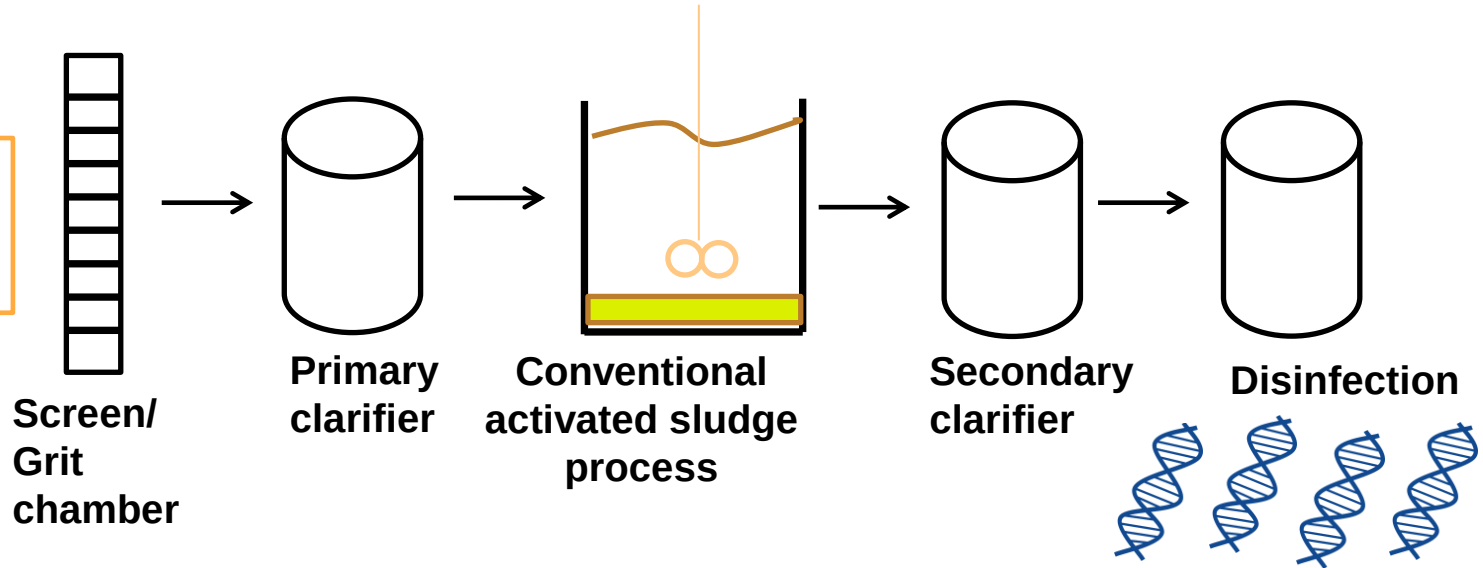
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Case study 2: Extracellular DNA

Activated sludge
treatment
process

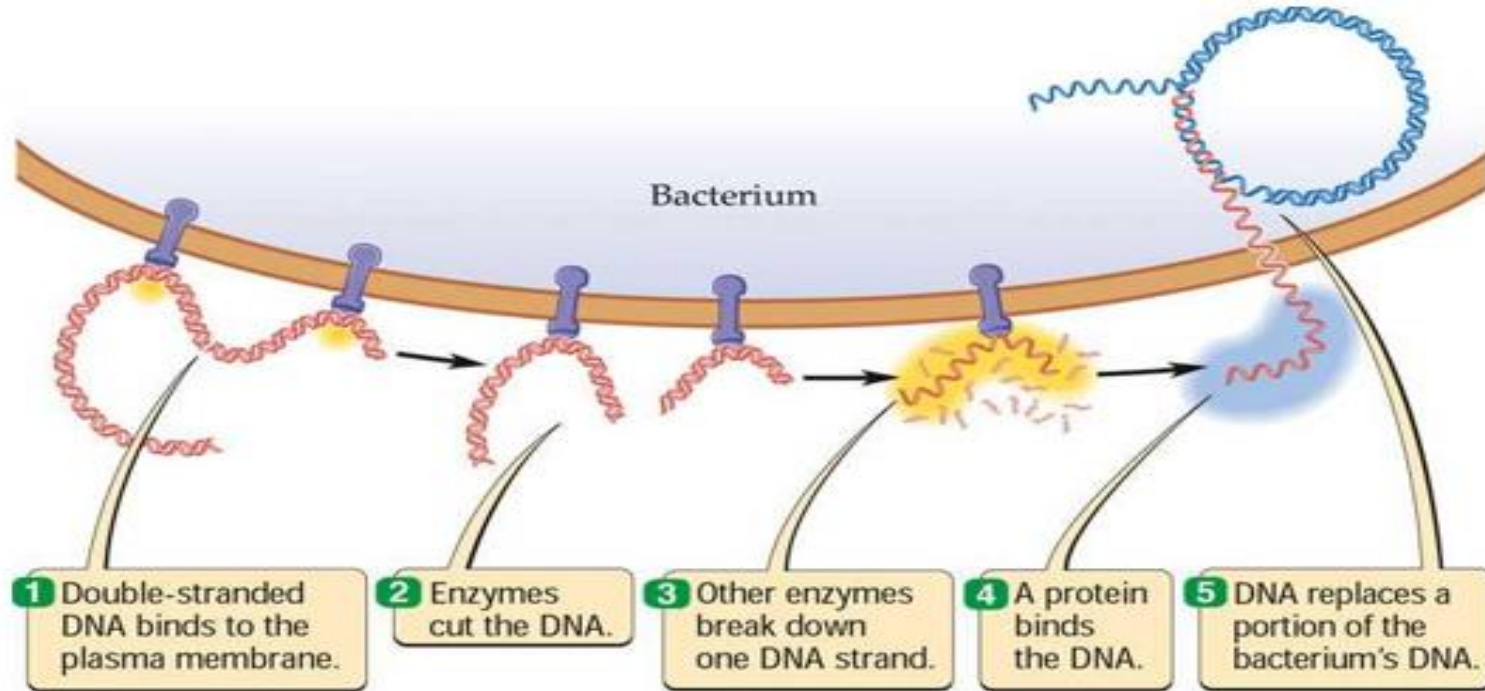


Case study 2: Extracellular DNA

Background problem: Extracellular DNA (eDNA) as emerging contaminants in reclaimed water

Hypothesis: The interaction of eDNA with various types of stressors (e.g. disinfectant byproducts) would result in an increase in horizontal gene transfer (e.g. natural transformation) among competent bacterial cells

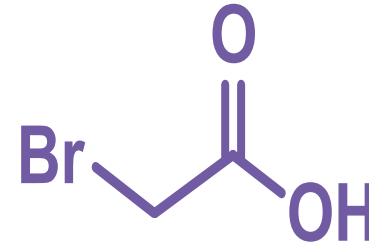
Case study 2: Extracellular DNA and natural transformation



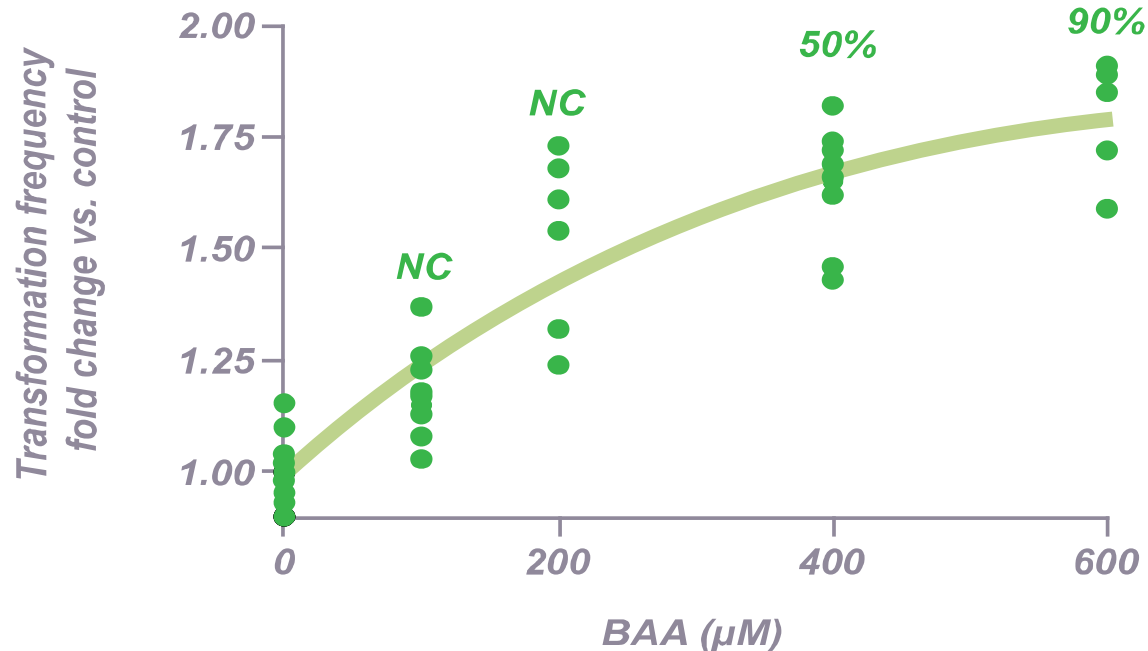
Case study 2: Extracellular DNA and natural transformation



Bromoacetic acid

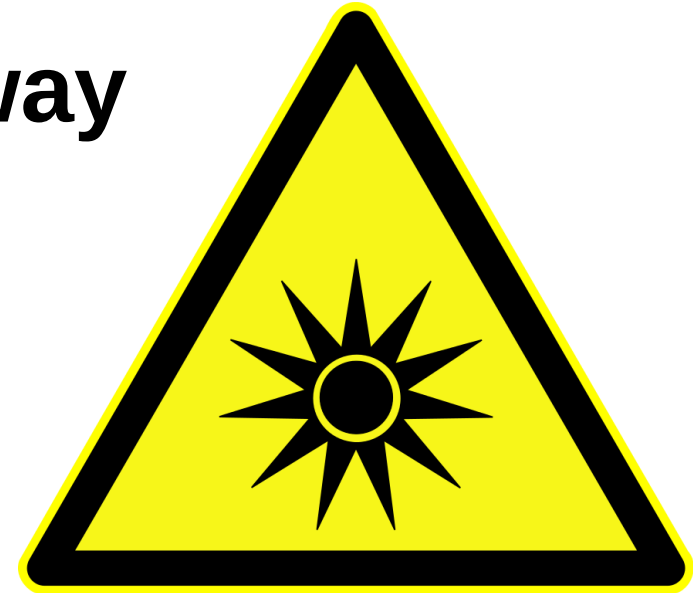


Case study 2: Increase in natural transformation due to BAA

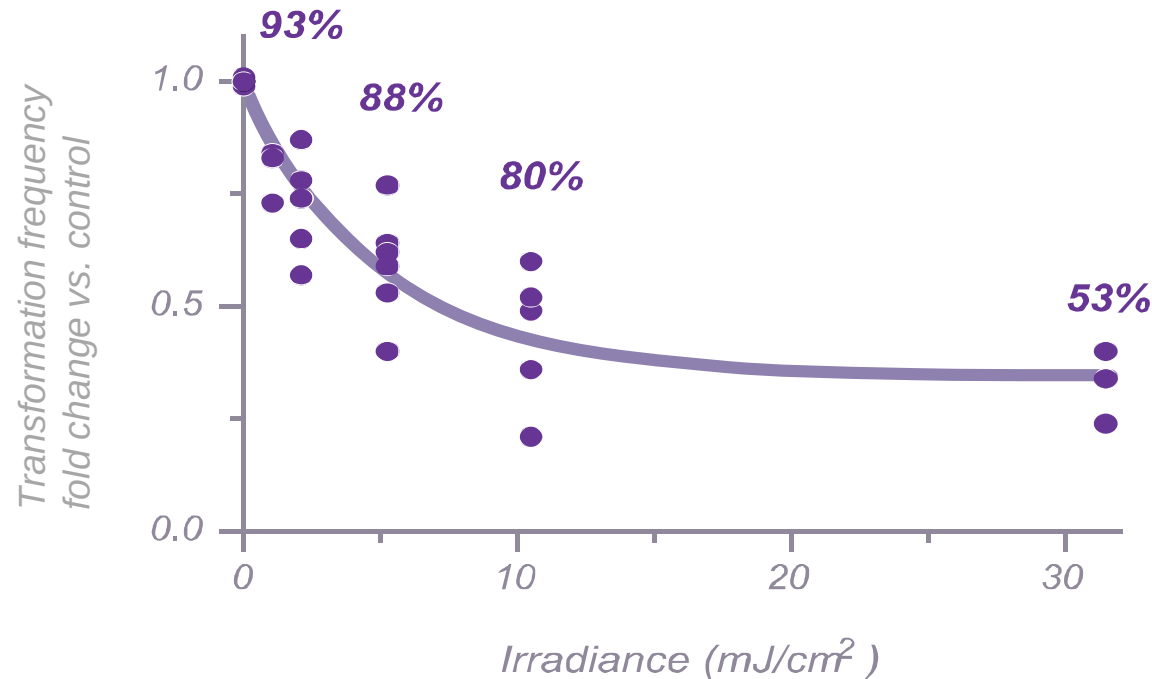


Case study 2: Alternative strategy to target eDNA

**Is there an alternative way
to disinfect without
increasing natural
transformation?**



Case study 2: Alternative strategy to target eDNA



Take home messages

- UV reduces natural transformation frequency by directly damaging the extracellular DNA
- UV may be an effective disinfection strategy to be used to inactivate emerging contaminants present in effluent post-membrane bioreactor

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Governor of Riyadh Region

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