

Inactivation and Growth of Pathogens in Greywater in the context of Blue Diversion Autarky Toilet

Mi Nguyen

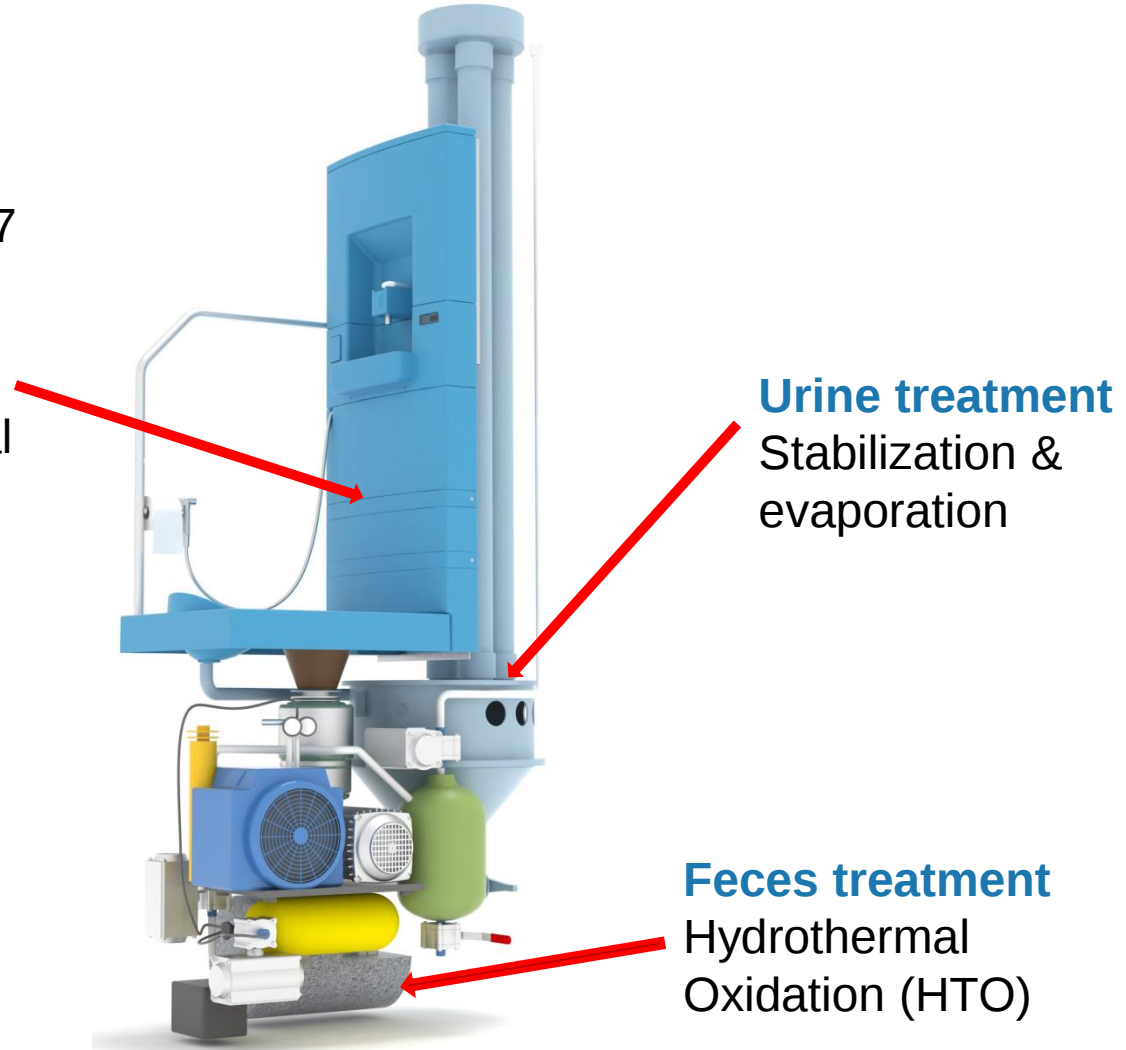
EAWAG-Swiss Federal Institute of Aquatic Science
and Technology

Blue Diversion Autarky Toilet (BDT)

Approx. 10 users

Safe running water 24/7

Greywater treatment
from handwashing, anal
cleansing & flushing



Greywater treatment

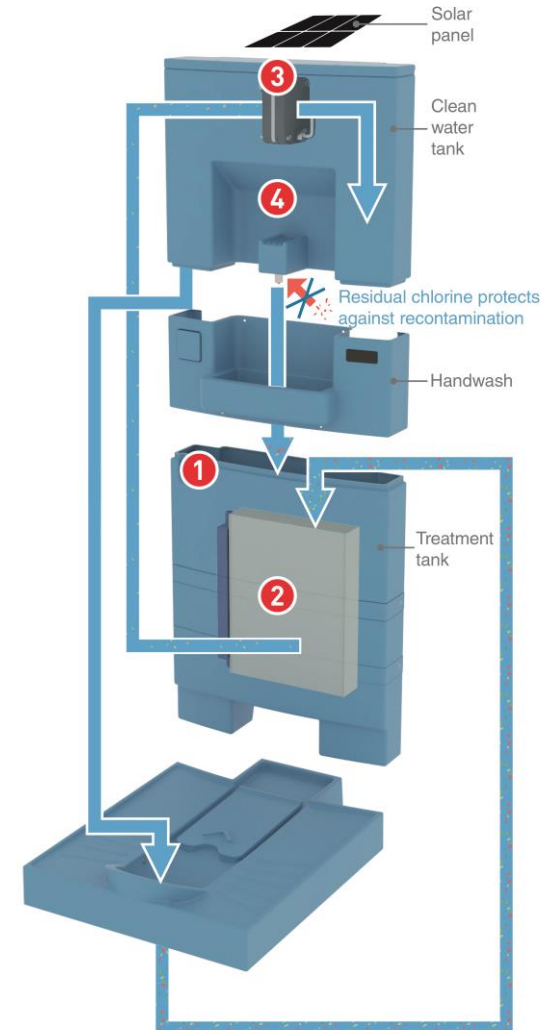


**1+2. Bioreactor membrane
(BAMBi)**

**3. Granular Activated Carbon
(GAC)**

4. Disinfection

- Chlorination
- Electrolysis
- UVC (254nm)



Scope of the study

Goals

1. Achieve safe water in the BDT.
2. Understand inactivation and growth of pathogens within the greywater treatment.

Research questions

1. Can bacterial pathogens grow in treated greywater?
2. Does pathogen growth depend on water characteristics?
3. Can pathogen growth be controlled by adjusting water characteristics? (results not presented)

Can bacteria grow in treated greywater?

Bacteria of interest

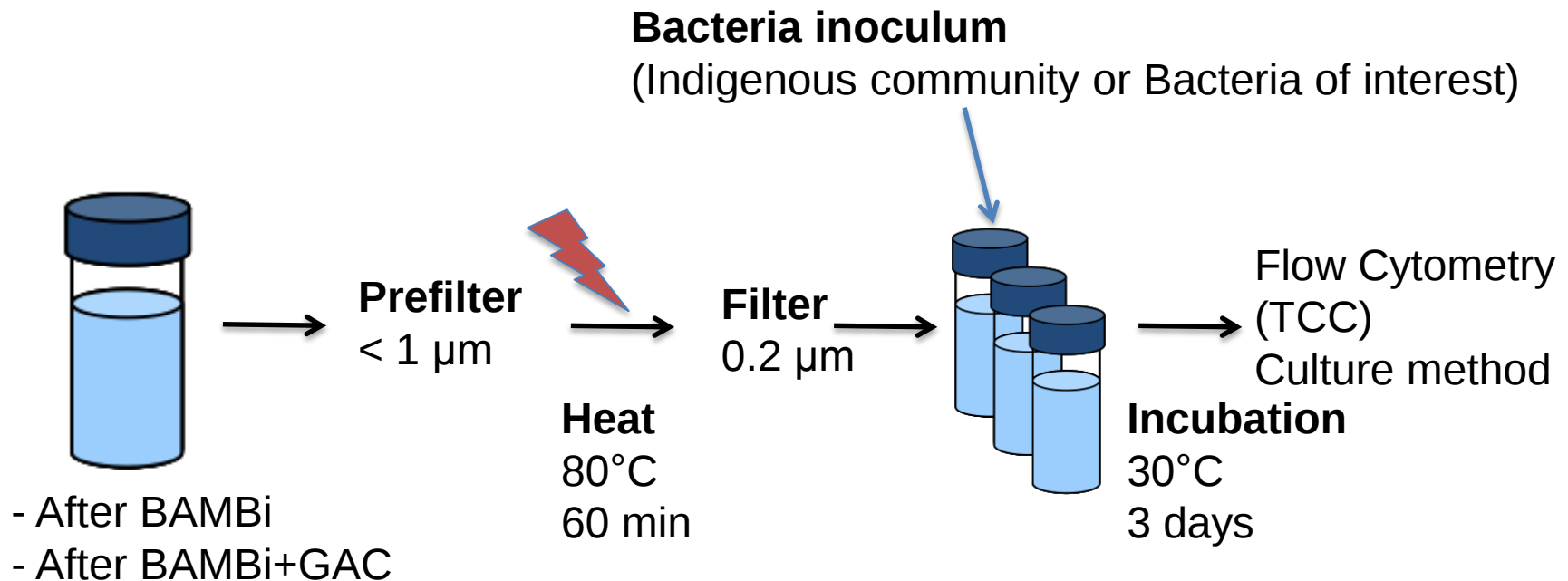
1. Indicators

- *E. coli* (Gram negative)
- *Enterococcus faecalis* (Gram positive)

2. Pathogens

- *Salmonella typhimurium* (from fecal contamination)
- *Pseudomonas aeruginosa* (from skin exposure)

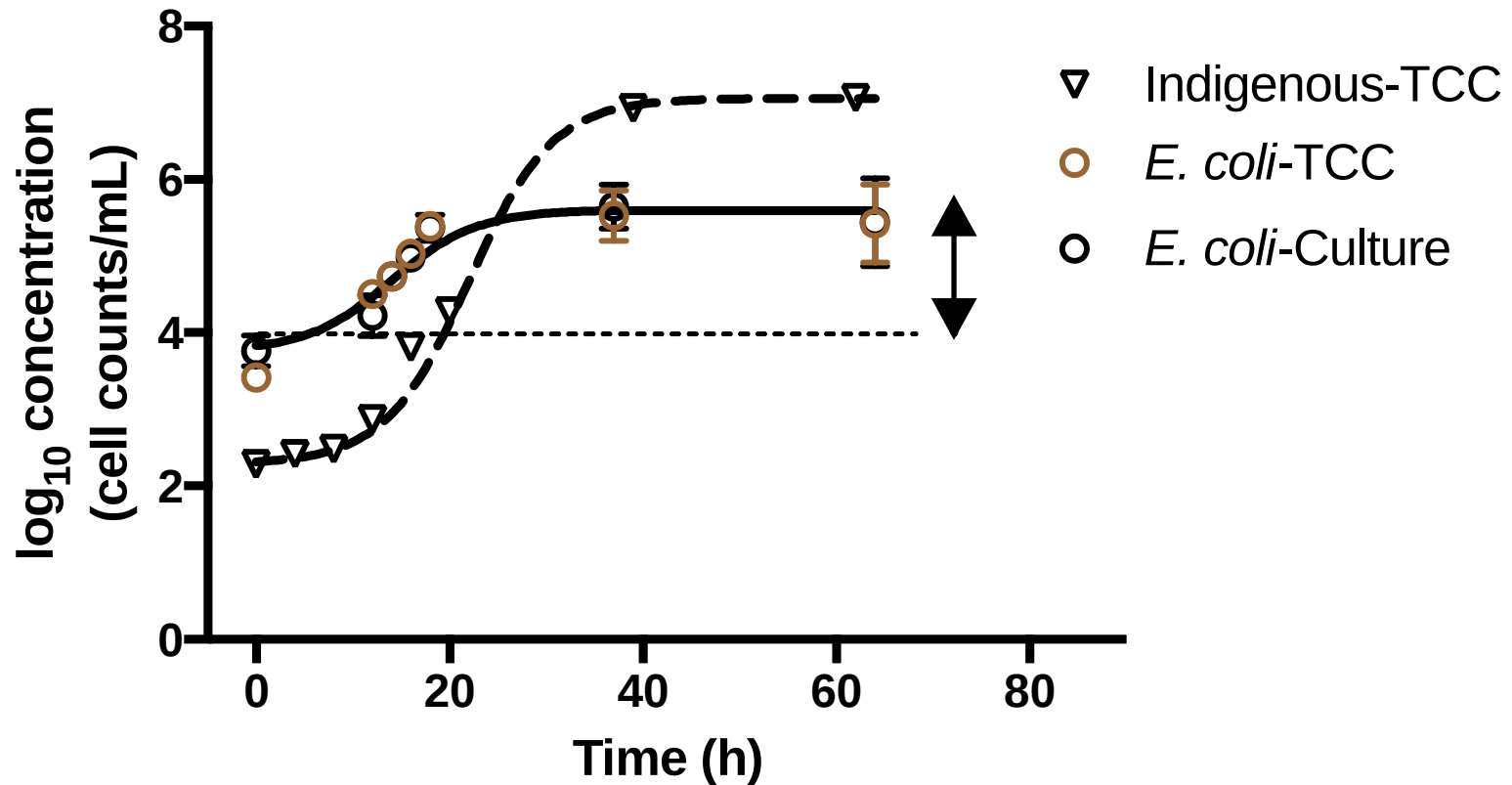
Experimental setup



Adapted from Vital et al. (2010) AEM 76(19)

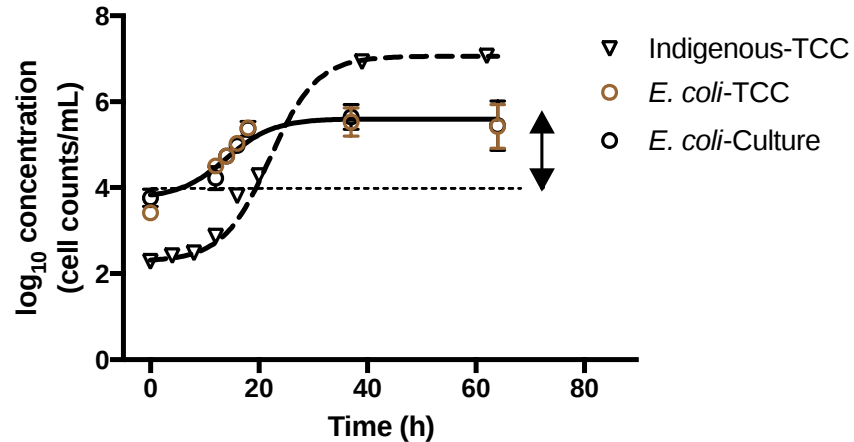
Growth of bacteria in BDT waters

(a) *E. coli* - After BAMBi

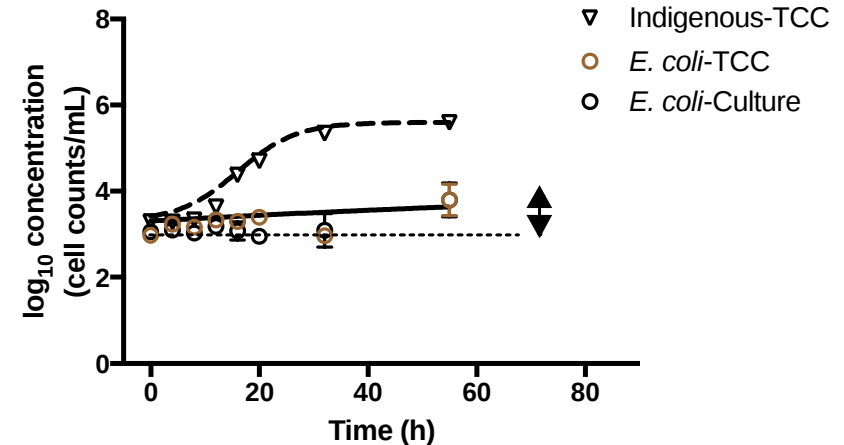


Growth of bacteria in BDT waters

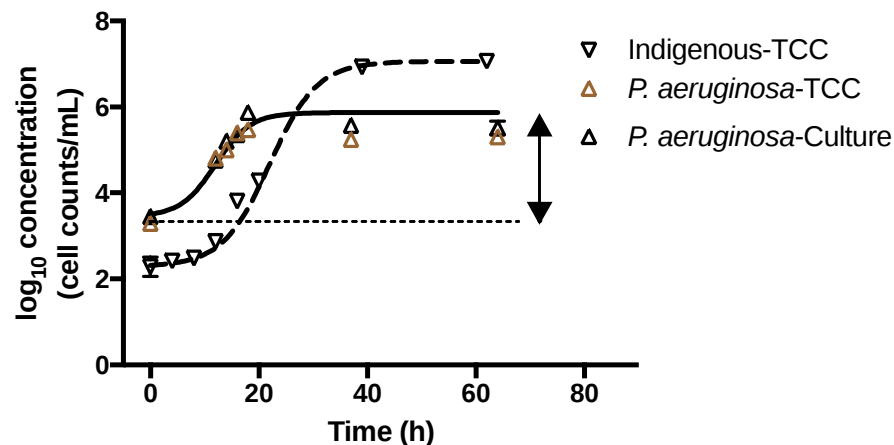
(a) *E. coli* - After BAMBi



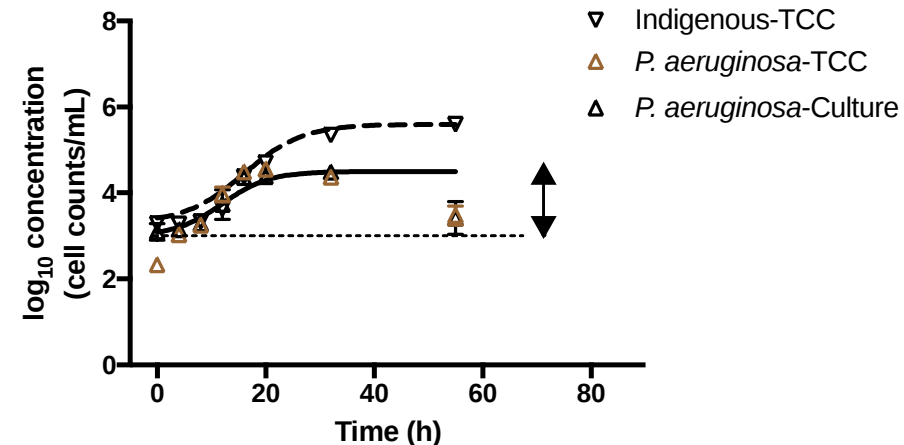
(b) *E. coli* - After BAMBi+GAC



(c) *P. aeruginosa* - After BAMBi



(d) *P. aeruginosa*- After BAMBi+GAC

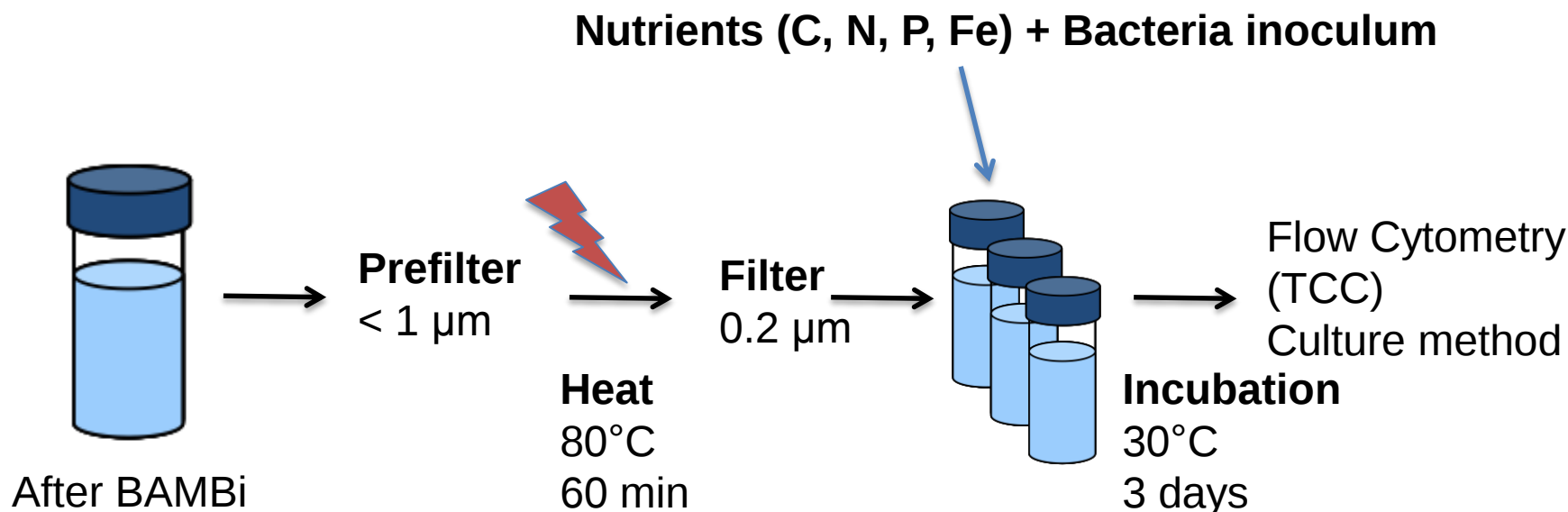


Does pathogen growth depend on water characteristics?

Characteristics of BDT waters

Parameters (mg L ⁻¹)	After BAMBi	After BAMBi+GAC	% Difference
AOC	1	0.04	96
DOC	34	2	94.1
Na ⁺	55	26	52.7
K ⁺	42	20	52.4
PO ₄ ³⁻ – P	8	6	25
NO ₃ ⁻ – N	25	20	20
Mg ²⁺	25	21	16.0
Ca ²⁺	88	83	5.7
pH	8.3	8.1	2.4
Cl ⁻	139	137	1.4
SO ₄ ²⁻ – S	67.2	67.5	0.4
NO ₂ ⁻ – N	<0.5	<0.5	-
NH ₄ ⁺ – N	<0.2	<0.2	-
Fe ^{3+/2+}	<0.2	<0.2	-

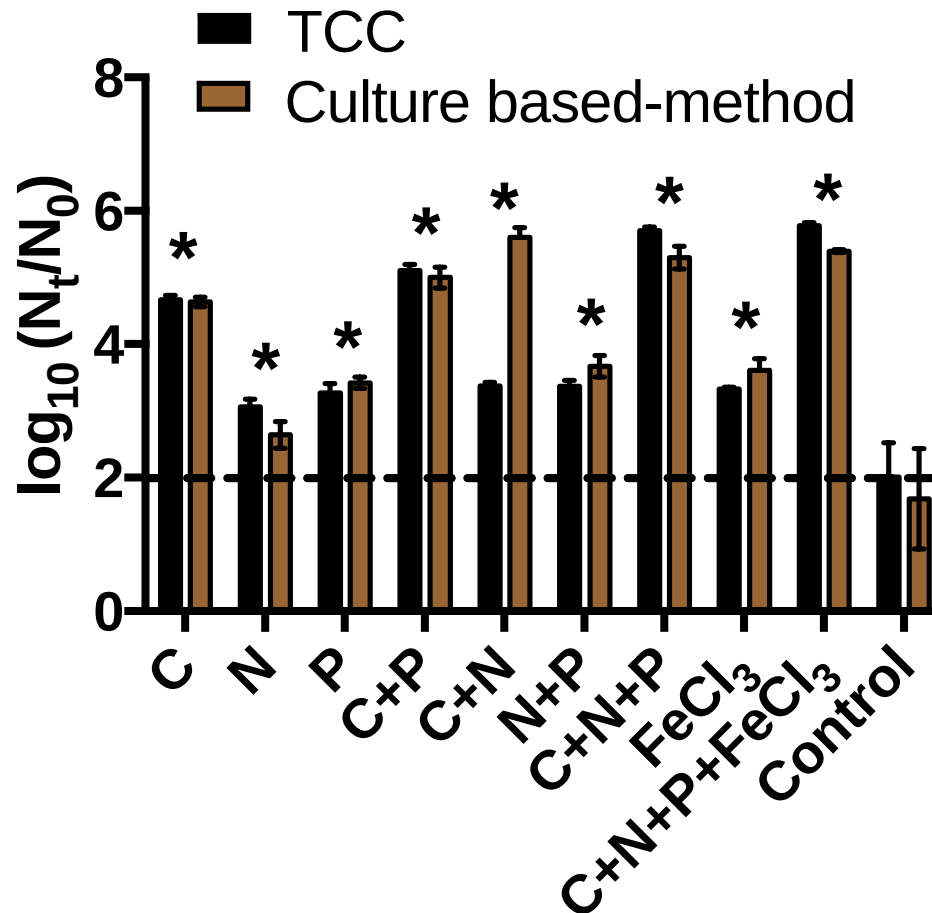
Effect of nutrients on bacterial growth



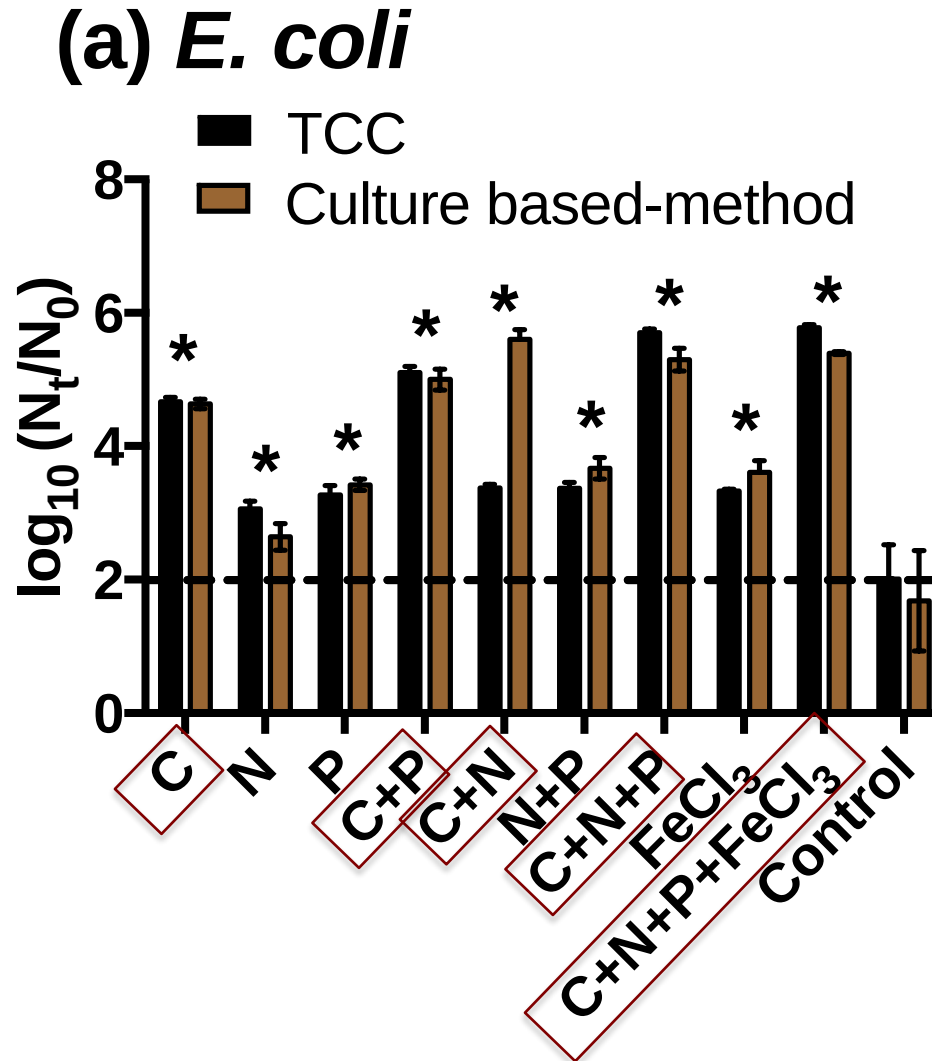
Nutrient	Final conc. (mg L ⁻¹)
C - Acetate	300
N - (NH ₄) ₂ SO ₄	5
P - Na ₂ HPO ₄	80
Fe - FeCl ₃	5

Effect of nutrients on bacterial growth

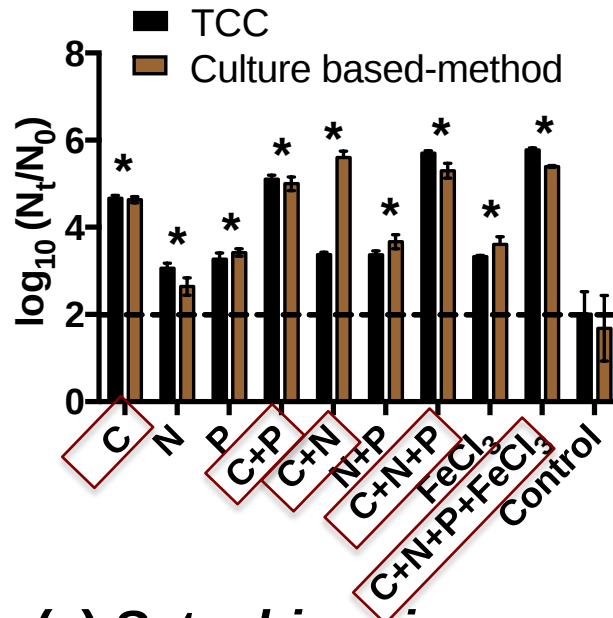
(a) *E. coli*



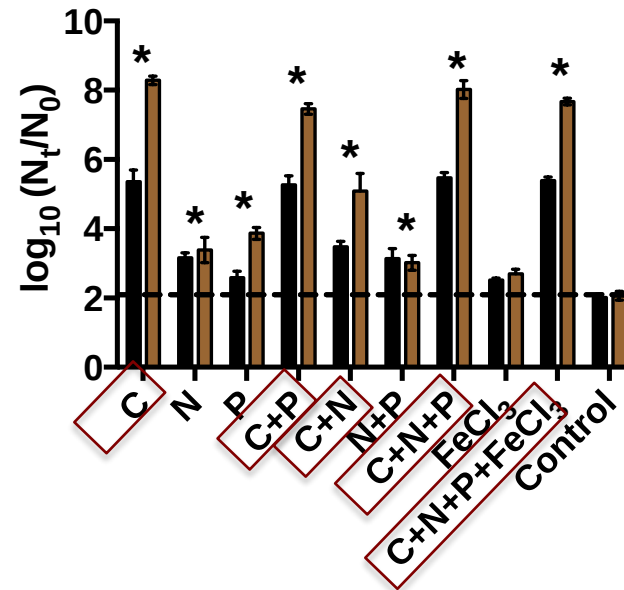
Effect of nutrients on bacterial growth



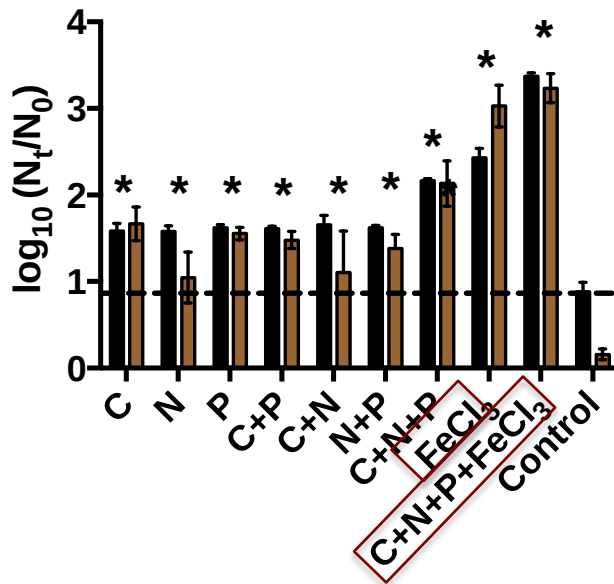
(a) *E. coli*



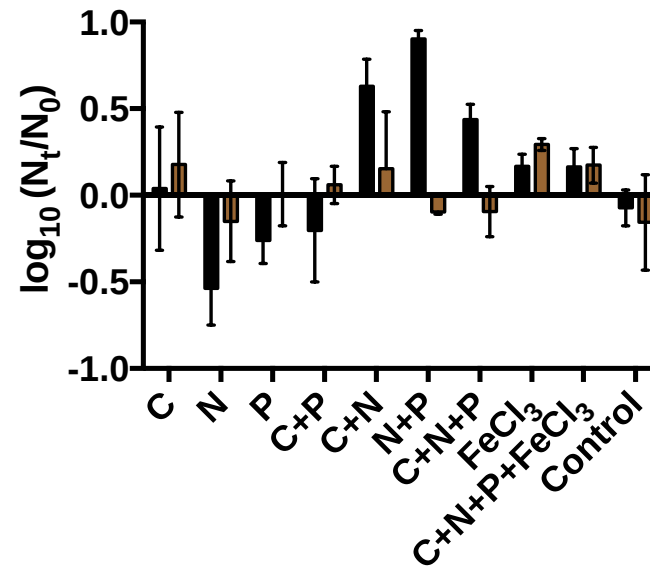
(b) *P. aeruginosa*



(c) *S. typhimurium*



(d) *Ent. faecalis*



(*) Significantly different than the control values.

Take home message

- *E. coli*, and *P. aeruginosa* grew in treated greywater.
- Bacterial growth strongly depended on nutrients.

Acknowledgement

- **Co-authors** (Lukas Allemann, Chris Ziemba, Odile Larive, Eberhard Morgenroth, Tim Julian)
- **Pathogens and Health group** (Ana Karina Pitol, Lea Caduff)
- **BDT group** (Kai Udert, Steffi Enssle)
- **Drinking water group** (Frederik Hammes, Stefan Koetzsch, Juerg Sigrist)
- **Process Engineering Department** (Adriano Joss, Julian Fleiner)
- **Funding: Bill and Melinda Gates Foundation**