Impact of UV radiation dose, suspended solids and organic matter on its efficiency to remove pathogens from greywater

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Greywater reuse

- Greywater (GW) is domestic wastewater excluding the toilet stream

- Using GW may reduce domestic water use by up to 50% and typically used for gardening and toilet flushing

- Many GW reuse standards require to lower indicator bacteria concentrations ➔ **Disinfection is needed**

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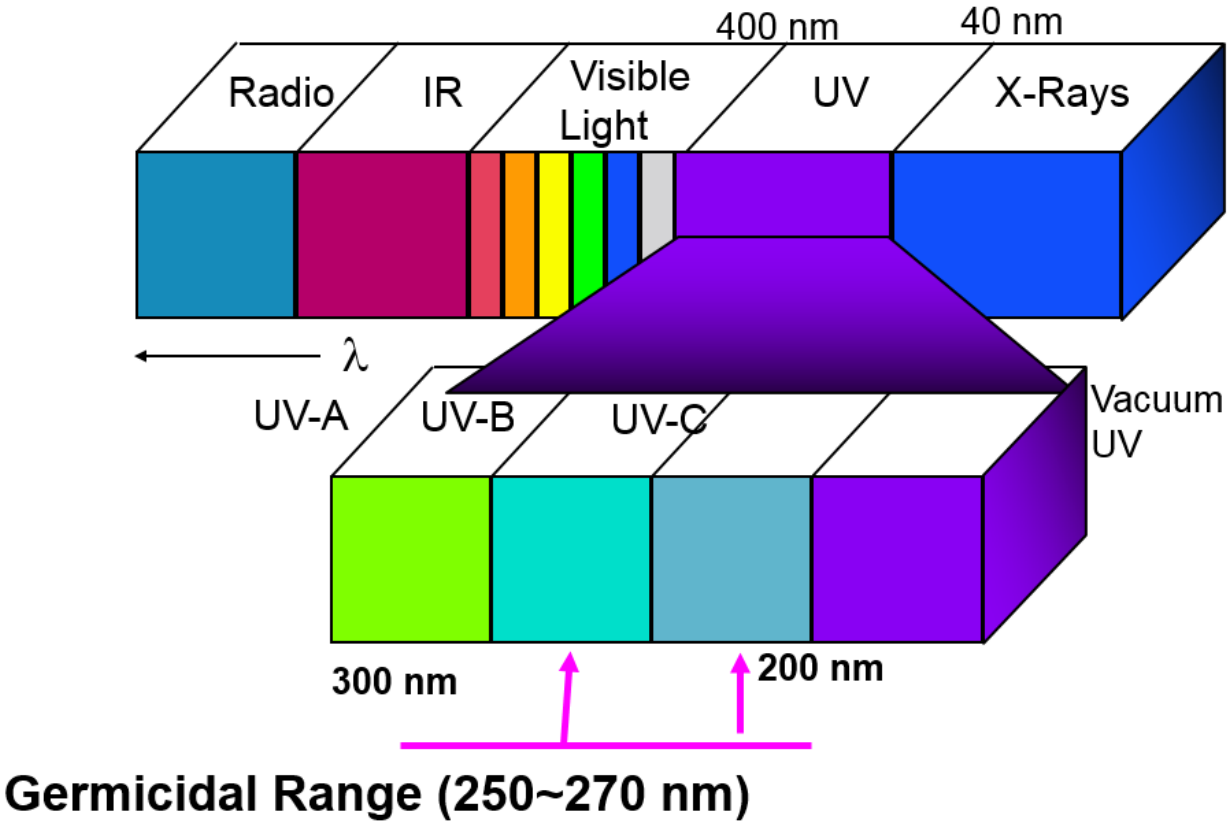
UV Disinfection



UV radiation damages bacterial/viruses nucleic acids (DNA/RNA) , thereby preventing them from replicating

Slide 3

E1 חושב שהשקף הזה מיותר
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Pros and cones using UV

Advantages:

- Does not require addition of chemicals
- Effective on a wide range of pathogens
- Fairly simple and low cost operation and maintenance
- Safe for operators in general and in comparison to chlorination
- No by- products

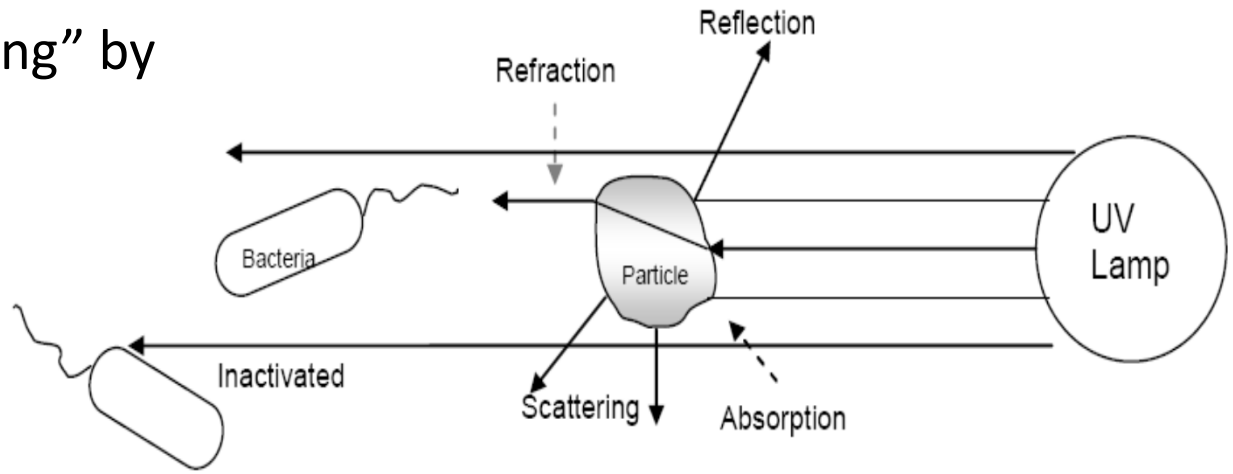
Disadvantages:

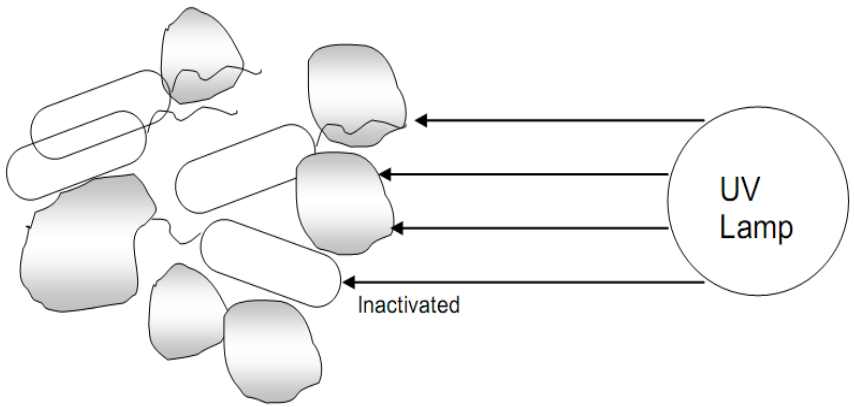
- Disinfection is limited as a result of repair mechanisms
- No residual effect
- Fouling of the quartz sleeve decreases the efficacy of disinfection
- Insufficient water quality might reduce UV efficiency.

Specifically, total suspended solids (TSS) and organic substances

Effect of TSS on UV disinfection efficiency

Impact of particle “shielding” by absorption, scattering, refraction and reflection





Impact of particles enmeshed/associated with microorganisms

Aims

- Investigate the **efficiency** of low-pressure UV disinfection of GW under a range of: **UV doses**, **TSS** and dissolved **BOD_5** concentrations

- Develop a **statistical model** for the prediction of the impact of TSS and BOD_5 on disinfection efficiency

- Correlate between a **collimated beam results** that is mostly used in the laboratory to **flow-through reactors** which are mostly used in the field

Laboratory setup:
Range of TSS and BOD were tested

Treated GW

Recirculating vertical flow constructed wetland

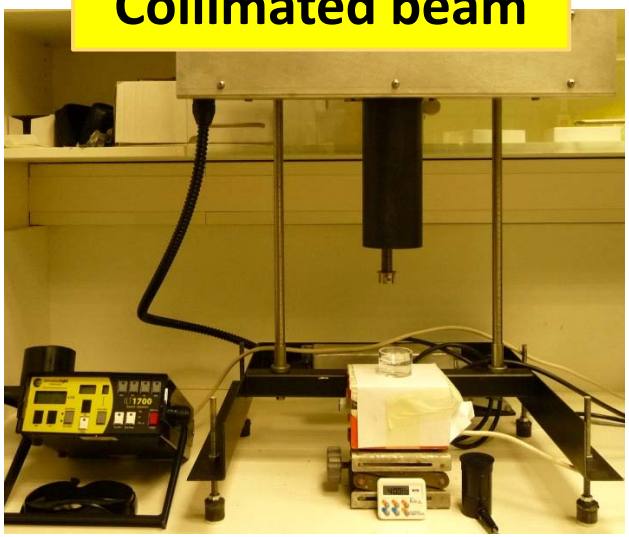
Changing concentration of TSS and BOD

Each sample, 3 replicates

Variable	Range
FC (CFU/100ml)	10^4 - 10^5
TSS (mg/L)	1-130
BOD (mg/L)	3-100

432 combinations

Collimated beam



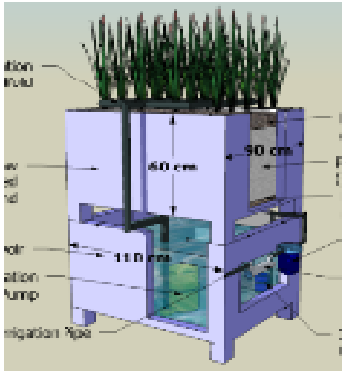
UV irradiation doses:
7.5, 15 and 30 mJ/cm^2

Field experimental setup: Range of TSS and BOD were tested

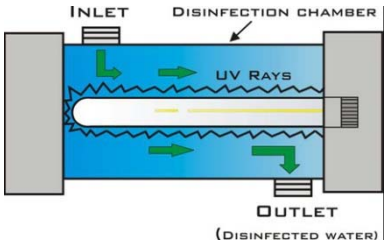
Household GW source (bathroom and laundry)

Storage of Raw GW

GW Biological Treatment

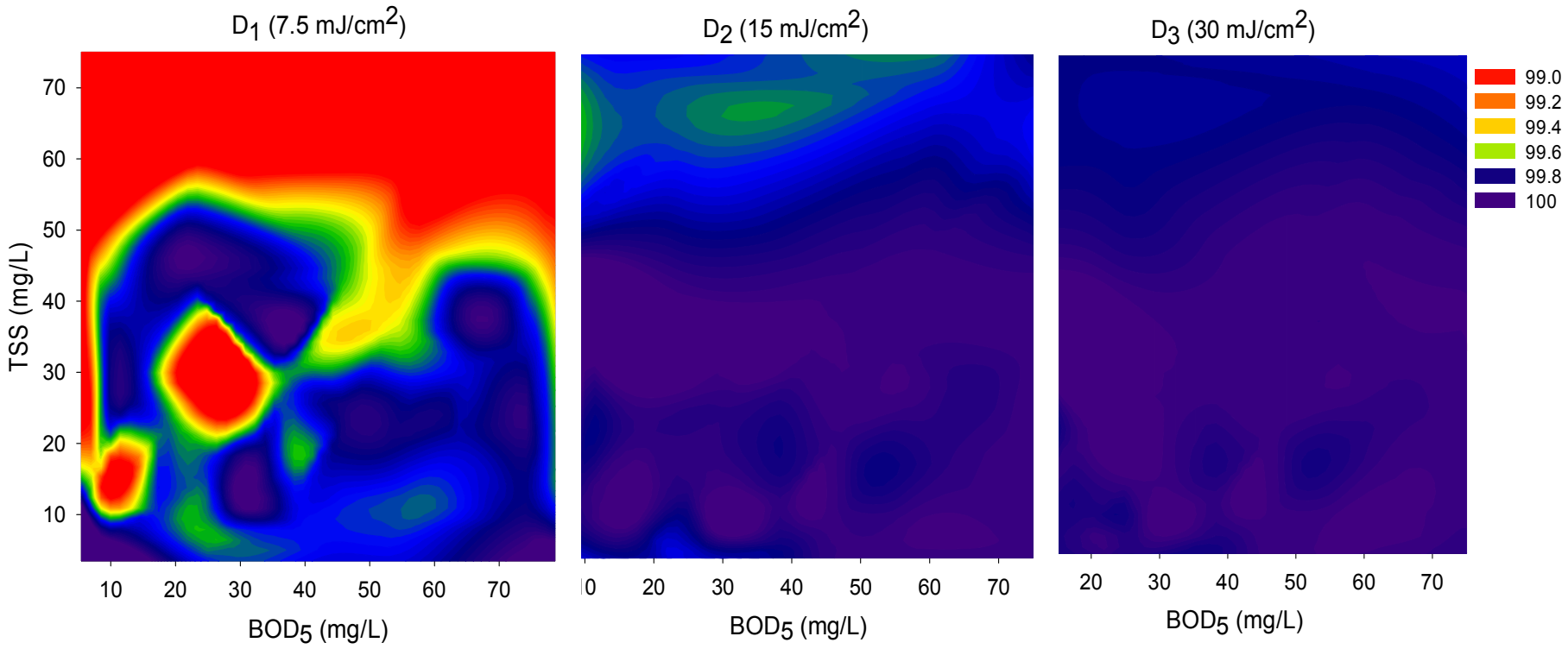


UV Disinfected GW dose: 44 mJ/cm²



Quality of pre-disinfected treated GW from 11 onsite treatment systems	Range
TSS (mg/L)	3.9-233
BOD (mg/L)	0-107
% Transmission$_{254\ nm}$	39-85
Turbidity (NTU)	1.47-512
FC (CFU/100ml)	0-10^6

Results:
Collimated beam

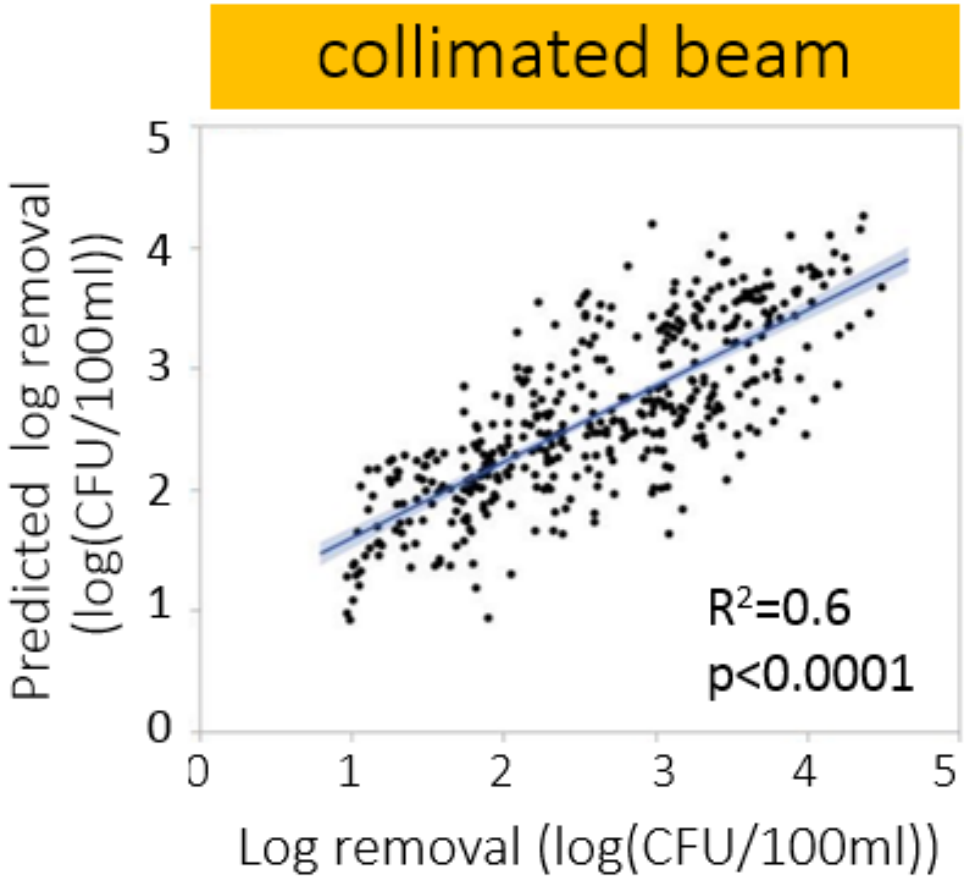


As expected, disinfection efficiency increased with increasing UV dose and was negatively affected by the presence of TSS and BOD.

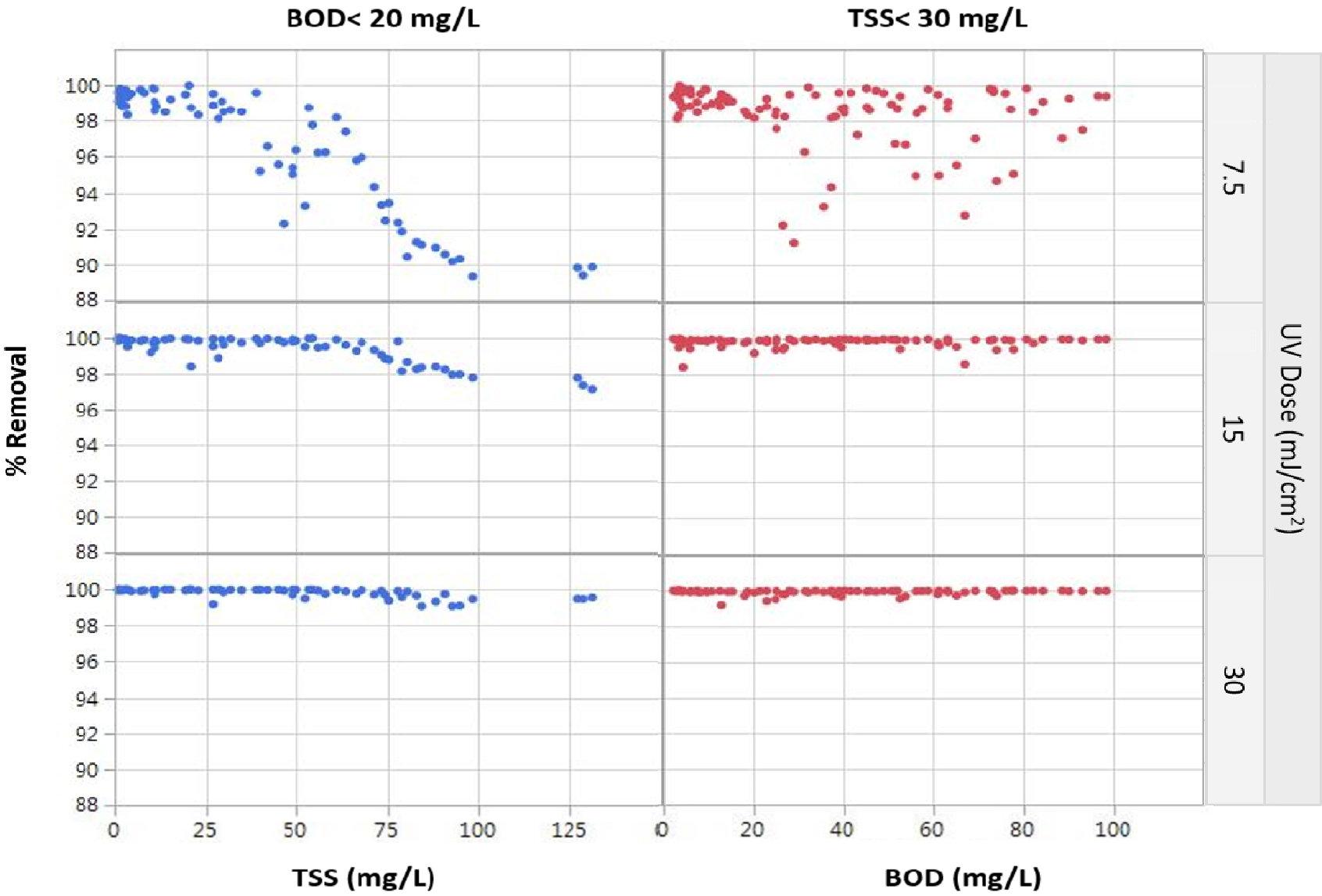
Results: Multiple linear regression (MLR) model

$$\log FC\ removal = \beta_1 \cdot [BOD] + \beta_2 \cdot [TSS] + \beta_3 \cdot [\log FC_{Gw}] + \beta_4 \cdot [UV\ dose]$$

Coefficient	Estimate	p-value
β_1	0.001	**0.2211***
β_2	-0.012	<0.0001
β_3	0.495	<0.0001
β_4	0.059	<0.0001



TSS reduced the UV disinfection efficiency more than BOD_5



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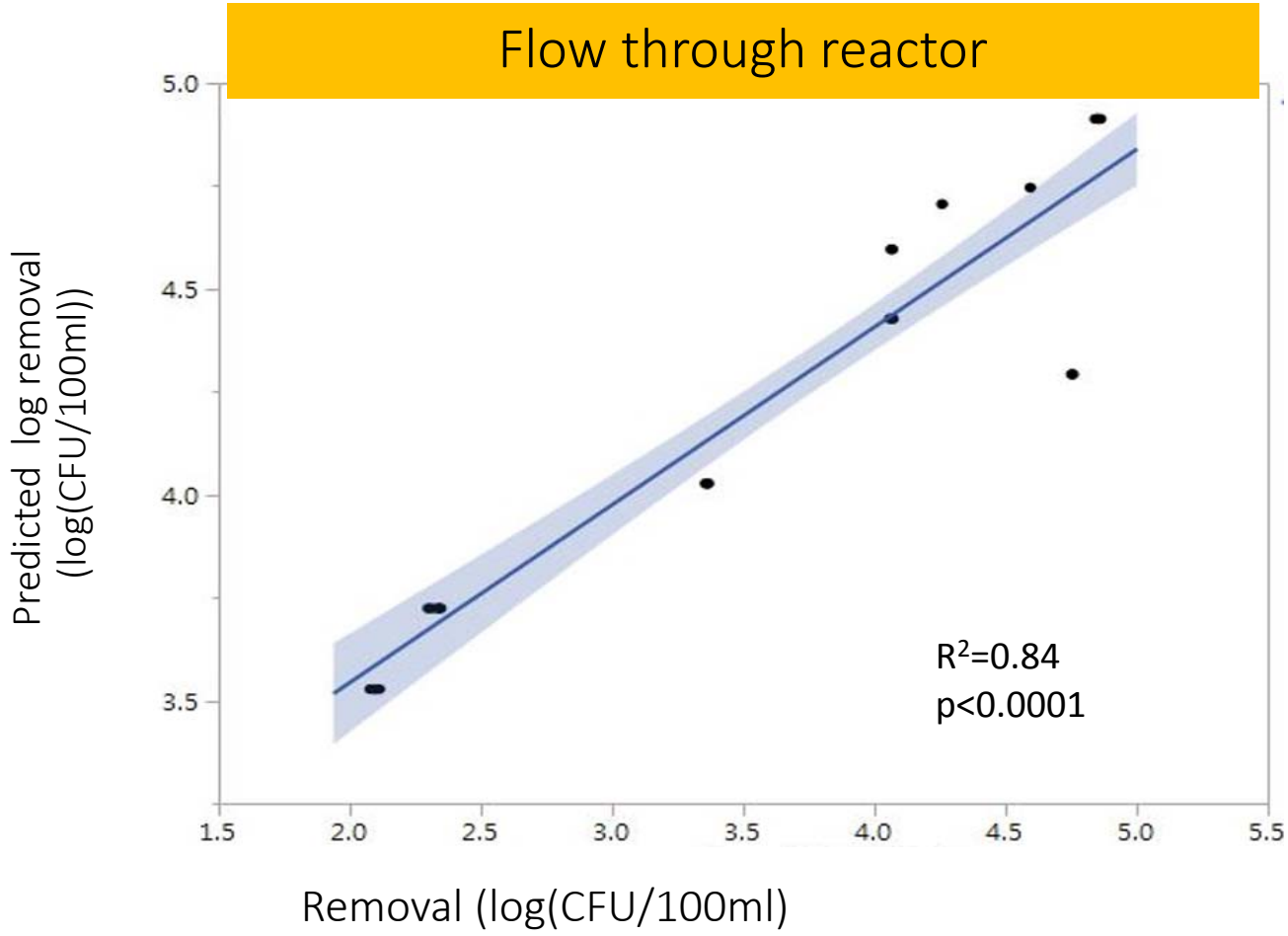

Results:
Correction Factor (CF)

For the same log removal dividing the measured UV dose in the flow-through **reactor** by the model-predicted UV dose (based on **collimated beam** results), resulted in a **correction factor** (CF) of 7.47

Reactor UV dose = 7.47 · UV collimated beam

Conclusions:

- UV disinfection efficiency decreases as a result of increasing TSS concentration beyond a threshold value of 50 mg/L.
- As UV dose ↑ the influence of TSS ↓ (30 mJ/cm CB).
- The effect of dissolved organic substances on UV disinfection efficiency is significantly smaller than of TSS.
- It is possible to predict GW disinfection efficiency by simple MLR model → take it into consideration for system design.
- A correction factor (7.5) was established between Laboratory based collimated beam results and Field, flow through reactors

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E3

Thank you for your attention

Questions?

ερωτήσεις ?

The research was supported by ***Rosenzweig-Coopersmith Foundation*** and the ***Zuck Maccabi Fund***.

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E2 הביטוי באנגלית לשאלות ביוונית
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E3 erotíseis
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