Potential interactions between UV filters and environmental microbial communities

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Patricia A. Holden, Ph.D., P.E.

Professor, Bren School of Environmental Science & Management

Earth Research Institute, Univ. of Calif., Santa Barbara, CA 93106, U.S.A.

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Approved active ingredients in sunscreen

Aminobenzoic acid
Avobenzone
Cinoxate
Dioxybenzone
Homosalate
Meradimate
Octocrylene
Octinoxate
Octisalate
Oxybenzone
Padimate O
Ensulizole
Sulisobenzone
Titanium dioxide
Trolamine salicylate
Zinc oxide

UV filters

https://www.fda.gov/drugs/understanding-over-counter-medicines/sunscreen-how-help-protect-your-skin-sun#ingredients

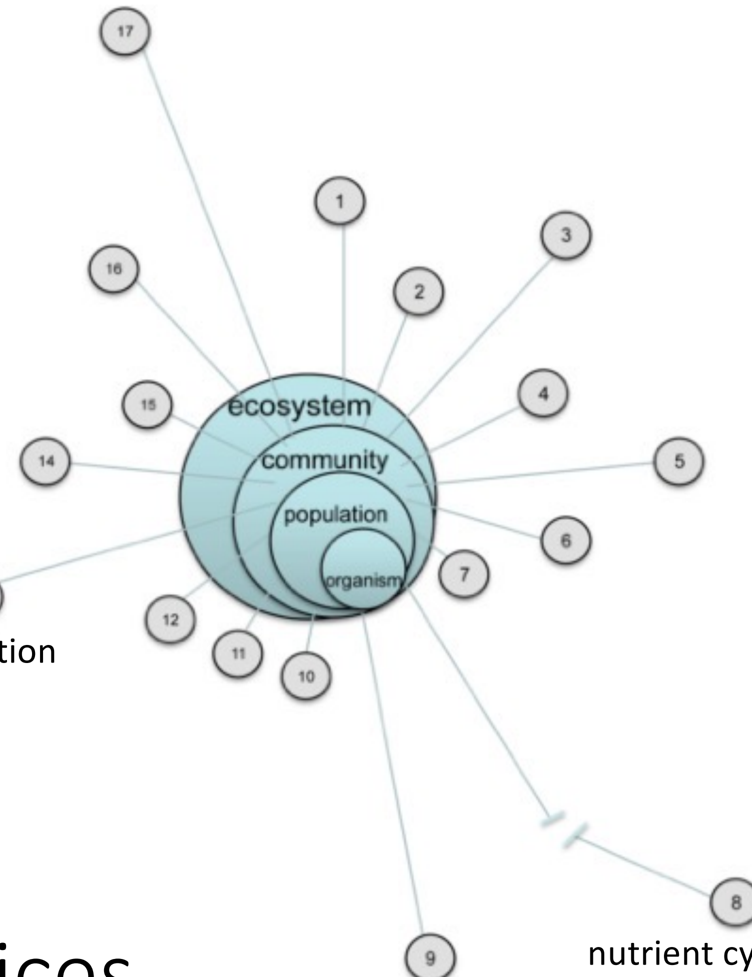
questions

- How might microbial communities transform UV filters?

- How might UV filters affect microbial communities?

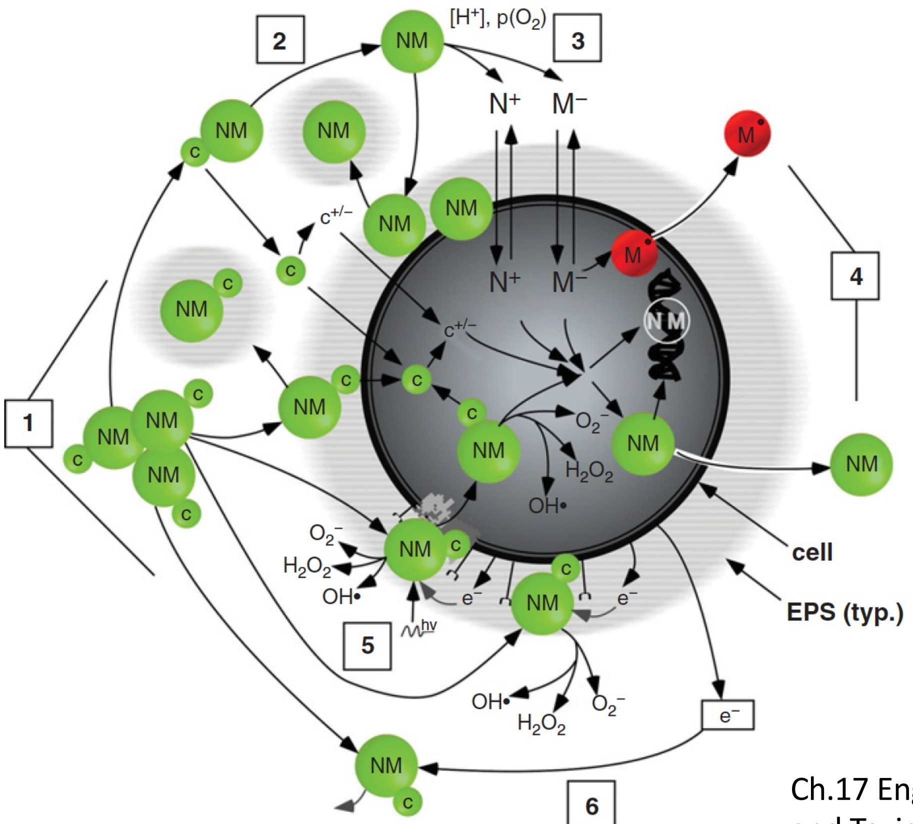
Microbial Communities

- Microbes
  - bacteria (*Bacteria* and *Archaea; 1 μm*)
  - fungi, algae, protozoa (*Eukarya 10 μm*)
  - viruses (1 nm)
  - symbioses



Ecosystem Services

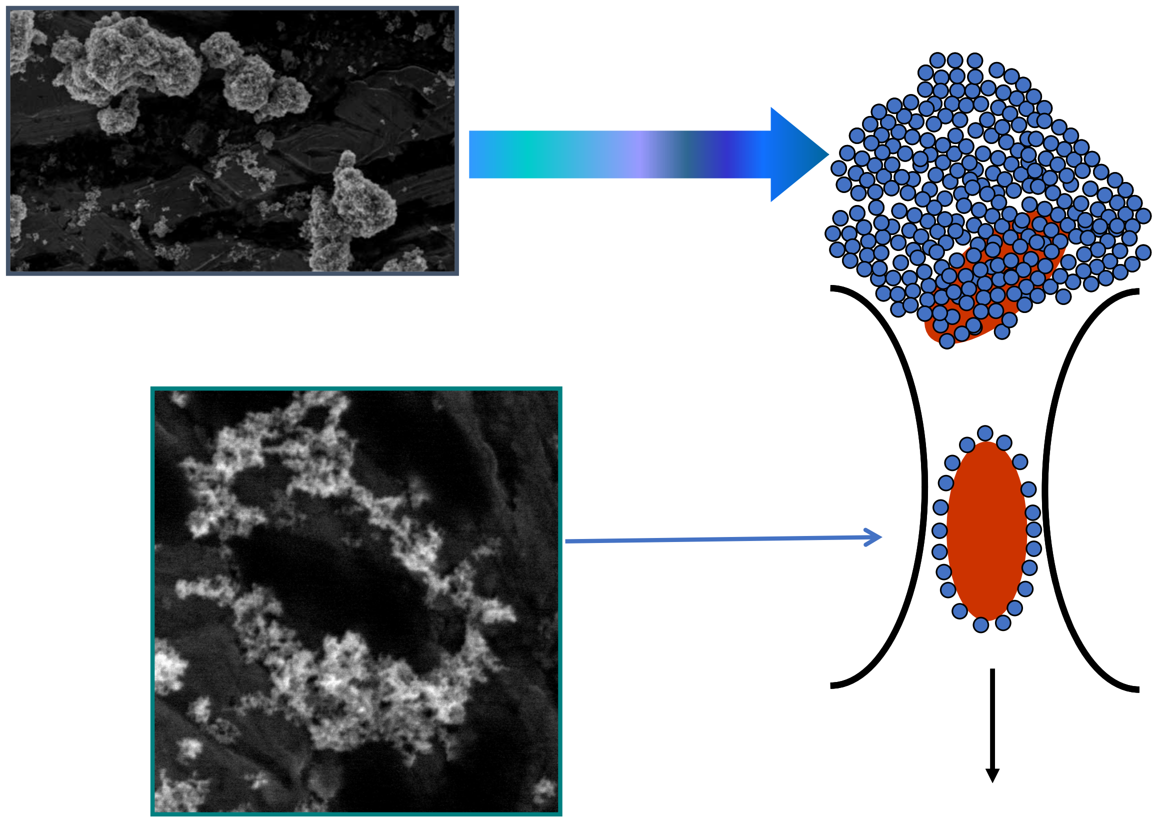
Potential Cell-NM Interactions



1. Sorption / desorption
2. Cap or coating loss
3. Decomposition
4. Expulsion
5. Membrane interactions
6. Extracellular e^- transfer

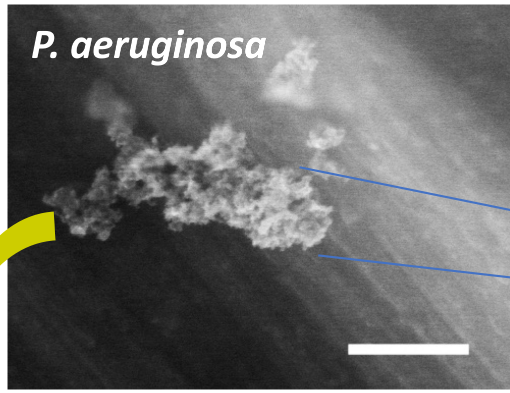
Ch.17 Engineered Nanoparticles and the Environment: Biophysicochemical Processes and Toxicity, First Edition. Edited by Baoshan Xing, Chad D. Vecitis and Nicola Senesi.

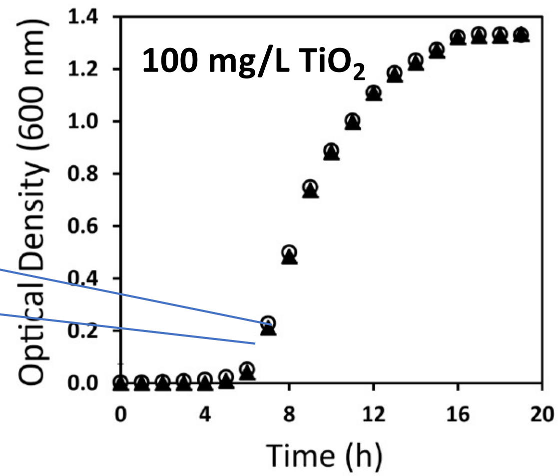
1. $nTiO_2$ sorbs to bacteria; disagglomerates



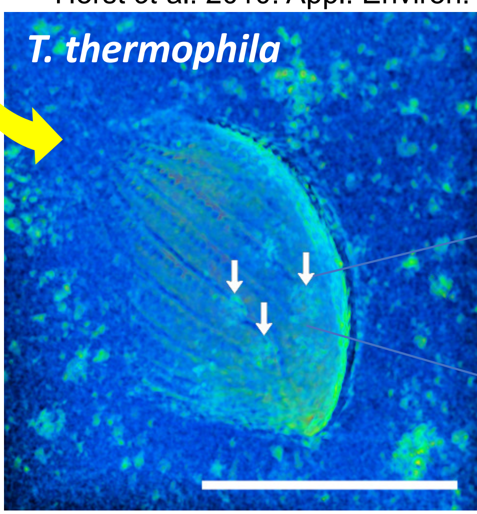
Horst *et* al. 2010. Appl. Environ. Microbiol.

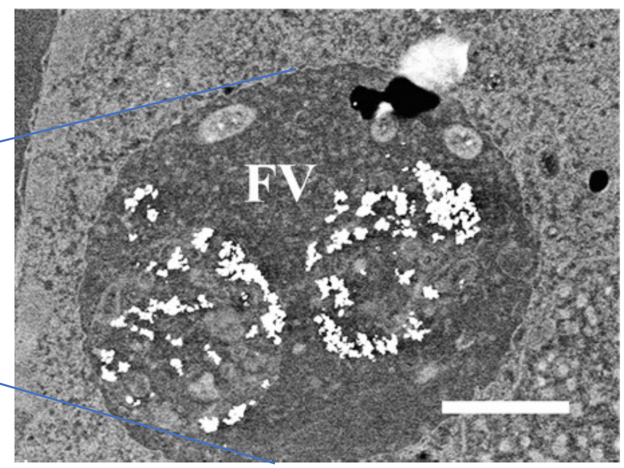
1. $nTiO_2$ Trophic Transfer to Protozoans





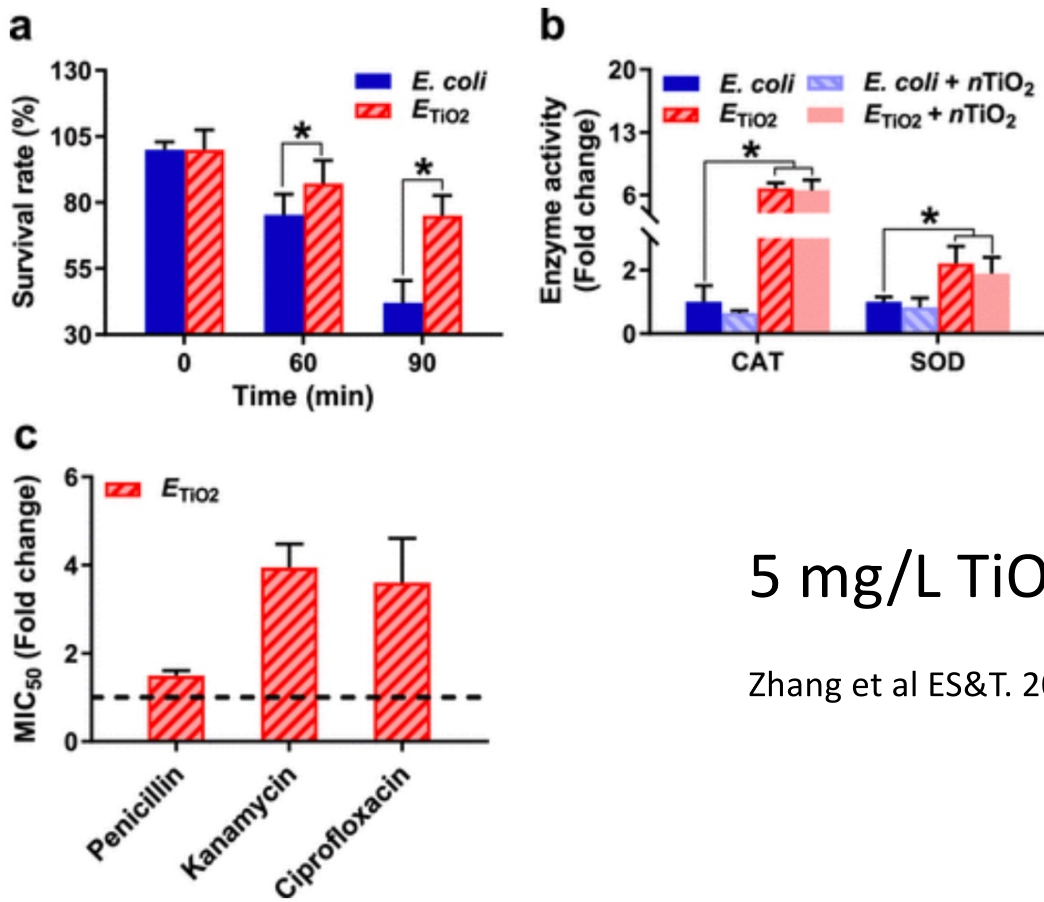
Horst *et al.* 2010. Appl. Environ. Microbiol.





Mielke et al. 2013. Appl. Environ. Microbiol.

2. Commensal to Pathogen Transition in *E. coli*

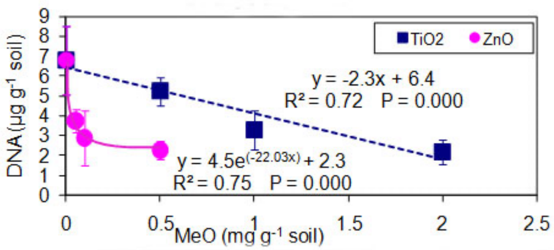


5 mg/L TiO_2

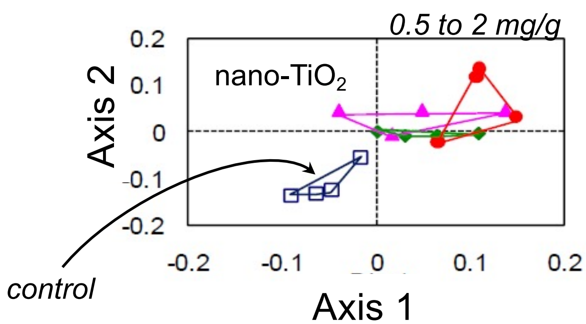
Zhang et al ES&T. 2020

2. Evidence for ZnO and TiO_2 MNMs Impacting Soil Bacterial Communities

Decrease Soil DNA

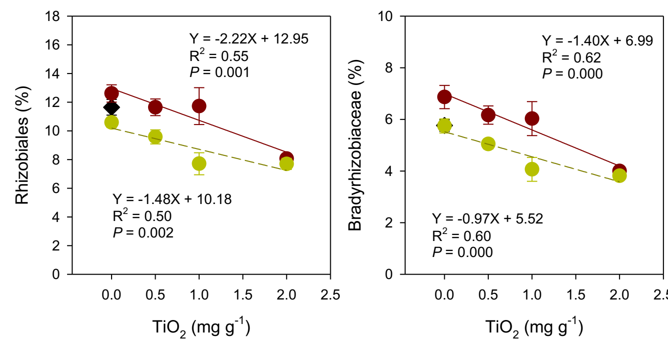


Change bacterial community



Ge et al. 2011. ES&T.

Alter select taxa abundance



Upper: 15d
Lower: 60d

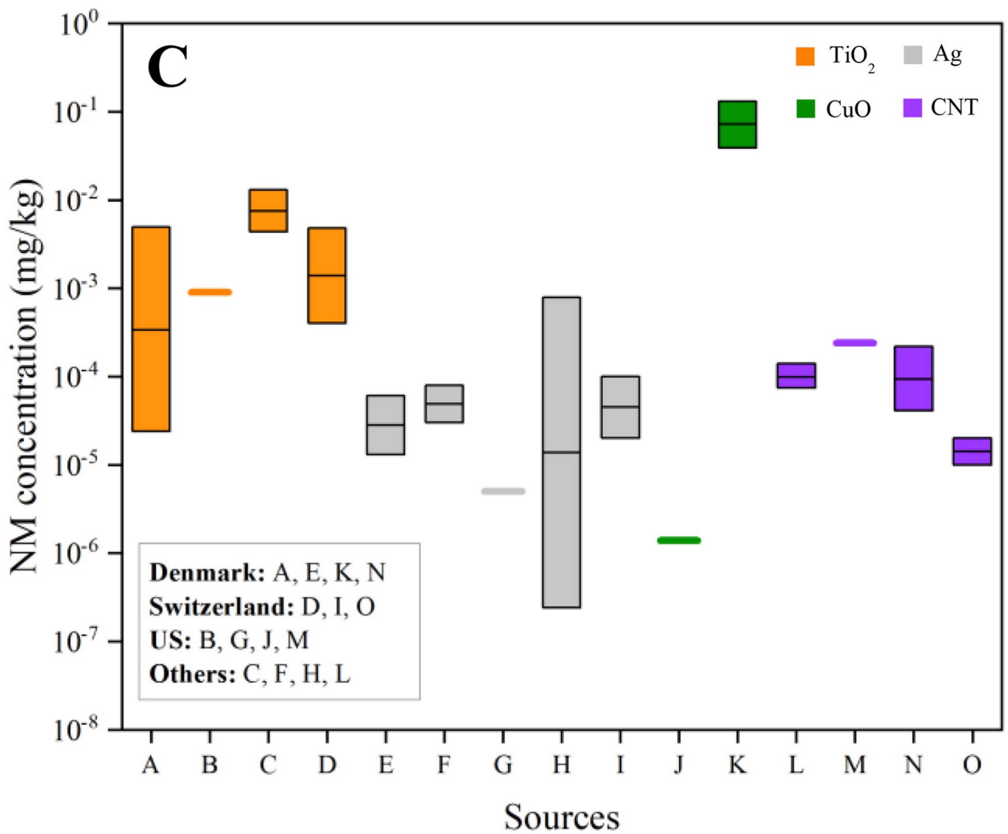
Incl.: N_2 fixation, C cycling, CH_4 oxidation

Potential Ecosystem Effects

Ge et al. 2012. Appl. Environ. Microbiol.

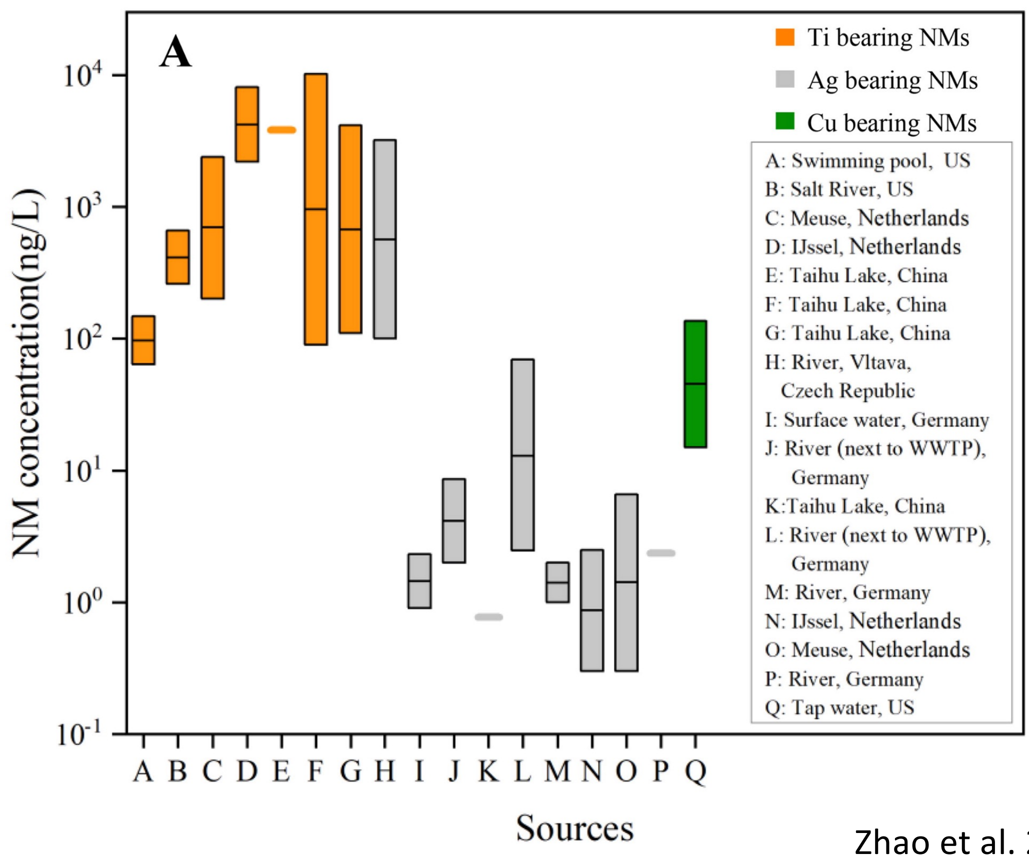
2. Concentrations (Ti NMs) in soil

1E6 X lower



Zhao et al. 2020. Crit. Rev. Environ. Sci. Technol.

2. Concentrations (Ti NMs) in waters

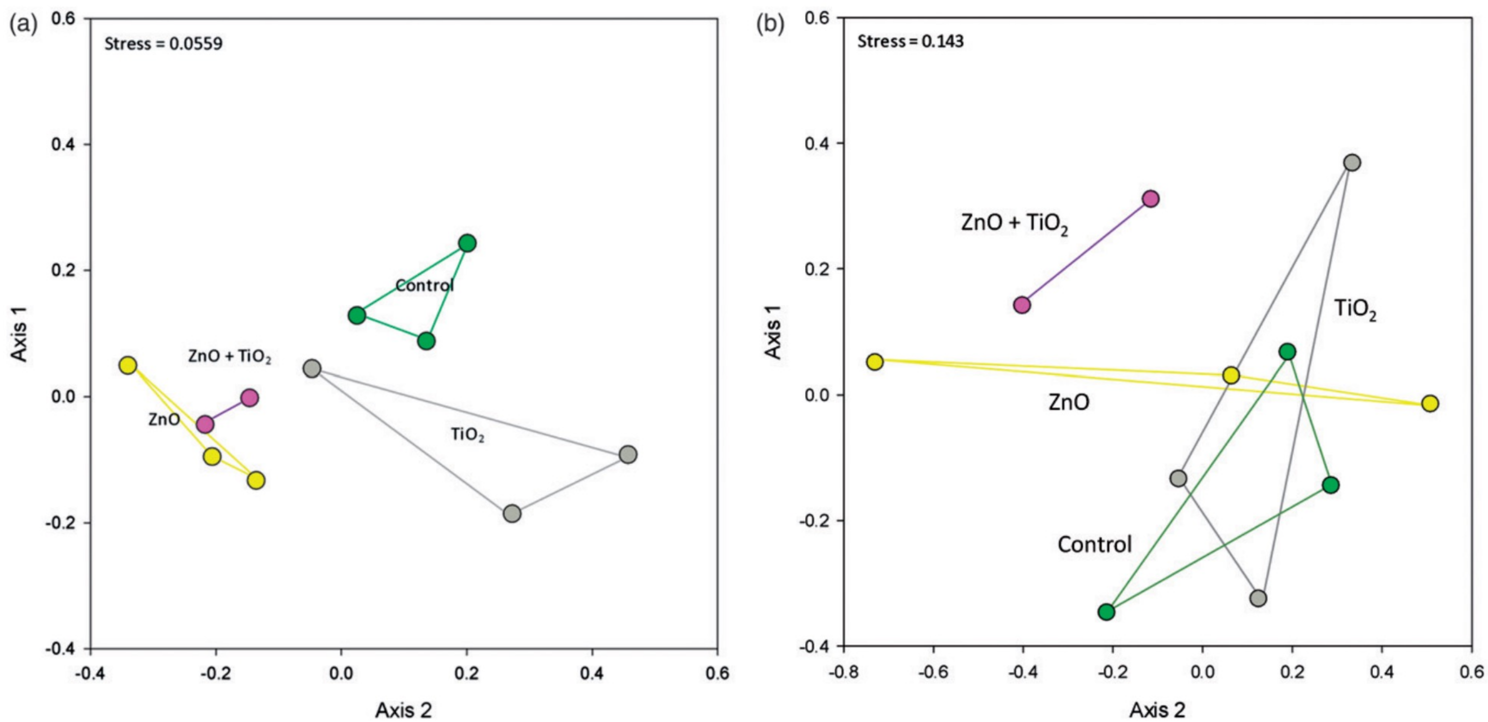


Zhao et al. 2020. Crit. Rev. Environ. Sci. Technol.

2. Effects on microbial communities

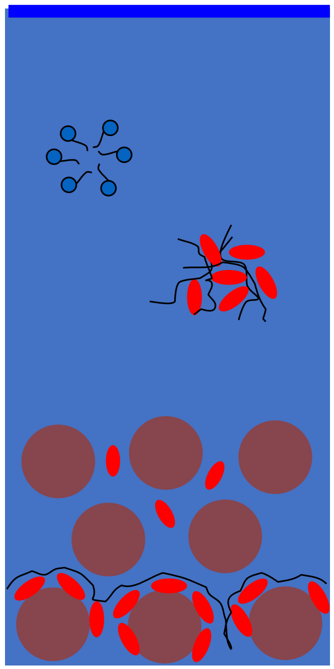
5 mg/L TiO_2: river water bacterial community membrane damage (light > dark; free living > biofilm) Battin et al. ES&T 2009.

700 μg/L TiO_2
70 μg/L ZnO
In river water;
Londono et al.
Nanotox. 2017

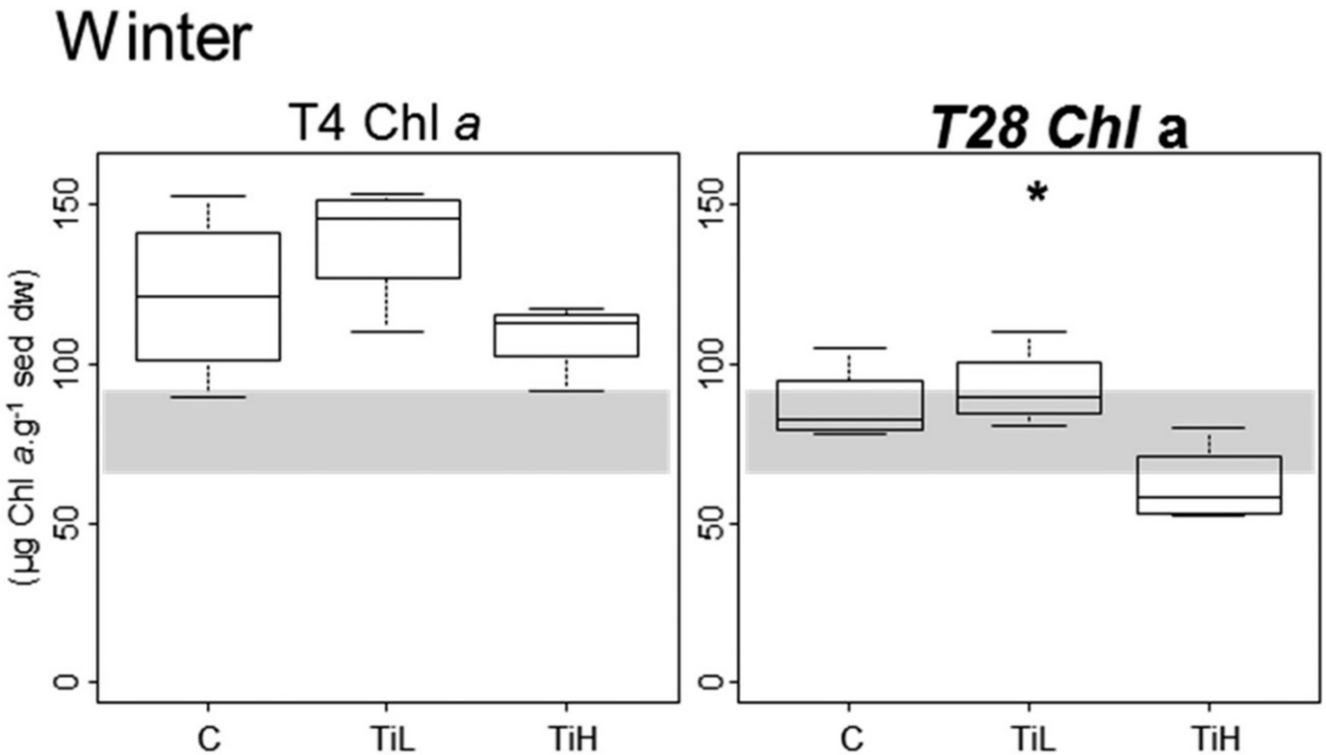


Microbes: aquatic Sub-compartments

- Air/ water interface (neuston)
- Column
  - Micelles
  - Flocs
  - Pore water
- Solid/water interface
  - biofilms



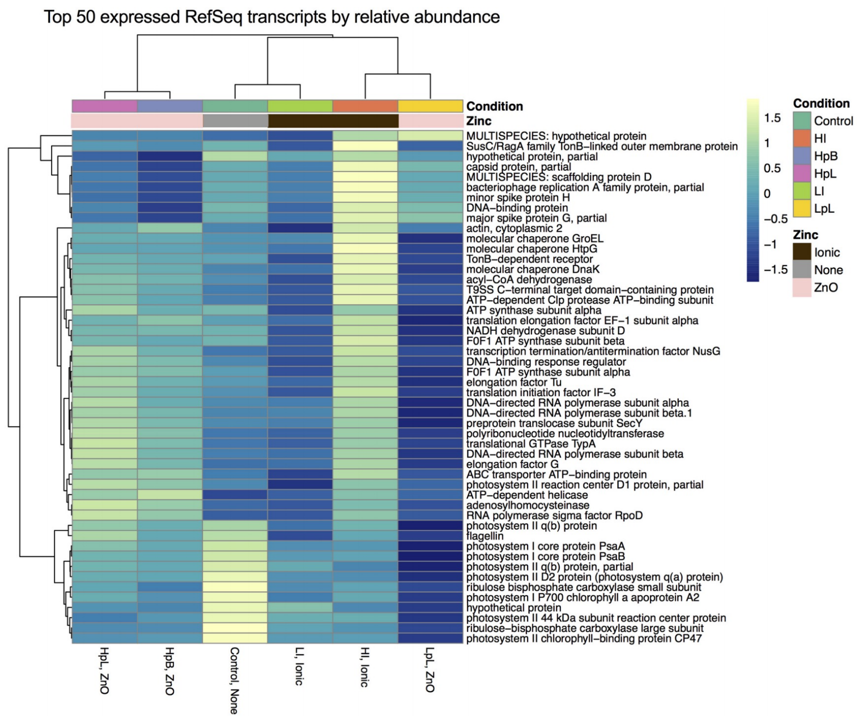
2. Primary production: coastal benthic algae



25 µg/L 25 mg/L

Passarelli et al. 2020. Environ. Sci. Nano.

2. Aquatic (riverine) biofilms responses to ZnO w/ coatings, and Zn ions



- Exposures on order of 100 $\mu g/L$
  - Biofilms concentrated Zn
- Gene abundances altered
  - Photosynthesis, N cycling, lipid degradation and synthesis, antibiotic resistance, xenobiotic degradation
- Yet overall function maintained through compensation
- Forms similar, although coatings matter
- Biofilm structure ('dissolution") changed (motility).

Bergsveinson et al. 2020. Front. Microbiol.

Summary Points

- *How might microbial communities transform UV filters?*
  - Physical association:
    - disagglomeration → dispersion → distribution
    - trophic transfer → food webs
  - EPS/ biomacromolecules: distribution, toxicological properties (corona)
- *How might UV filters affect microbial communities?*
  - community → composition → diversity → functional groups
    - f(concentration, media, physical state, compartment)
    - functional implications inferred
  - transcription
  - function (primary production, N cycling, waste treatment)
  - Pathogenicity
- Factors:
  - NM coating, concentration
  - Environmental compartment
  - Growth habit: biofilm vs floc or planktonic
- Methods: ”omics” revealing process-related effects w/o necessarily large changes in diversity or stress response. Ecosystem-relevant microbial functional changes evidenced.