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2022

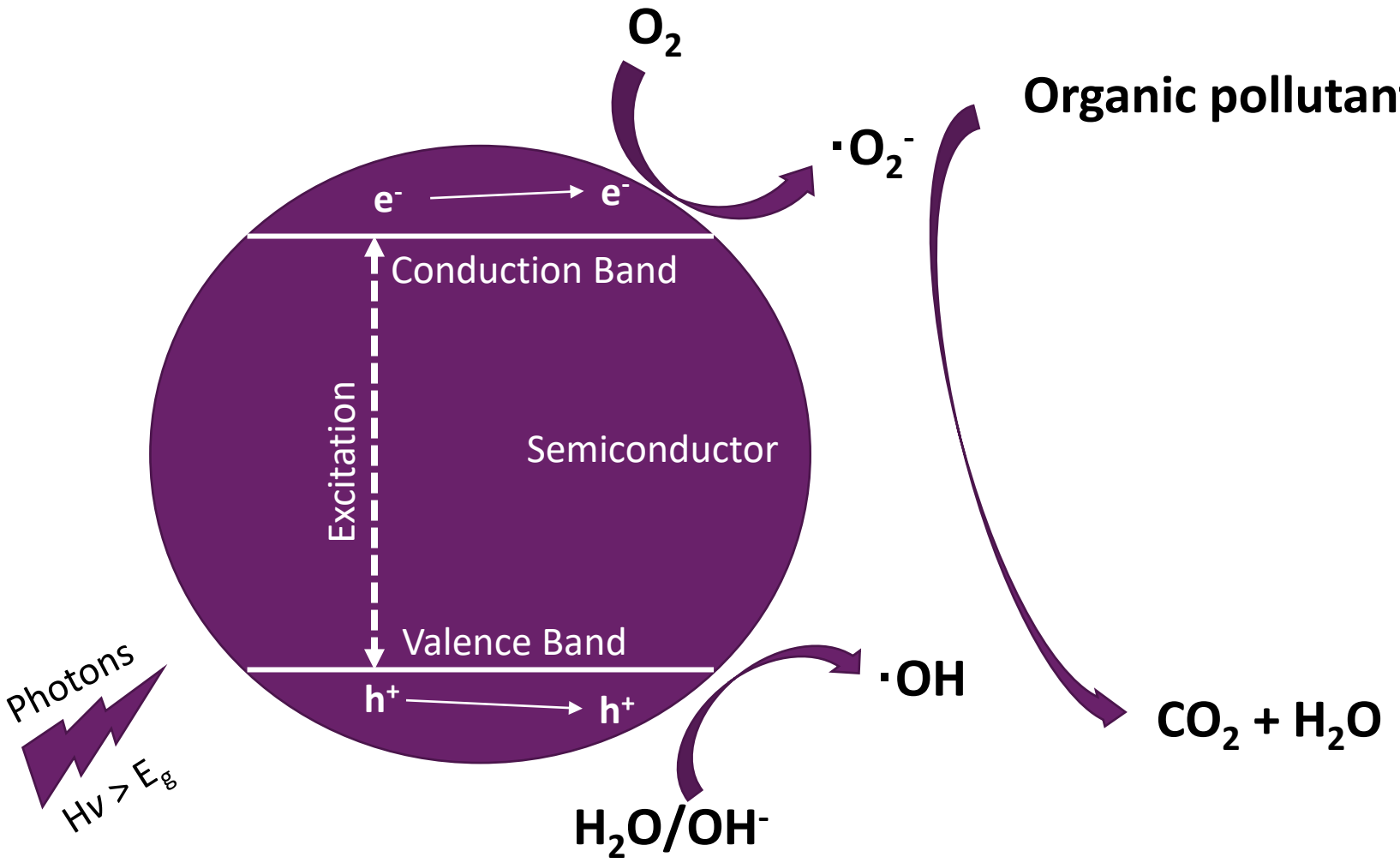
ROBERT GORDON UNIVERSITY ABERDEEN

A paradigm-shift in water treatment: In-reservoir UV-LED-driven TiO_2 photocatalysis for the removal of cyanobacteria – a mesocosm study

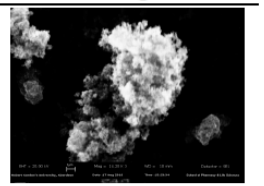
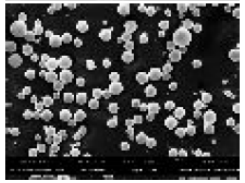
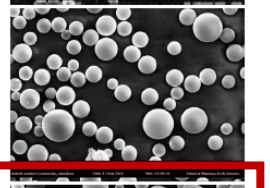
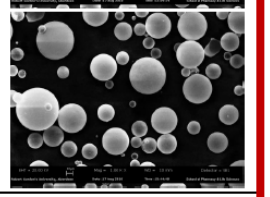
Carlos J. Pestana, José Capelo-Neto, Jianing Hui, Peter K.J. Robertson, Mario U.G. Barros, Samylla Oliveira, Ricardo Rogers, Allan A. Santos, Ana Beatriz F. Pacheco, Sandra M.F.O. Azevedo, Christine Edwards, John T.S. Irvine, Linda A. Lawton


Treated
Control

Semiconductor photocatalysis



TiO_2 immobilisation onto hollow glass spheres

Material	Properties	Image
Degussa P25	Nanoparticulate powder, BET surface area: 50 m^2 g^{-1}, average particle size 20 nm	
Photospheres™15μm	Coated silica beads, BET surface area: 38 m^2 g^{-1}, average particle size 15 μm	
Photospheres™MTO/0131	Coated silica beads, no surface area information available, average particle size 15 μm	
Photospheres™40μm	Coated silica beads, BET surface area: 48 m^2 g^{-1}, particle size 40 μm (range from 10 to 60 μm)	

Microcystin Variant	Dark adsorption (%)	Complete degradation (min)
Nodularin	14	4
Microcystin-RR	21	3
Microcystin-LR	27	5
Demethylated Microcystin-RR	32	4
Microcystin-LA	34	4
Homotyrosine	43	5
Demethylated Microcystin-LR	44	5
Methylated Microcystin-LR	45	4
Microcystin-YR	46	4
Microcystin-LY	48	2
Microcystin-LW	64	2
Microcystin-LF	70	2

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Journal of Hazardous Materials
journal homepage: www.elsevier.com/locate/jhazmat

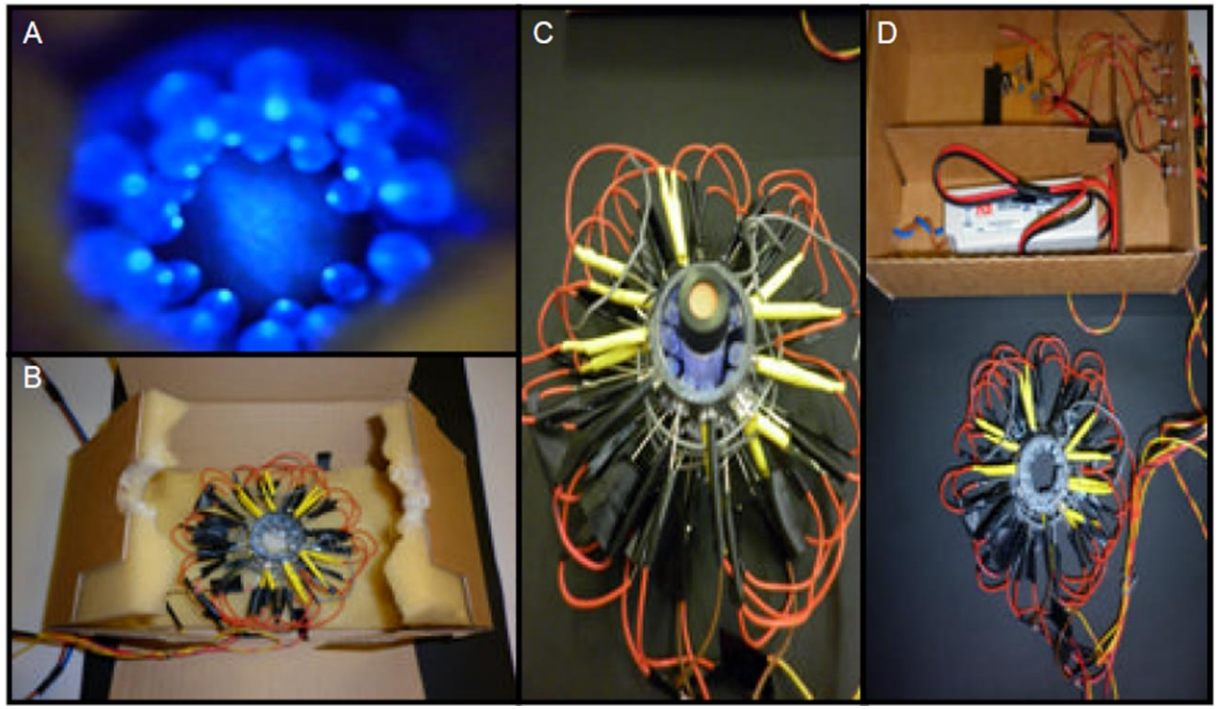
Photocatalytic degradation of eleven microcystin variants and nodularin by TiO_2 coated glass microspheres

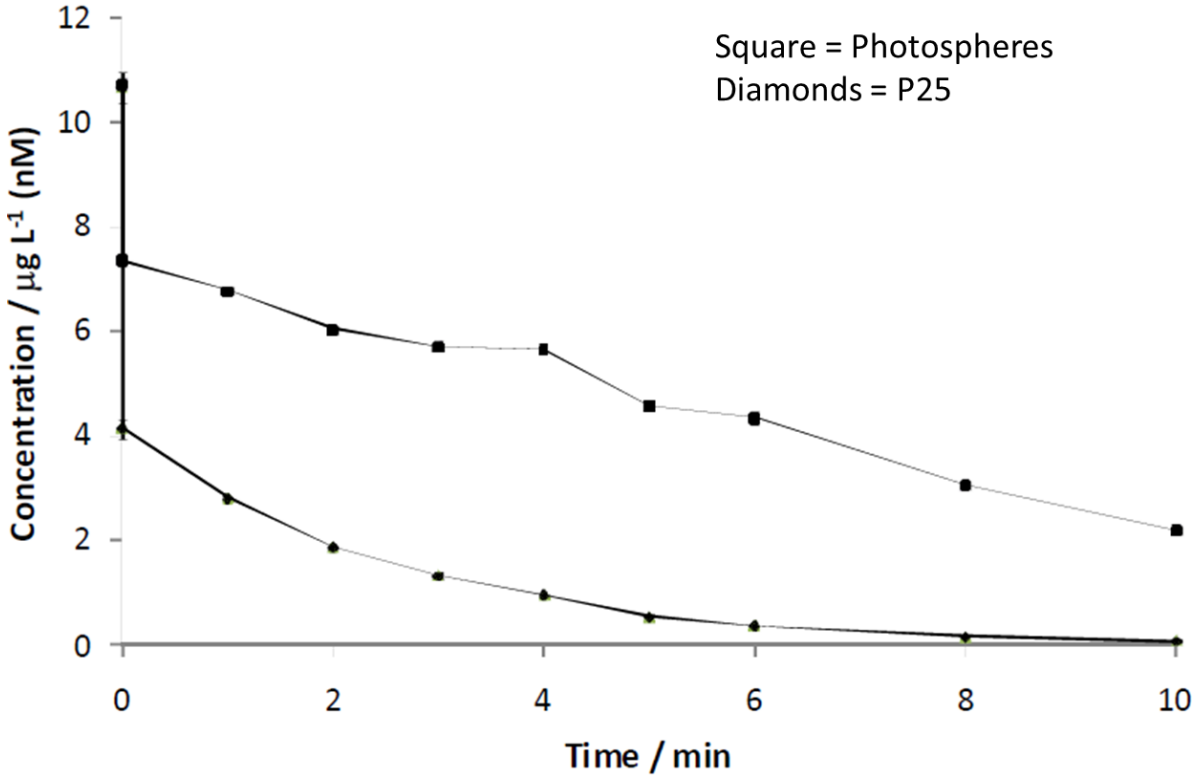
Carlos J. Pestana[a], Christine Edwards[a], Radhakrishna Prabhu[a], Peter K.J. Robertson[b,*], Linda A. Lawton[a]

[a] Innovation, Design and Sustainability (IDeaS) Research Institute, Robert Gordon University, Riverside East, Garthdee Road, Aberdeen AB10 7GJ, UK
[b] Centre for the Theory and Application of Catalysis (CenTACat), School of Chemistry and Chemical Engineering, Queen's University Belfast, David Keir Building, Stranmillis Road, Belfast BT9 5AG, UK

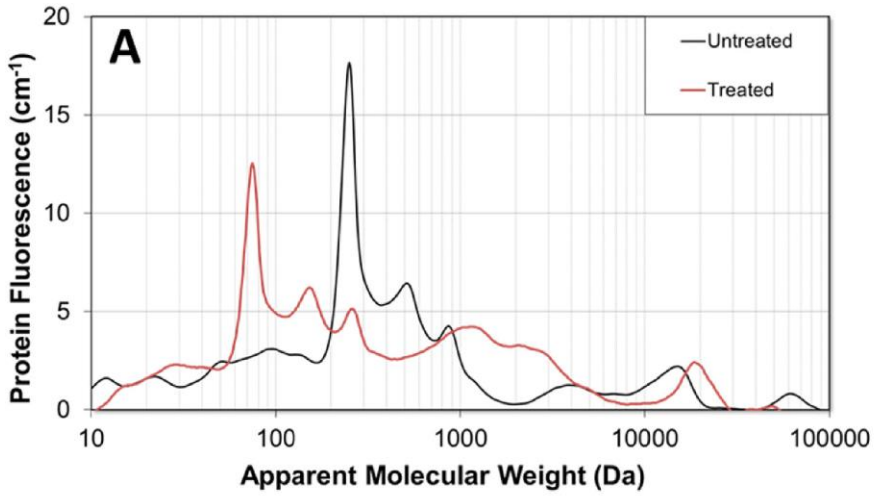
First tries with UV-LED irradiation

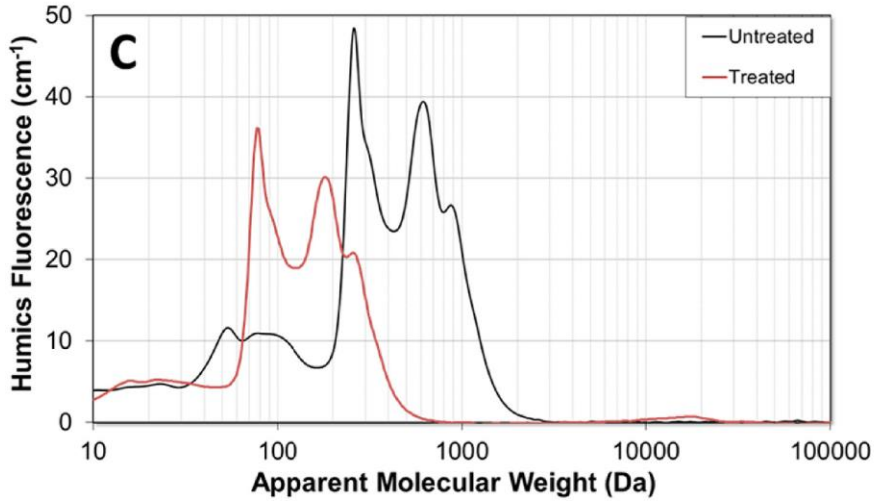
- **mini-reactor with 30 LEDs**
- **$7 per LED**





Photocatalysis in complex matrices





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Removal of microcystins from a waste stabilisation lagoon: Evaluation of a packed-bed continuous flow TiO_2 reactor

Carlos J. Pestana [a, b, *], Peter Hobson [a], Peter K.J. Robertson [c], Linda A. Lawton [b], Gayle Newcombe [a]

[a] Australian Water Quality Centre, South Australian Water Corporation, 250 Victoria Square, Adelaide, SA, 5000, Australia
[b] School of Pharmacy and Life Sciences, Robert Gordon University, Sir Ian Wood Building, Garthdee Road, AB10 7GJ, Aberdeen, UK
[c] School of Chemistry and Chemical Engineering, Queen's University, David Keir Building, 39 Stranmillis Road, BT9 5 AG, Belfast, UK

But could it be used to treat this???

Drinking water reservoir NE Brazil

Source: Dr Mario Barros

Where to tackle the problem?

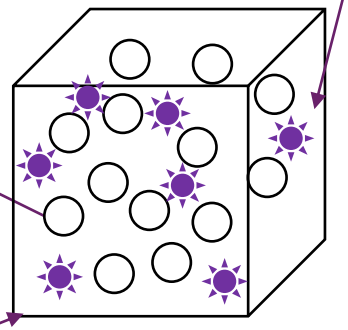
- Water treatment plant?
- Product Water?
- In-Reservoir?

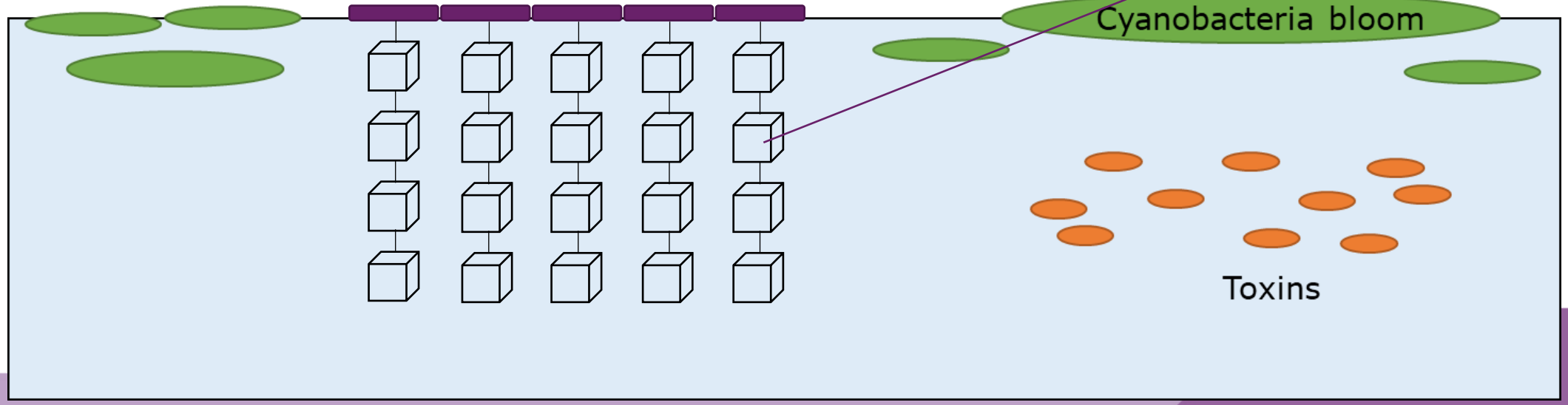
Where to tackle the problem?

In-Reservoir!

The vision

UV-LEDs

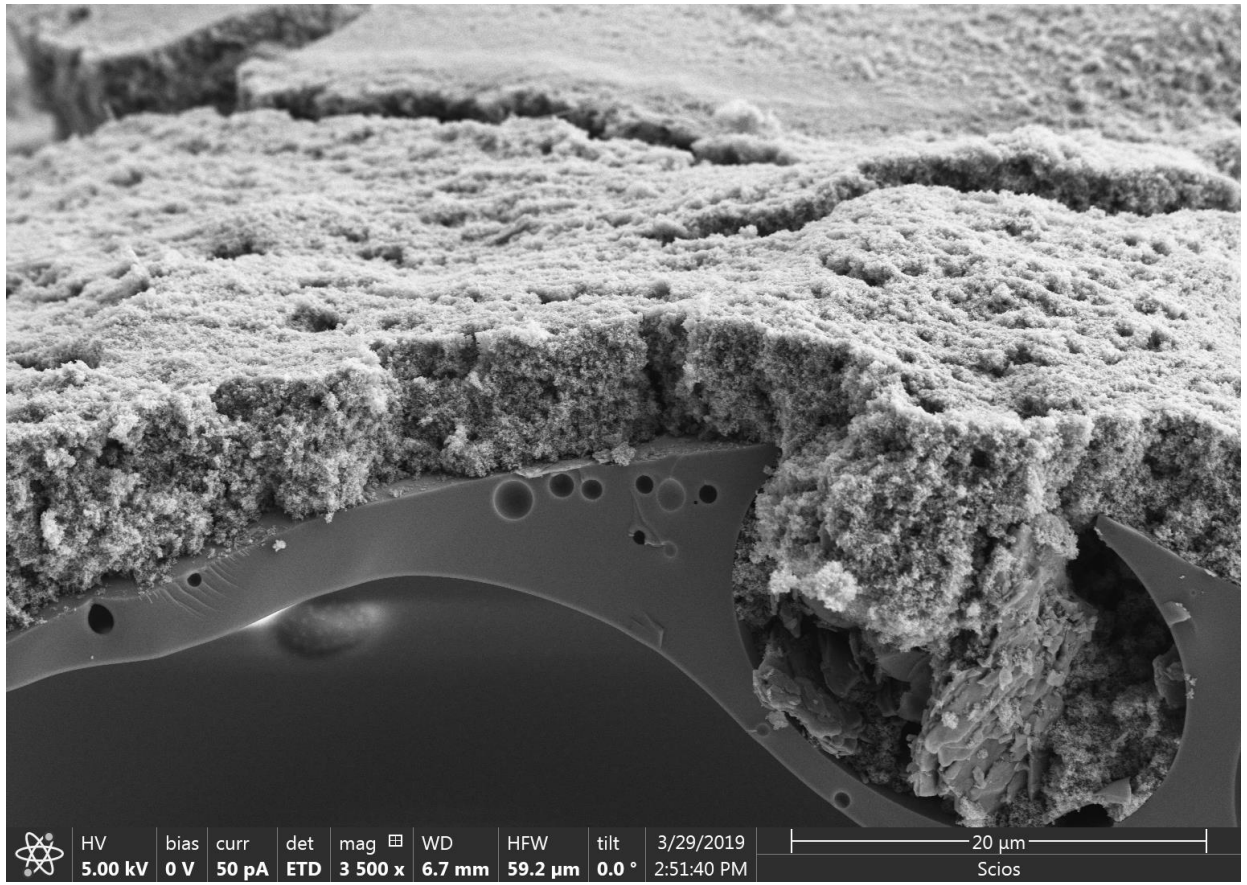




TiO_2 coated glass beads

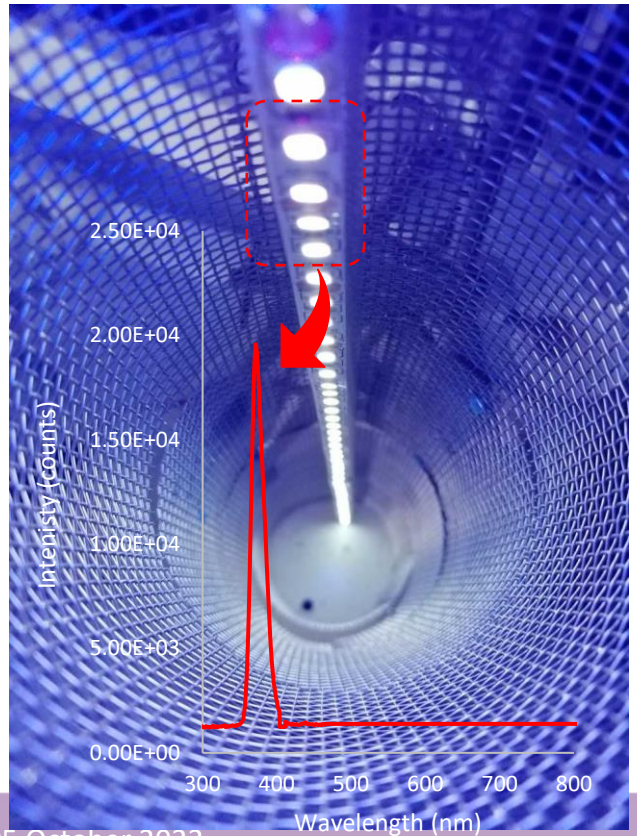
+

=



Development of LED-reactors

From Lab… → ***To Lake***



LED array construction

Prototype construction

Photocatalytic removal of dissolved cyanotoxins

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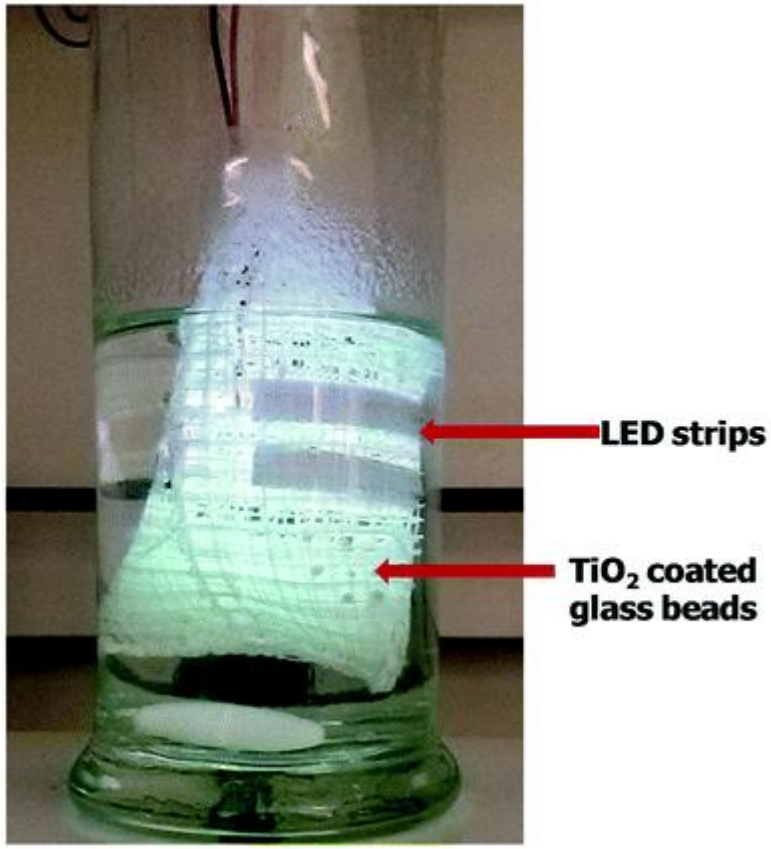
Cite this: *Environ. Sci.: Water Res. Technol.*, 2020, **6**, 945

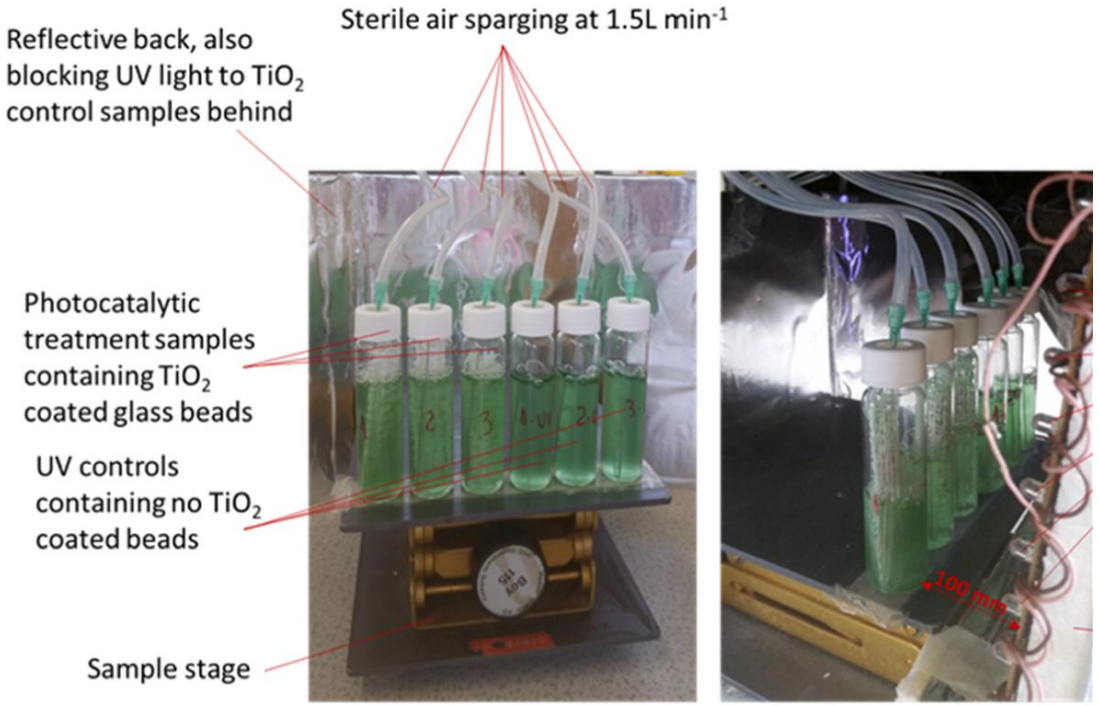
'All in one' photo-reactor pod containing TiO_2 coated glass beads and LEDs for continuous photocatalytic destruction of cyanotoxins in water†‡

H. Q. Nimal Gunaratne, *[c] Carlos J. Pestana,[a] Nathan Skillen, [c] Jianing Hui,[b] S. Saravanan,[b] Christine Edwards,[a] John T. S. Irvine, *[b] Peter K. J. Robertson *[c] and Linda A. Lawton*[a]



[4]Gunaratne et al., 2020; https://doi.org/10.1039/C9EW00711C

Removal of cyanobacteria by UV-LED photocatalysis



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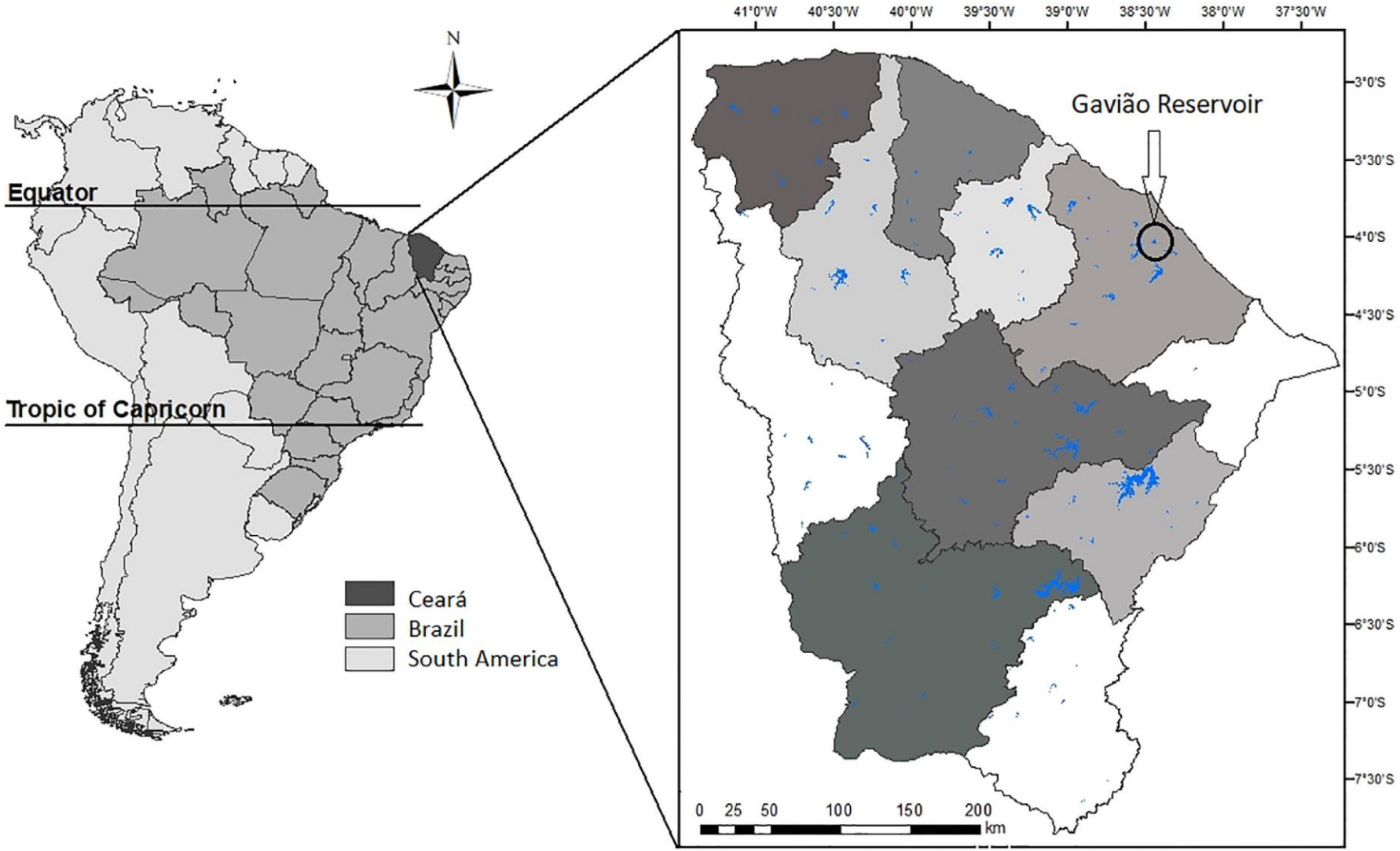
journal homepage: www.elsevier.com/locate/scitotenv

Photocatalytic removal of the cyanobacterium *Microcystis aeruginosa* PCC7813 and four microcystins by TiO_2 coated porous glass beads with UV-LED irradiation

Carlos J. Pestana [a,*], Jolita Portela Noronha [a,b], Jianing Hui [c], Christine Edwards [a], H.Q. Nimal Gunaratne [d], John T.S. Irvine [c], Peter K.J. Robertson [d], José Capelo-Neto [b], Linda A. Lawton [a]

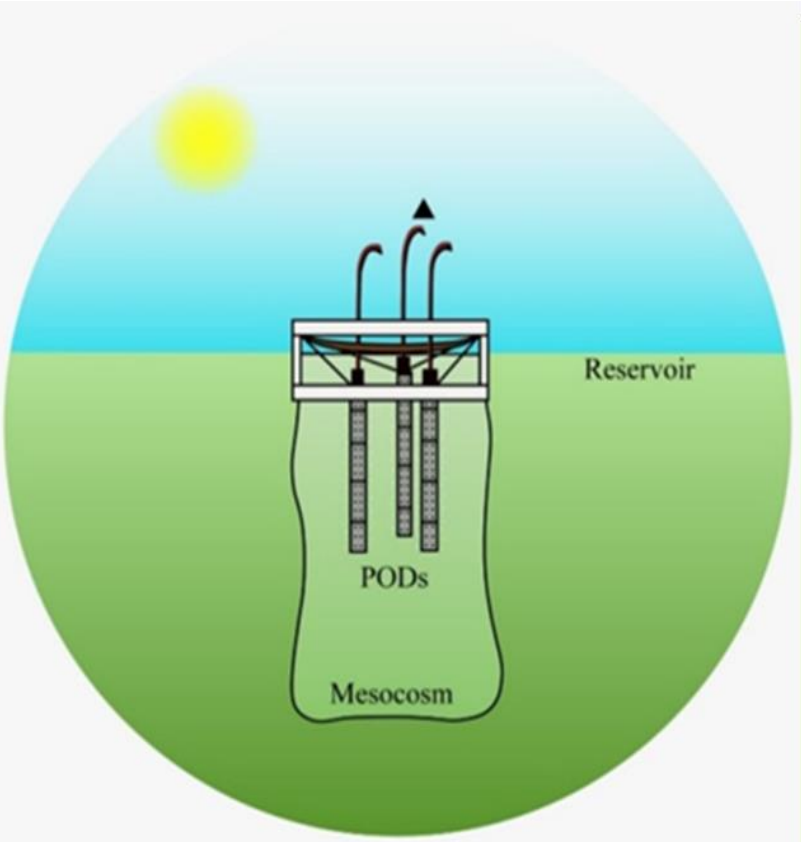
[3]Pestana et al., 2020; https://doi.org/10.1016/j.scitotenv.2020.141154

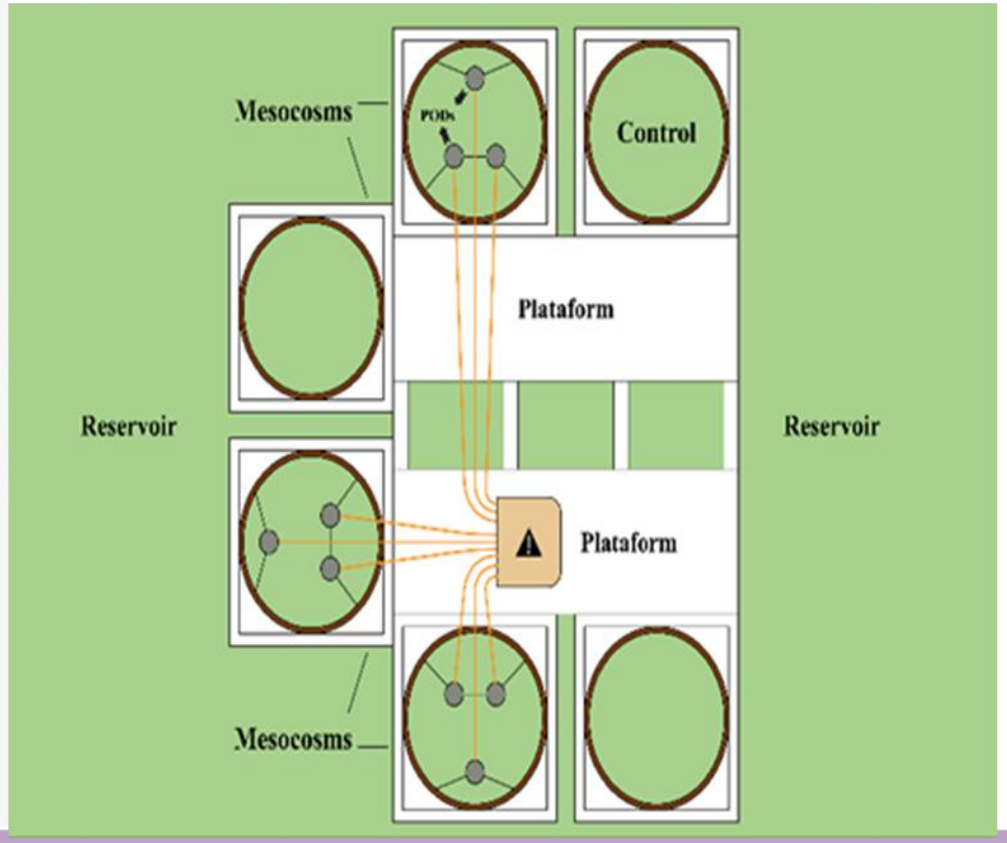
Study Site: Ceará State, Brazil

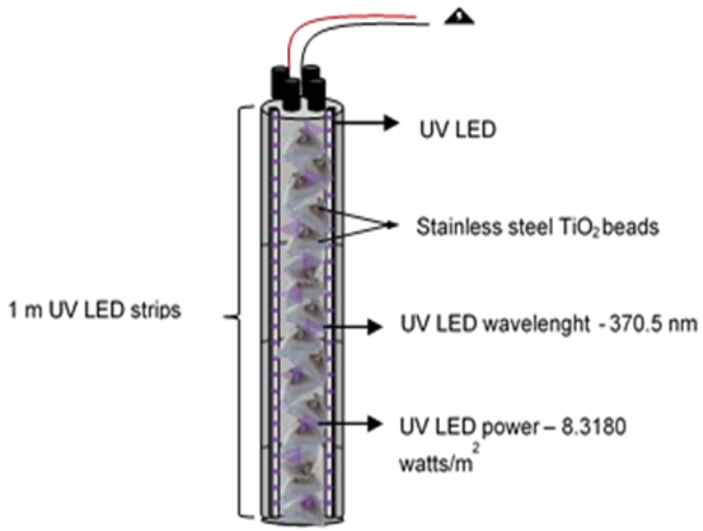


TiO_2 photocatalysis *in situ*

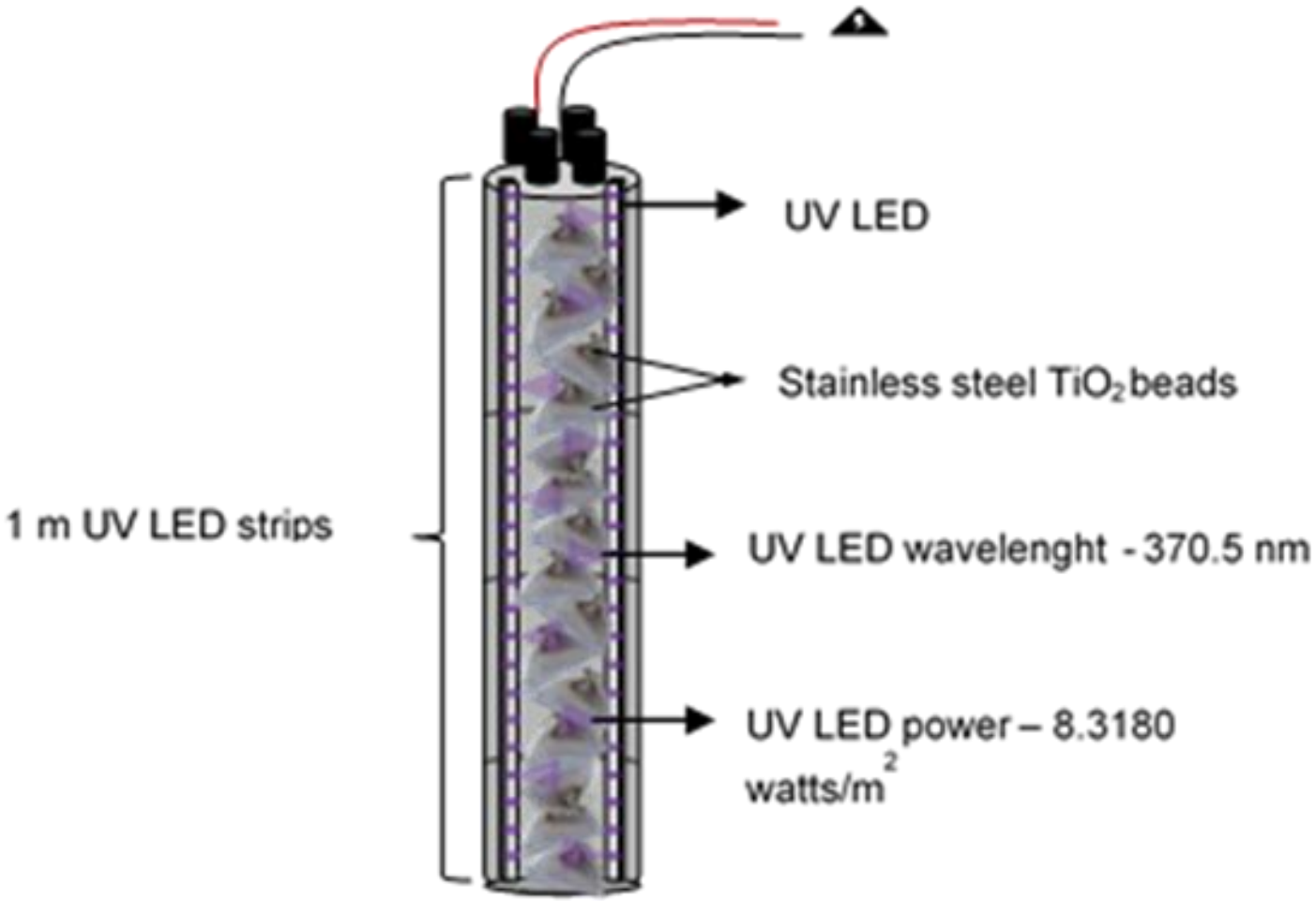
- **Photocatalytic treatment units with TiO_2 coated glass beads and waterproof UV-LEDs in mesocosms in Fortaleza**

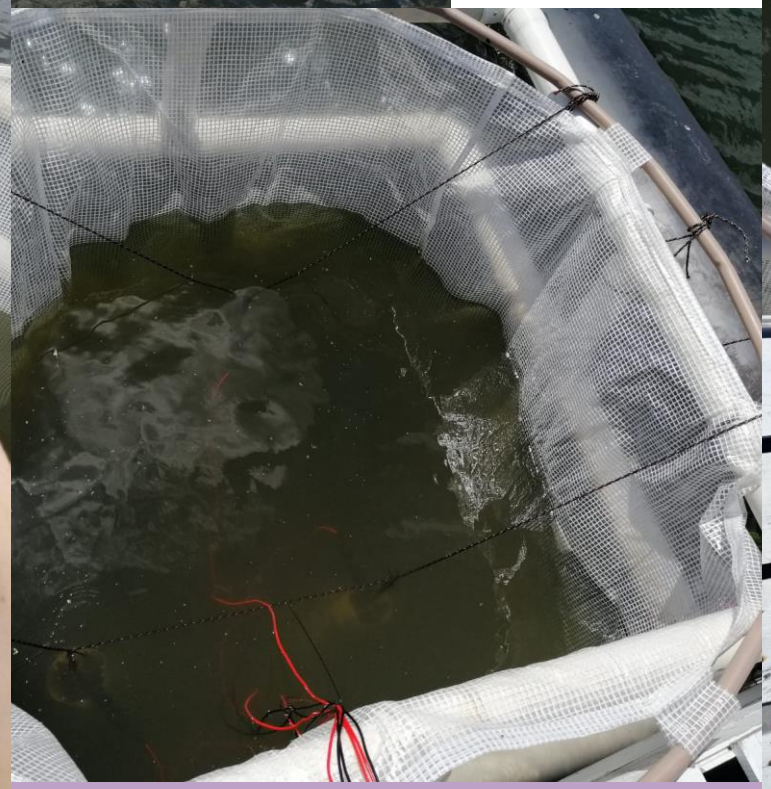


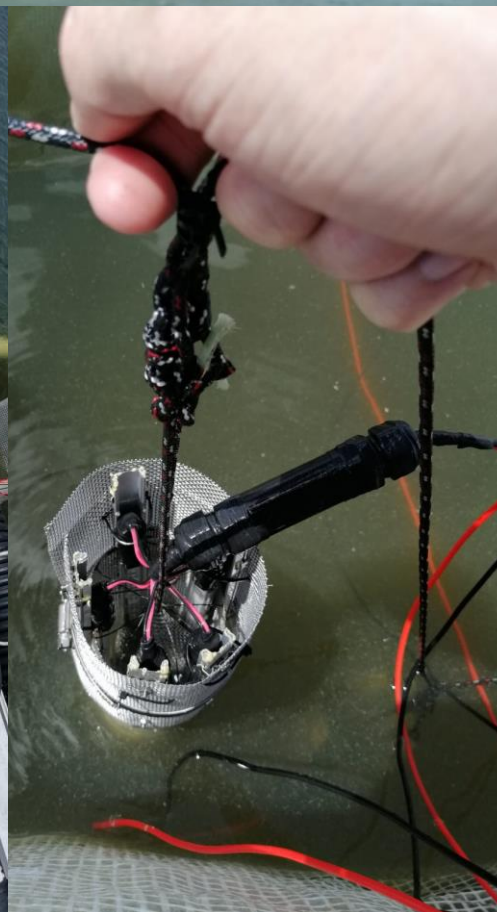




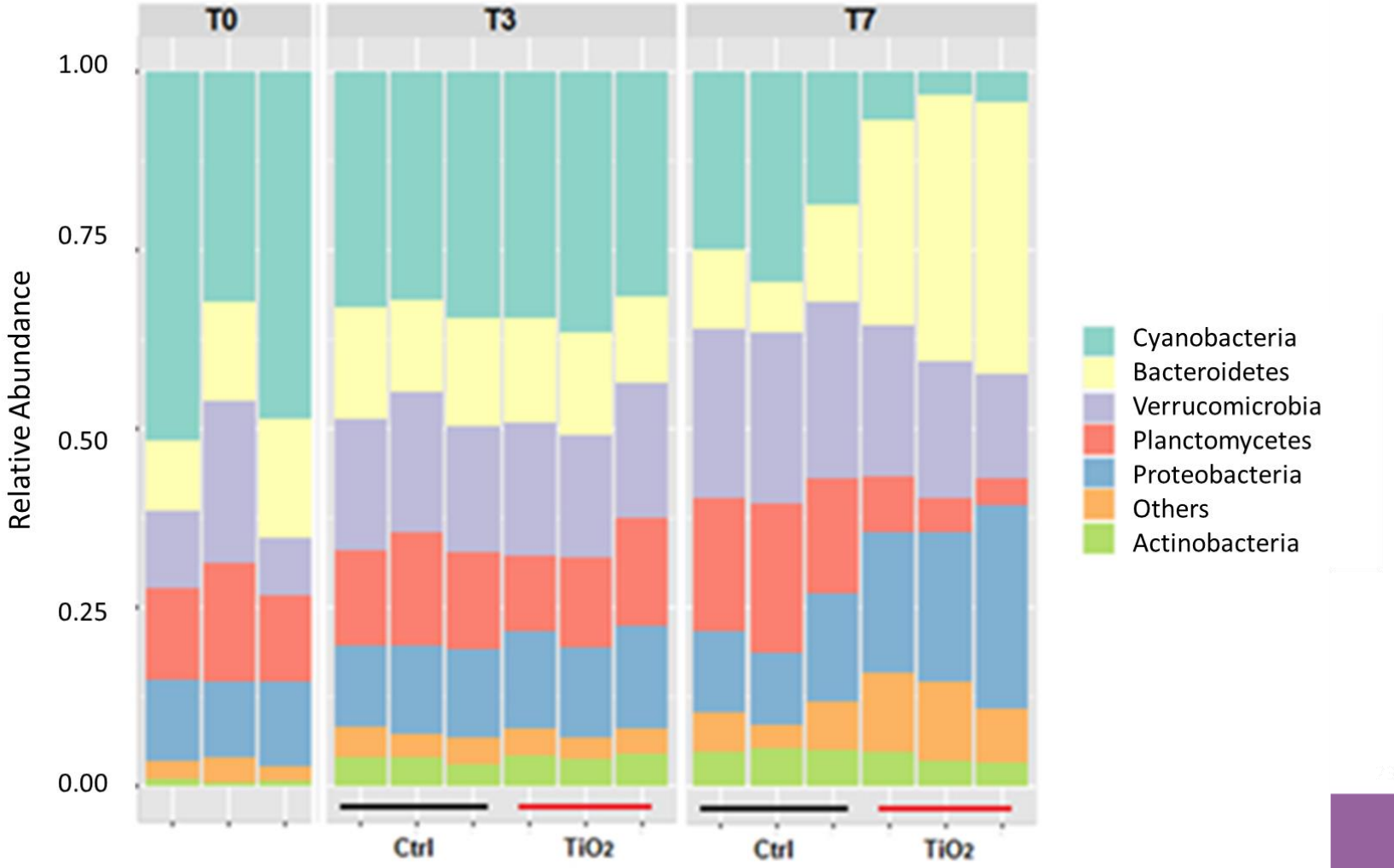
Reactor design



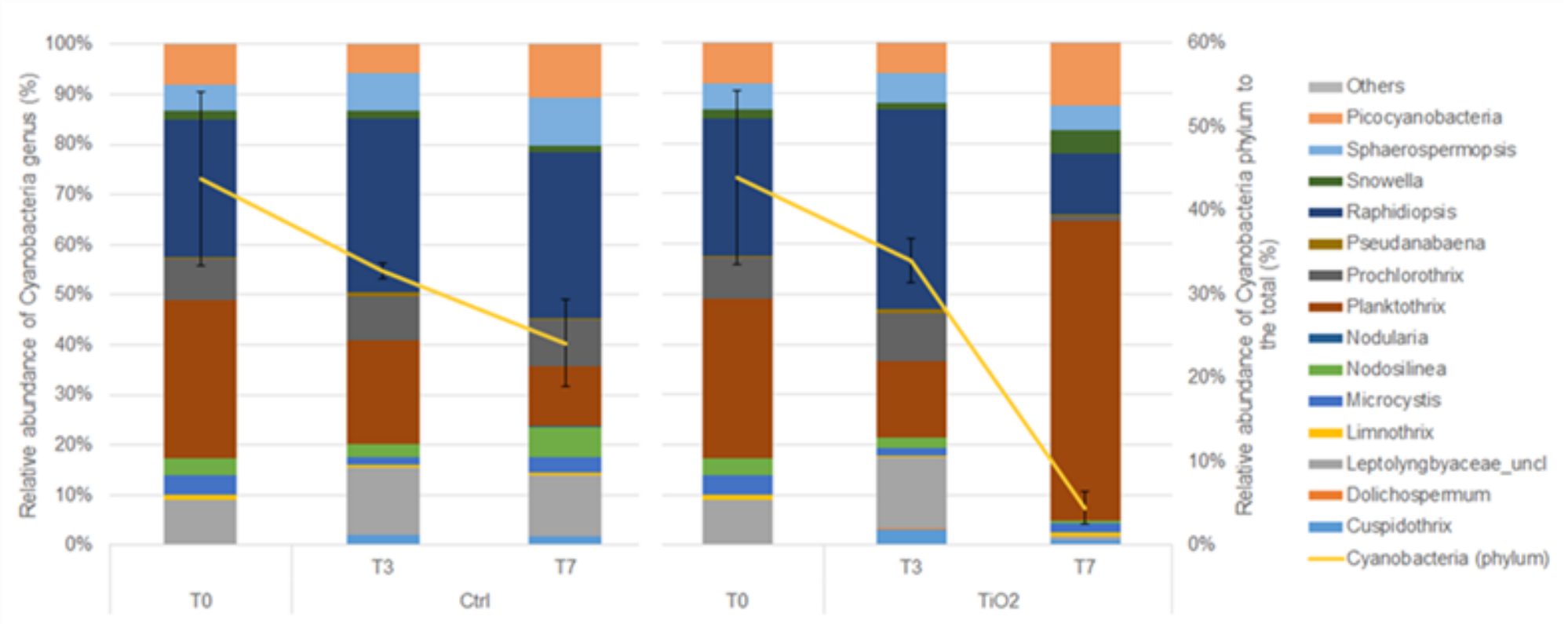




Cyanobacterial abundance decreased



Cyanobacterial assemblage changes



Water quality parameters

- Turbidity decreased by 50%
- Transparency increased by 90%
- Small decreases in DOC and TOC
- No significant effect on nutrients

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