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AUSTRALIA

CREATE CHANGE

Detection and Fate of Organic UV Filters in Freshwater and Wastewater

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Queensland Alliance for Environmental Health Sciences





Organic UV filters

Ensulizole (PBSA)

Avobenzene (BMDBM)

Octinoxate (EHMC)

Oxybenzone (BP3)

Dioxybenzone (BP8)

Sulisobenzene (BP4)

Dihydroxybenzophenone (BP1)

Enzacamene (4-MBC)

Octisalate (OS)

Octocrylene (OC)



Organic UV filters

Ensulizole (PBSA)

Avobenzene (BMDBM)

Octinoxate (EHMC)

Oxybenzone (BP3)

Dioxybenzone (BP8)

Sulisobenzene (BP4)

Dihydroxybenzophenone (BP1)

Enzacamene (4-MBC)

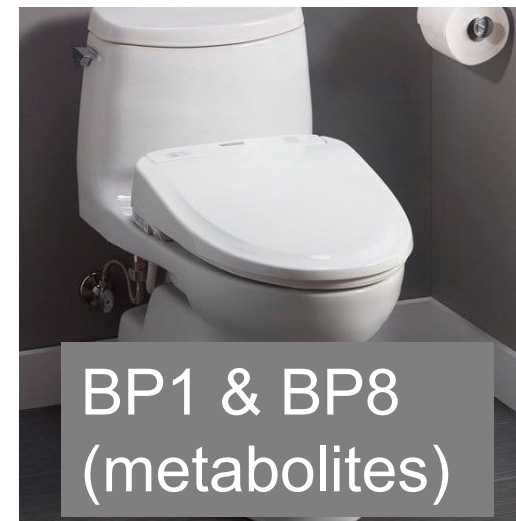
Octisalate (OS)

Octocrylene (OC)

<u>Organic UV filters</u>	<u>Log Kow</u>
Ensulizole (PBSA)	0.01
Avobenzene (BMDBM)	2.4
Octinoxate (EHMC)	5.8
Oxybenzone (BP3)	3.8
Dioxybenzone (BP8)	3.9
Sulisobenzene (BP4)	0.9
Dihydroxybenzophenone (BP1)	3.2
Enzacamene (4-MBC)	4.9
Octisalate (OS)	5.8
Octocrylene (OC)	6.9



PBSA
BP4
4-MBC
BP3



BP1 & BP8
(metabolites)



PBSA, BP4, BP3,
BP1

Research Questions

- How effectively are UV filters removed in Australian WWTPs?
- How prevalent are UV filters in wastewater effluent?
 - Wastewater (Part 1)
- How prevalent are UV filter in a recreational swimming area?
- How do their concentrations change over time?
 - Environmental occurrence (Part 2)
- How long do UV filters persist in a freshwater environment?
- What are their degradation mechanisms?
 - Degradation Study (Part 3)

Wastewater

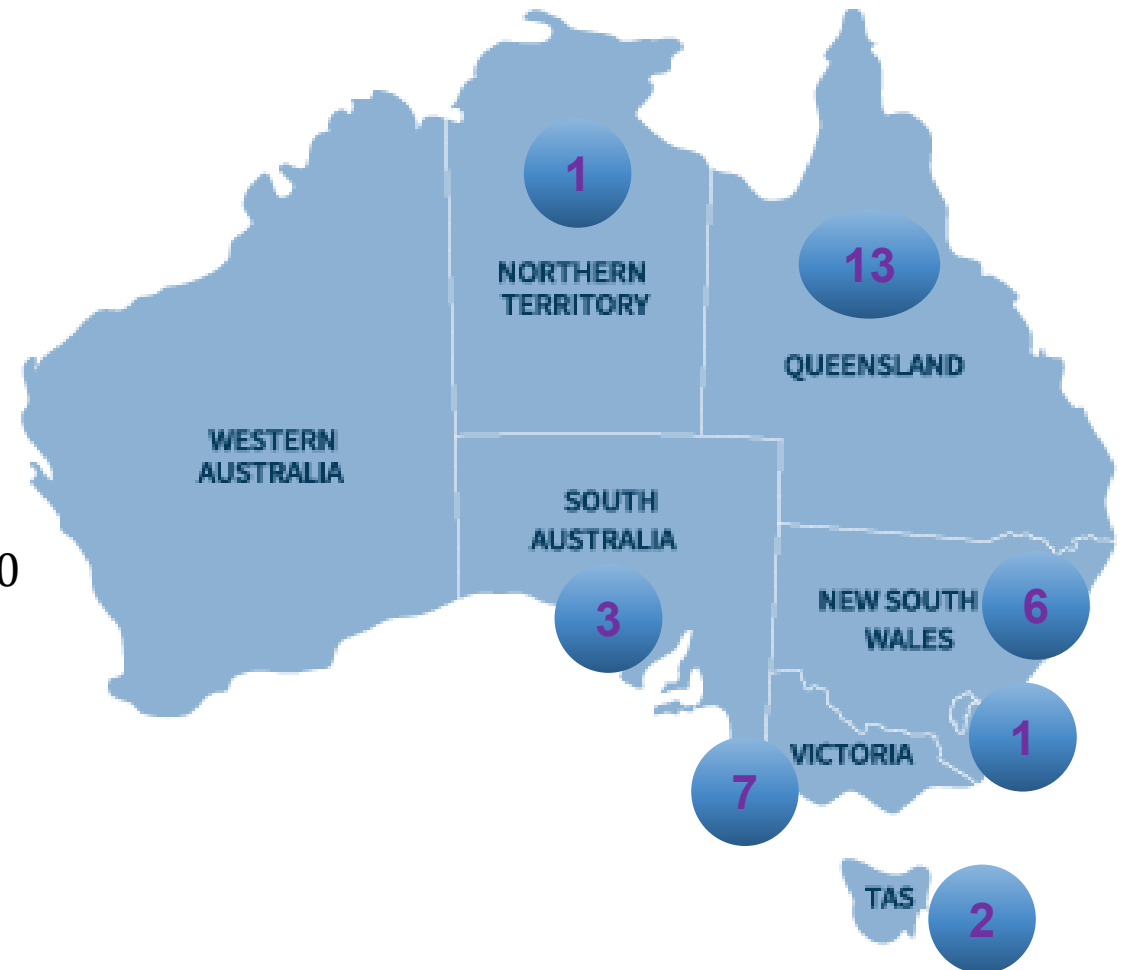
Effluent samples - 33 sites

- Samples collected in Winter
- Two daily composite samples, acidified
- Analysed via LC-MS/MS, direct injection

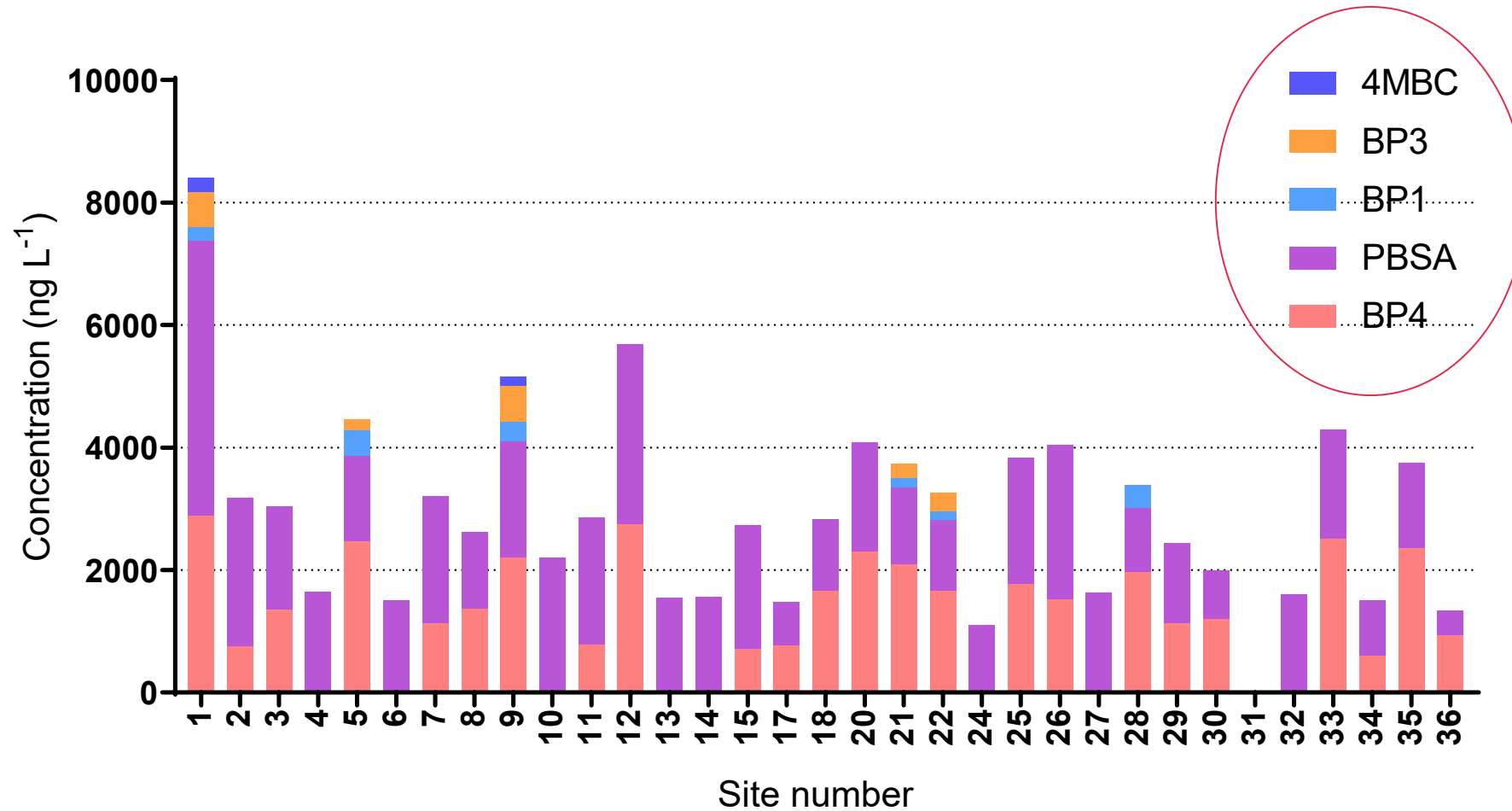
$$\text{Removal efficiency (\%)} = \frac{[\text{influent}] - [\text{effluent}]}{[\text{influent}]} * 100$$



6500+ QTrap

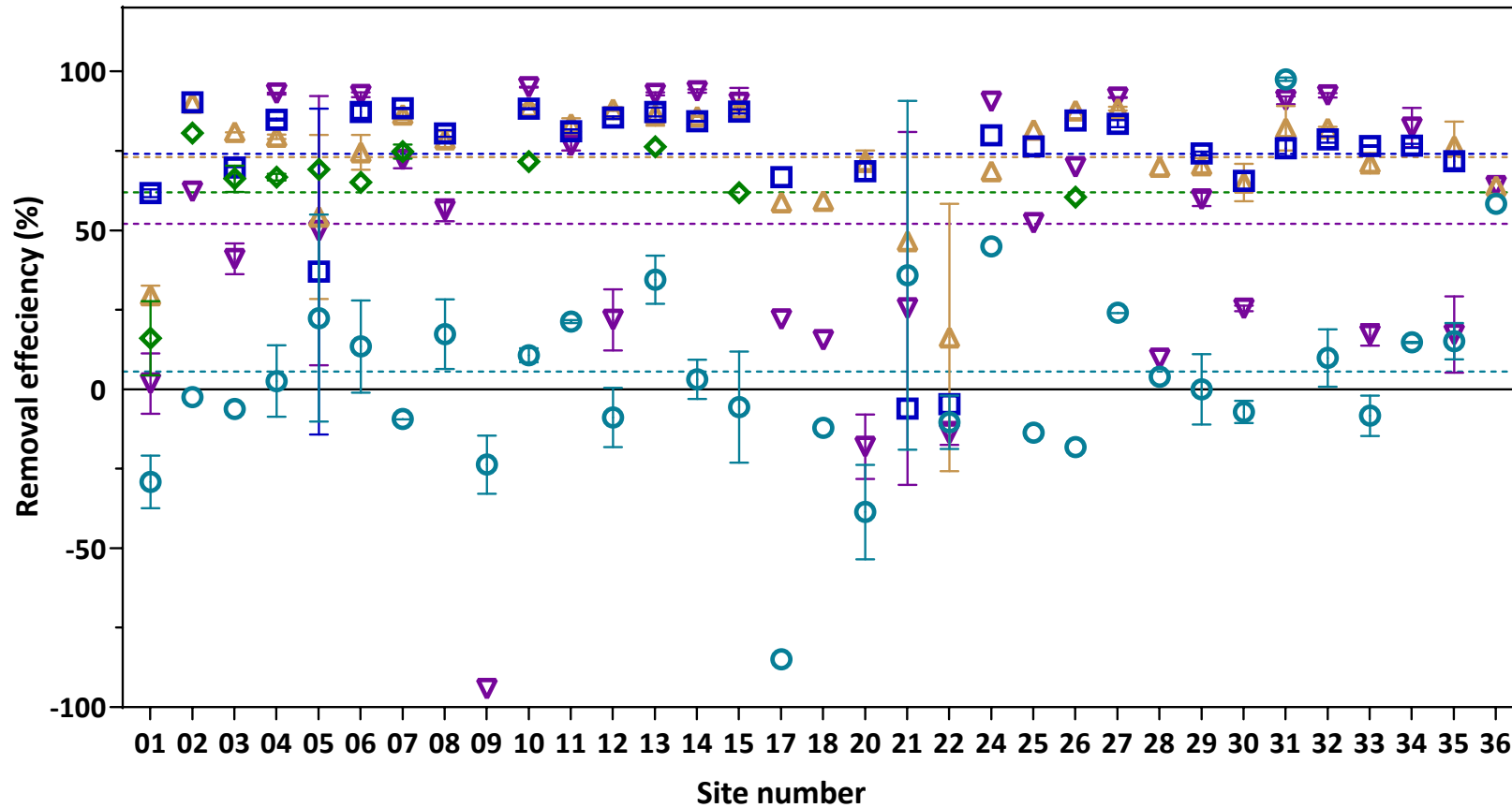


UV filters in effluent



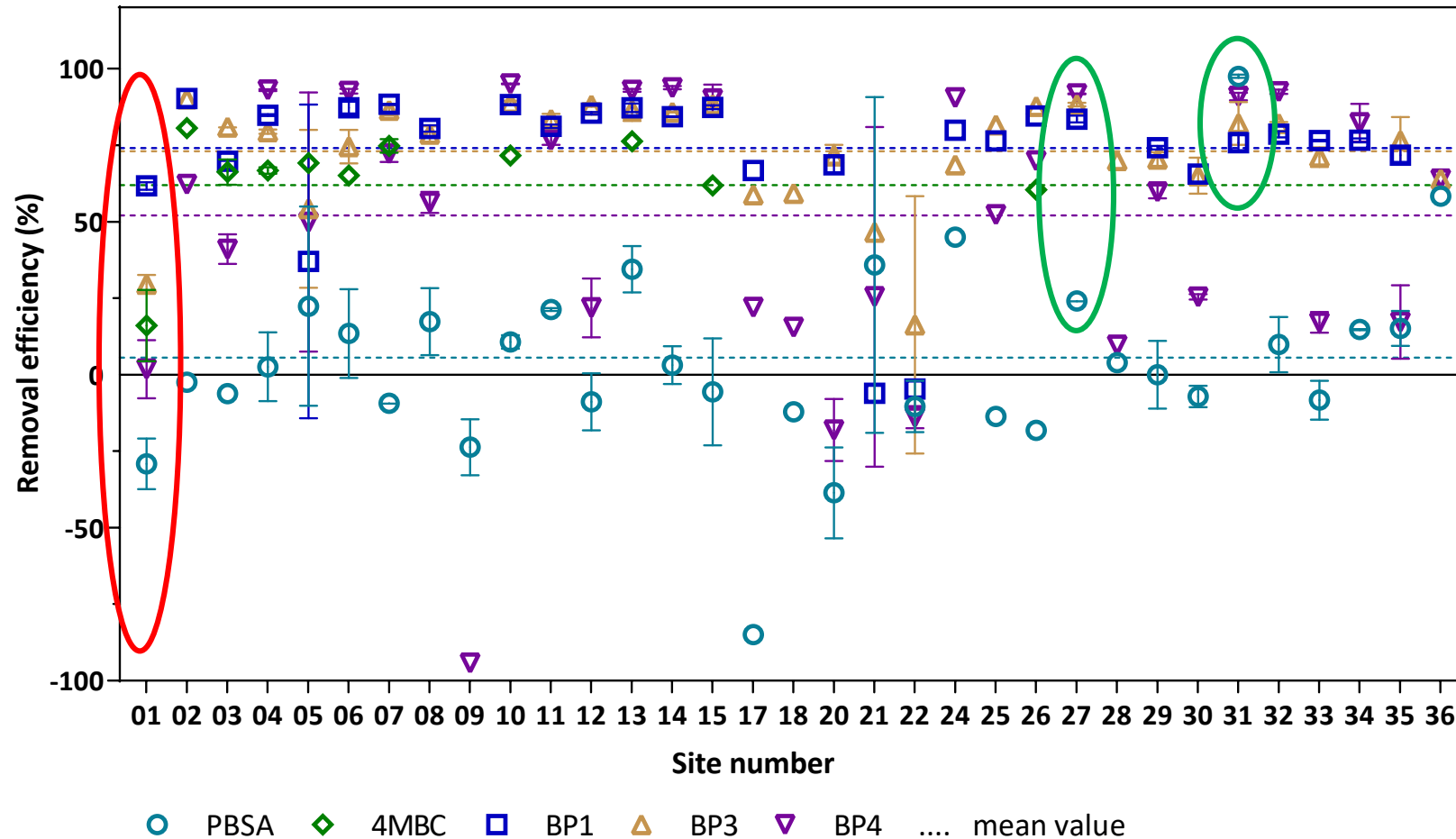
Low Kow

Removal efficiencies



BP1 74% BP3 73%
4MBC 62%
BP4 52%
PBSA 5%

Removal efficiencies



BP1 74% BP3 73%
4MBC 62%
BP4 52%
PBSA 5%



Direct wash-off



**Indirect release
from wastewater**



Environmental occurrence

Enoggera Reservoir

Originally for drinking water

Recreational facility since 2014

Swimming, fishing, kayaking, bushwalking

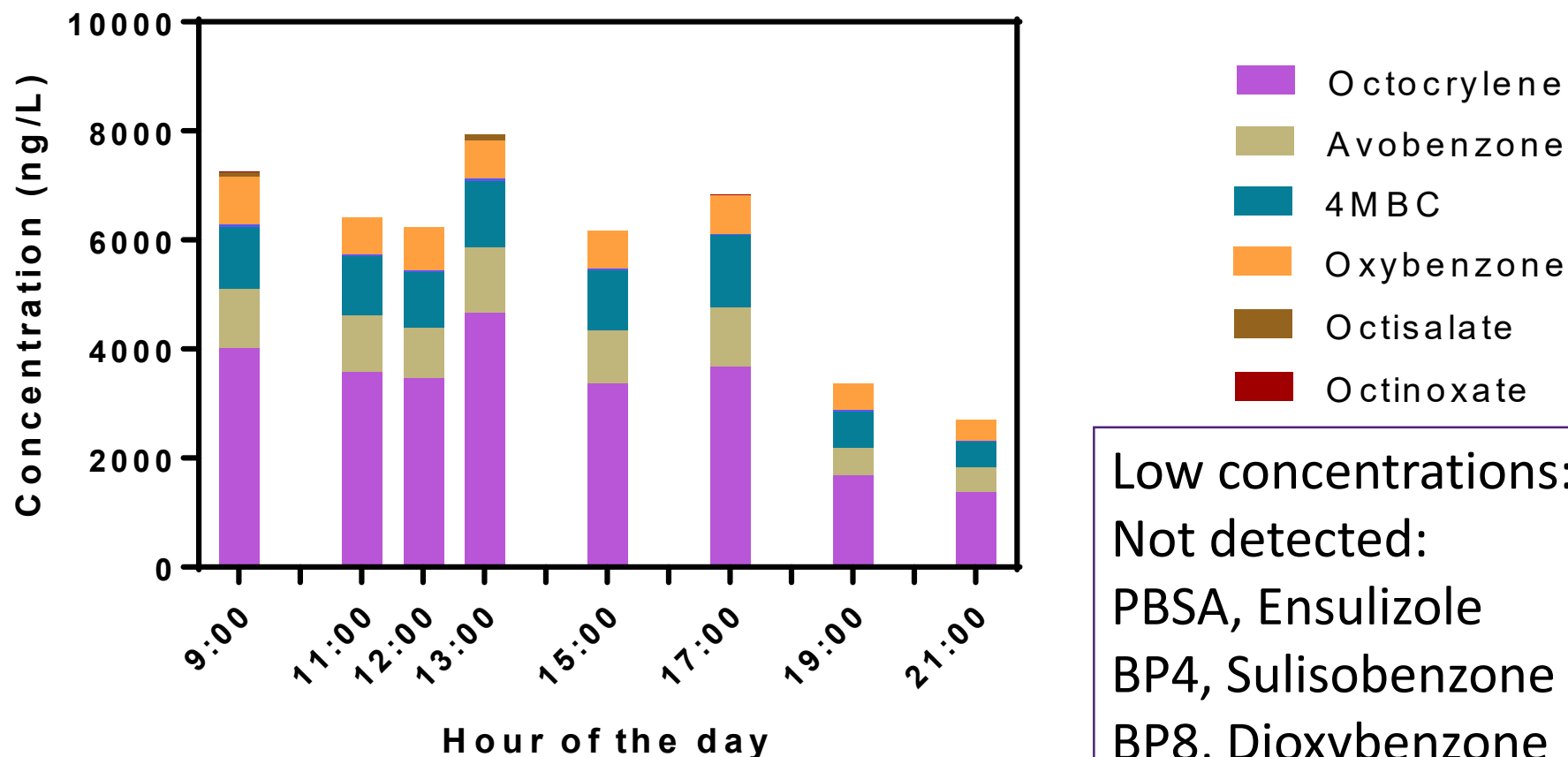


Environmental occurrence

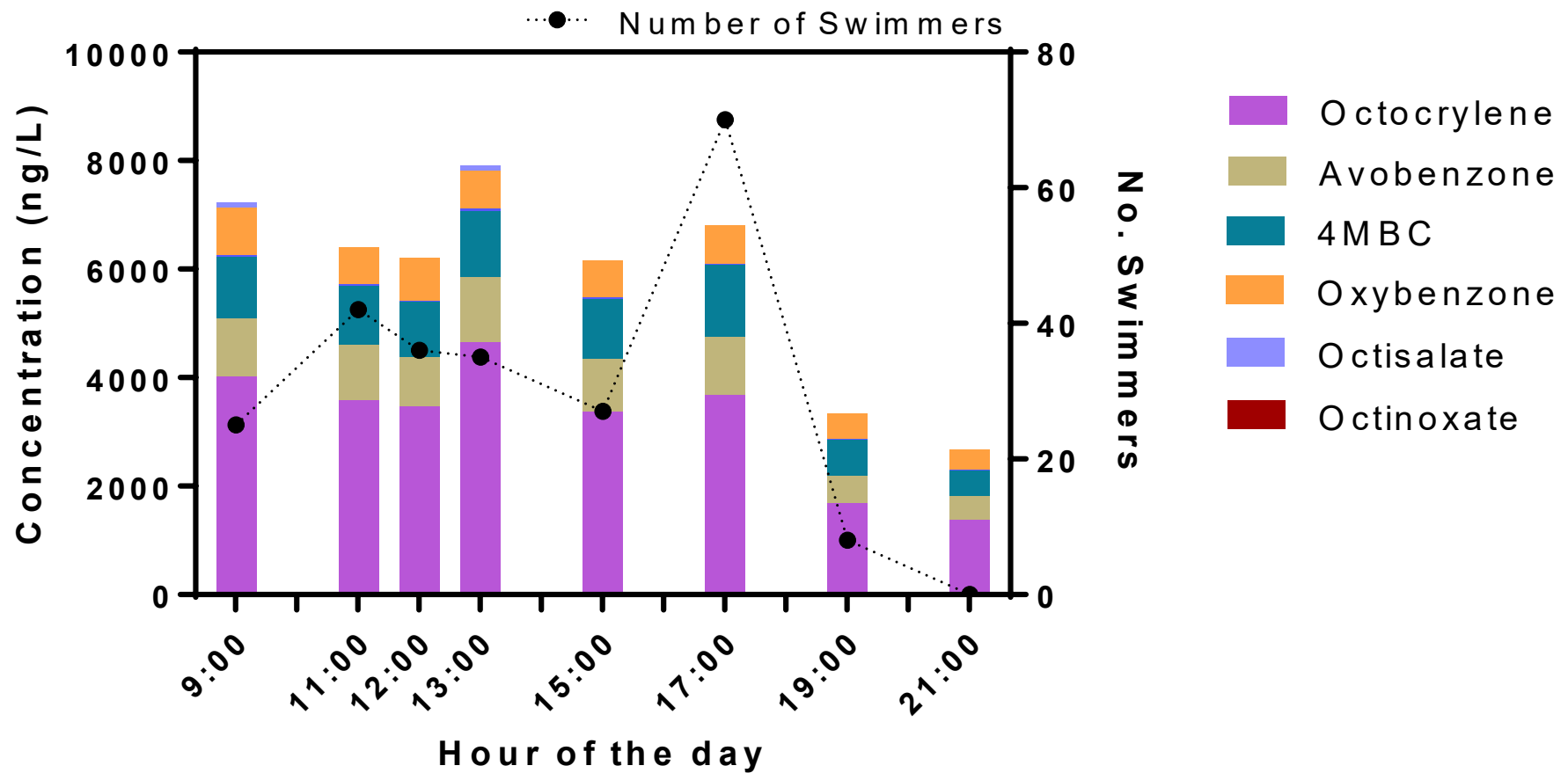
- Summer daily temporal trend
- Samples collected from 9am to 9pm
- Extracted via SPE
- Analysed via LC-MS/MS



Enoggera Reservoir



Enoggera Reservoir



Degradation Study

9:30 am

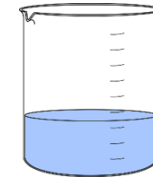
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4:30 pm



- Enoggera reservoir water
- Added UV filters (5 ug/L)
- Collected samples over a week
- Four different treatment types

Degradation Study

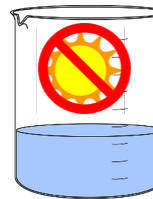


All processes

x2



Limited Biodegradation



Limited Photodegradation



Control

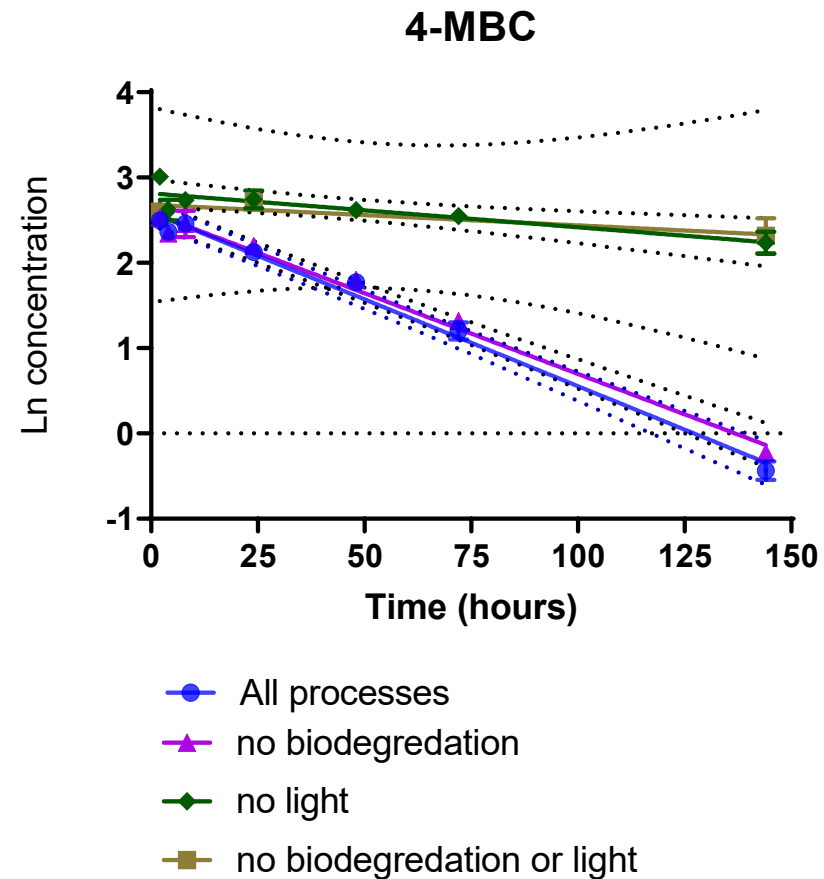
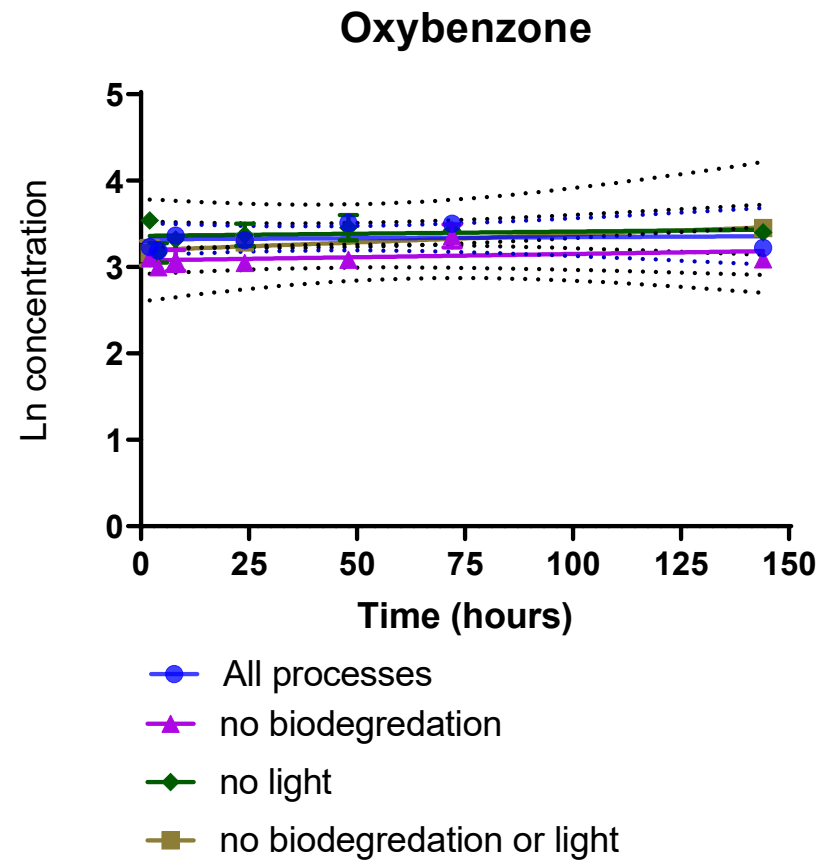
Half life (hours)

All degradation processes

Oxybenzone	Octocrylene	Ensulizole	Enzacamene	Dioxybenzone	Avobenzone	Octinoxate
BP3	OC	PBSA	4-MBC	BP8	BMDBM	EHMC
n/a	n/a	n/a	34 ± 1.5	20 ± 0.6	29 ± 7.0	23 ± 4.2

n/a, slope of linear regression is not significantly different to zero

Half life (hours)



Half life (hours)

All degradation processes

Oxybenzone	Octocrylene	Ensulizole	Enzacamene	Dioxybenzone	Avobenzone	Octinoxate
BP3	OC	PBSA	4-MBC	BP8	BMDBM	EHMC
n/a	n/a	n/a	34 ± 1.5	20 ± 0.6	29 ± 7.0	23 ± 4.2
Dispersion			Photodegradation		Bio & Photodegradation	

n/a, slope of linear regression is not significantly different to zero

Half life (hours)

All degradation

Oxybenzone

BP3

n/a

n/a, slope of linear regression

Limitations

- Each water body will be different
- Differing microbial communities
- Results may vary with mixtures

Octinoxate

EHMC

23 ± 4.2

degradation

Summary

- BP4 and PBSA most dominant in effluent
- With low removal efficiencies
- $< 8,500 \text{ ng L}^{-1}$ summed UV filters
- Sourced from industrial and personal care products
- Risk dependant upon release point



Annual release of selected UV filters via effluent from wastewater treatment plants in Australia

Elissa O'Malley*, Jake W. O'Brien, Rory Verhagen, Jochen F. Mueller

QAEHS, Queensland Alliance for Environmental Health Science, The University of Queensland, Brisbane, Australia



Summary

- Within recreational swimming area < 7800 ng/L summed UV filters
- Highest concentrations:
Octocrylene 1380 – 4660 ng/L, $T_{1/2}$ n/a
- Chemical fate varies across UV filters and is an important component of risk



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The presence of selected UV filters in a freshwater recreational reservoir and fate in controlled experiments

Elissa O'Malley ^a, Michael S. McLachlan ^b, Jake W. O'Brien ^a, Rory Verhagen ^a, Jochen F. Mueller ^a



Thank you

Supervisors: Prof. Jochen Mueller
Dr. Jake O'Brien

Sampling: SewAus Wastewater Treatment Plants
Moreton Bay Research Station
Quandamooka Yoolooburrabee
Aboriginal Corporation (QYAC)

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Moreton Bay Research Station
Research Training Program Stipend



Enoggera Reservoir

