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Smarter Systems, Cleaner Water: Improving Biofilter Performance with Real-Time Control

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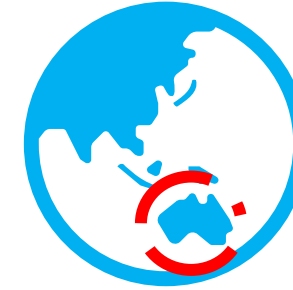
UNSW
SYDNEY

Background

Nature-based solutions (NBS) – increasing amount of attention gained



Source: Image – Aerometrex, City of Sydney.



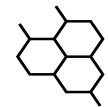
Reduce flooding



Control urban heating



Water quality treatment



Recycling water
is strongly encouraged



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SYDNEY

Background

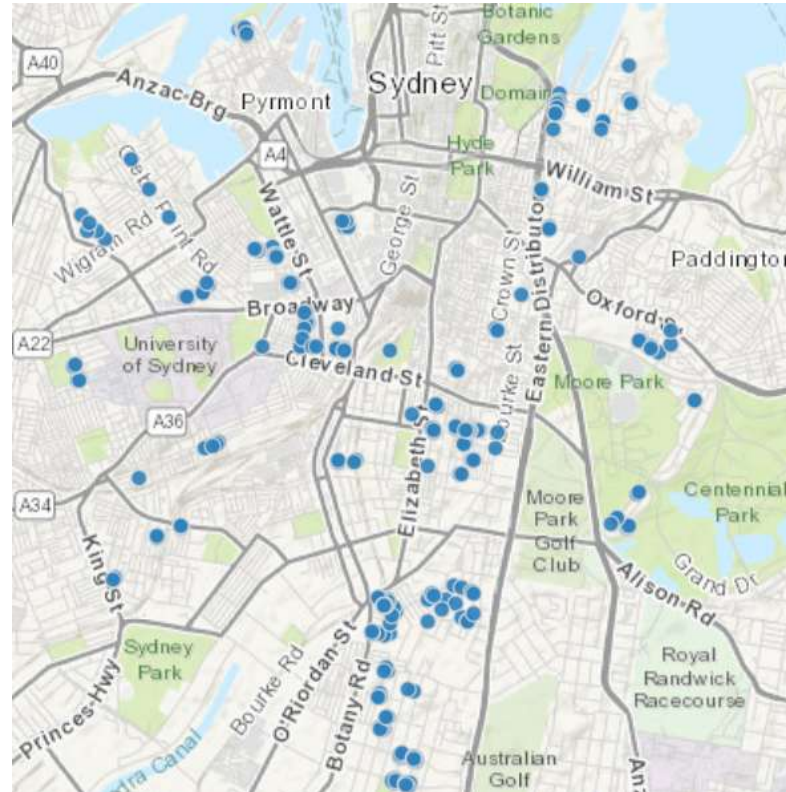
Increased amount of NBS – however **pollutant removal varied**

Stormwater Treatment – Nature-Based Solution



- ❖ Constructed wetland
- ❖ Stormwater basins
- ❖ Stormwater biofilter

- ✓ Feasibility
- ✓ Treatment



Location of Biofilters in the City of Sydney

Source: <https://data.cityofsydney.nsw.gov.au>

Treated stormwater



Harvestable



Not Harvestable

Harvestable?



Emerging trace-level
organic chemicals

Background

Emerging Organic Chemicals – why they prevent stormwater from being harvestable?

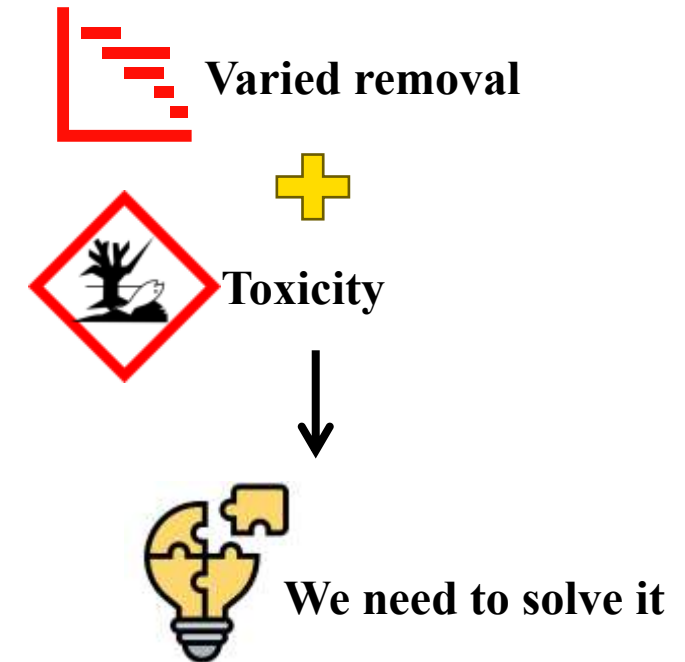
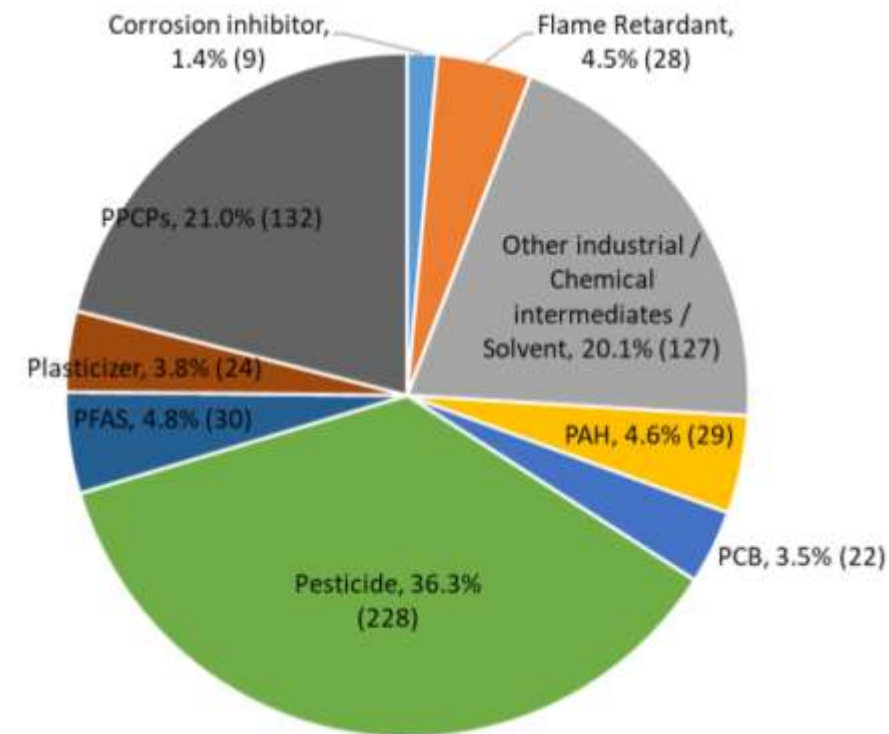
Reviews on Trace-level organic chemicals

Diversity

- ❖ They are everywhere (600+) detected

Varied removal in biofilter

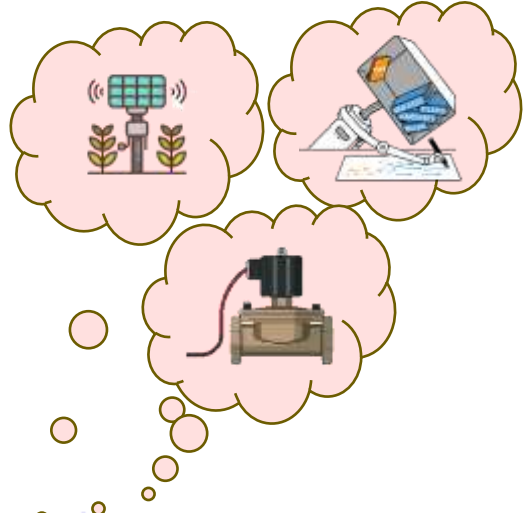
- ❖ Removal ranged from 0-99%
- ❖ Varied among chemicals, rainfalls



Background

Real time control - a smarter way to control biofilters

Sensors, actuators, AI...



Biofilter updates

Conventional biofilters



RTC biofilters



Targeted achievements:

➤ Simple operation



just water release

➤ Automatic operation



has to be guided by sensors

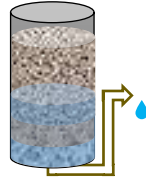
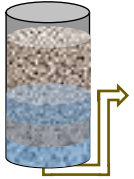
➤ Less sampling needs



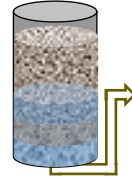
AI helps in predict removal

Explored simple Rule-based RTC Strategies

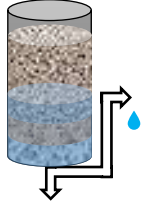
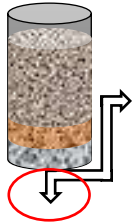
Non-RTC



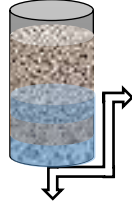
Baseline operation



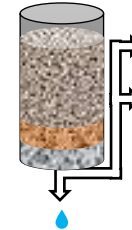
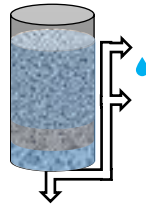
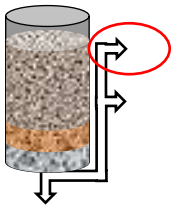
RTC-PreDrain



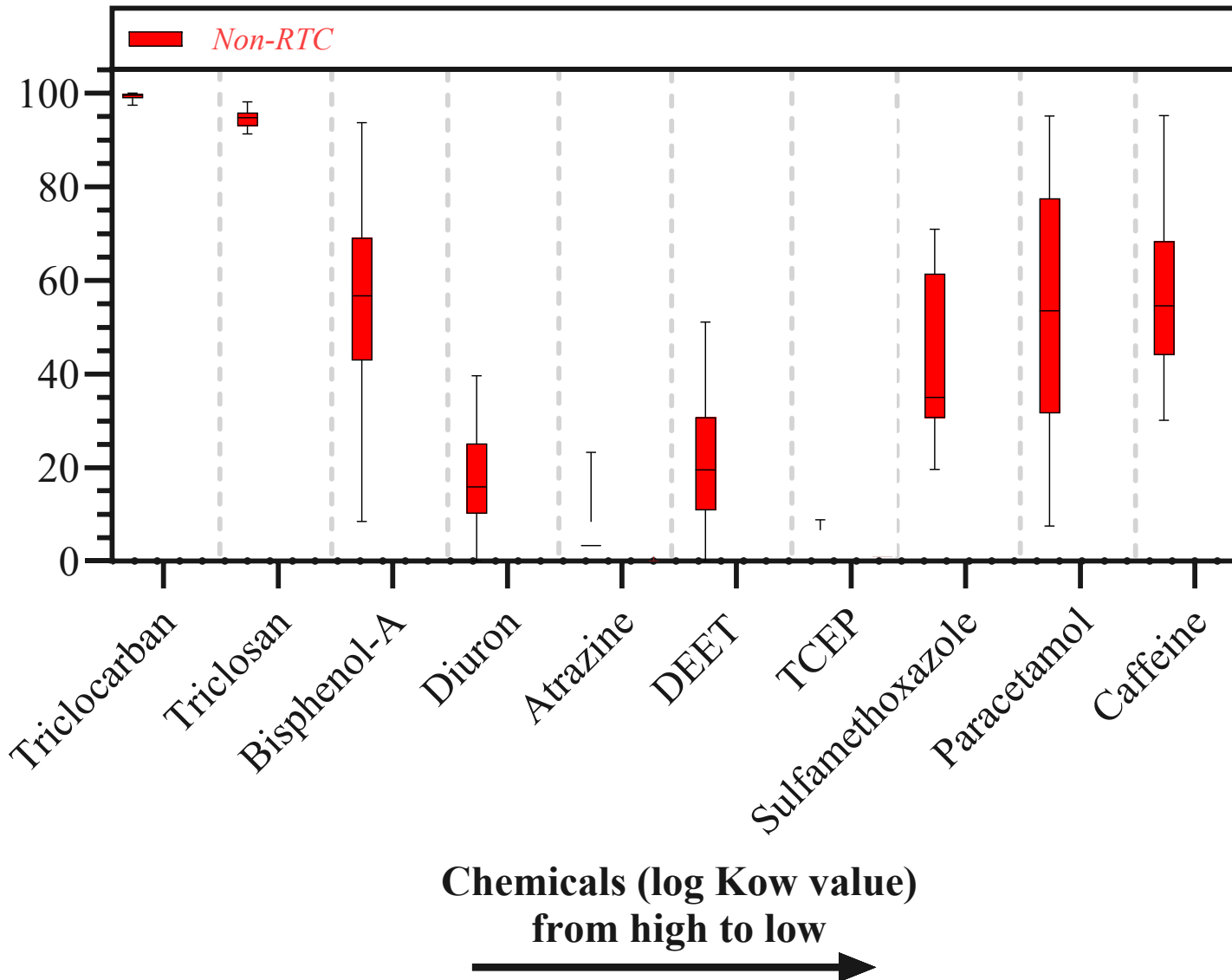
RTC: time-driven operation



RTC-Moisture



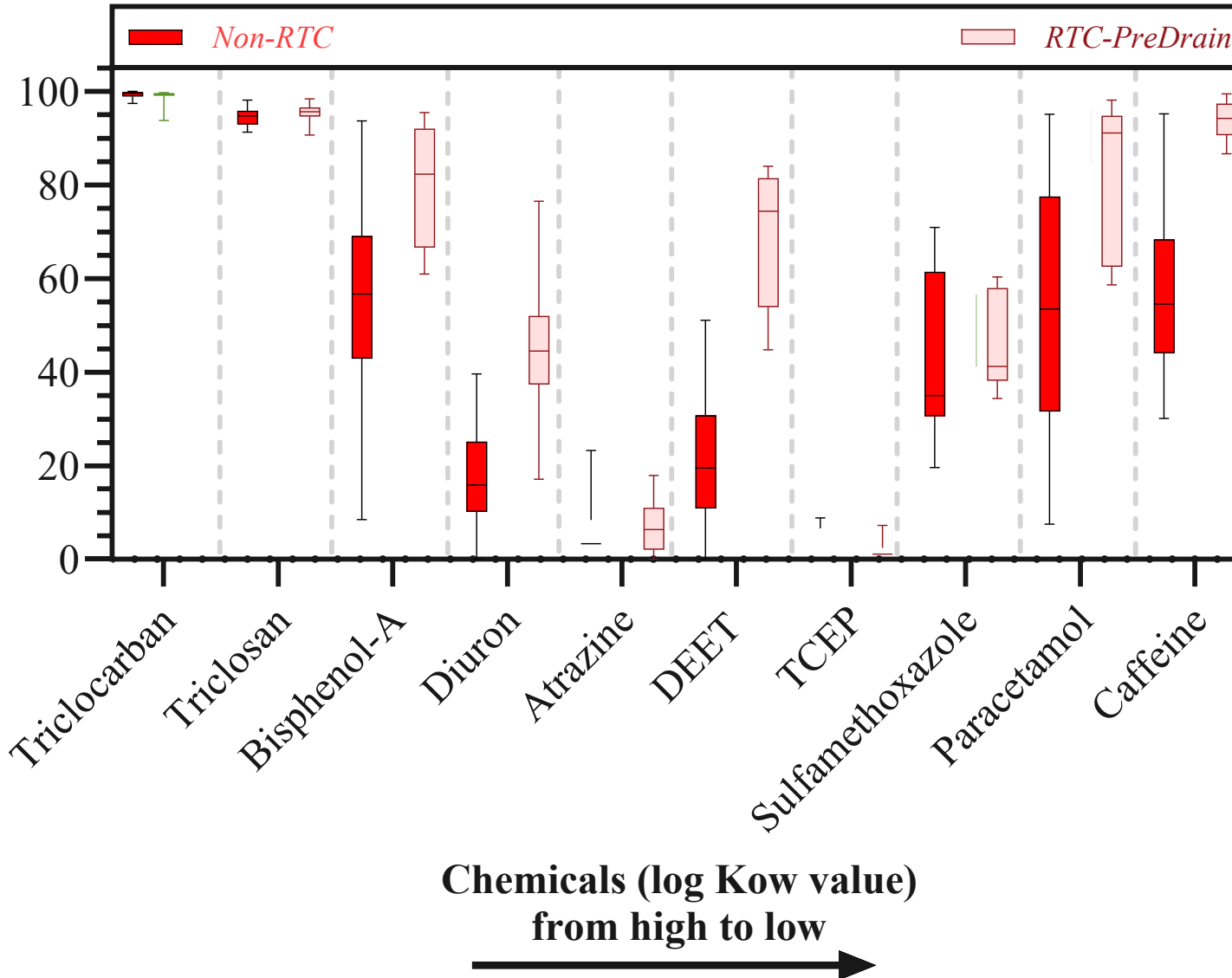
RTC significantly enhanced the removal



Traditional biofilters:

- Varied & low removal
- Huge variances

RTC significantly enhanced the removal



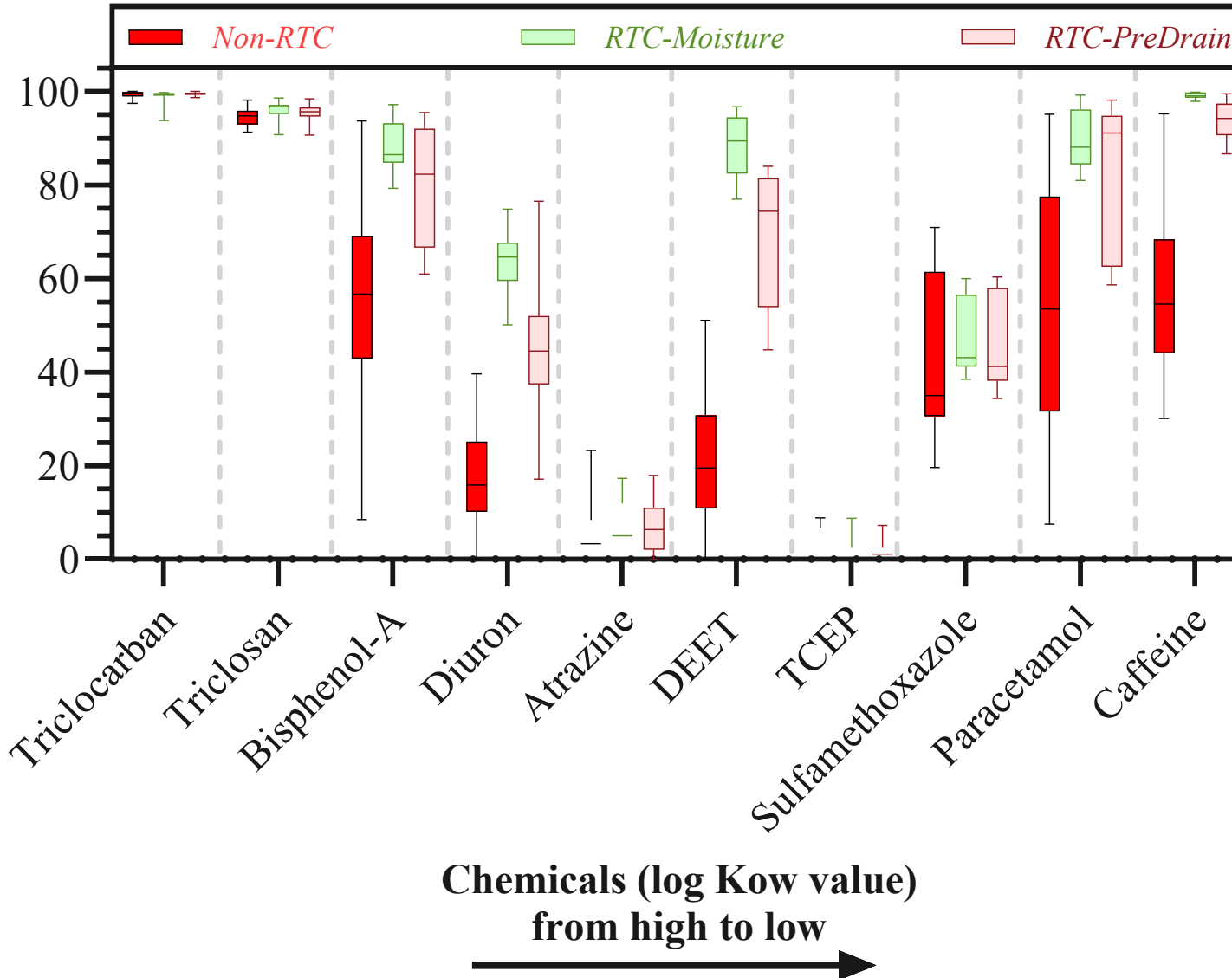
Traditional biofilters:

- Varied & low removal
- Huge variances

RTC biofilter (one more release)

- Improved performance
- Less variance

RTC significantly enhanced the removal



Traditional biofilters:

- Varied & low removal
- Huge variances

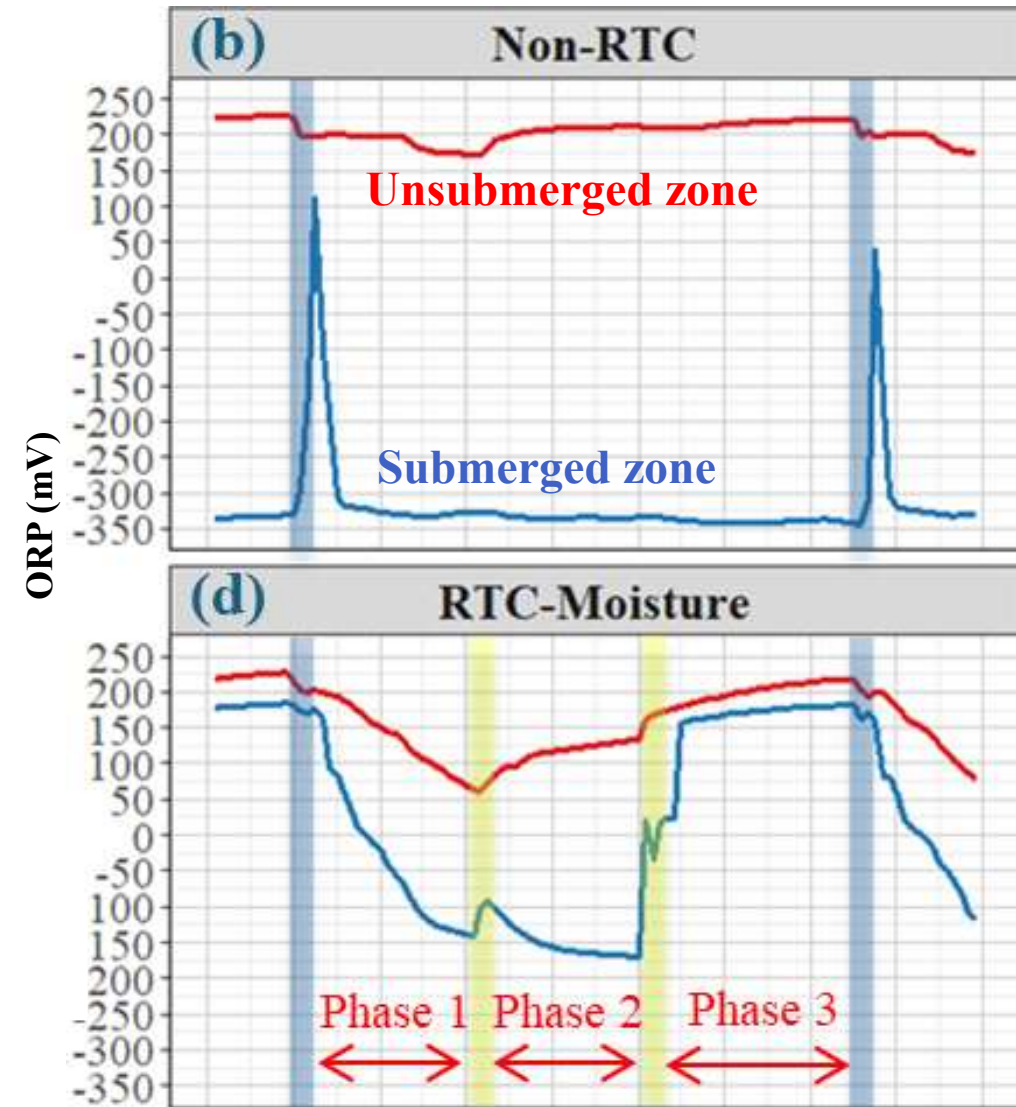
RTC biofilter (one more release)

- Improved performance
- Less variance

RTC biofilter (two more releases)

- Peak performance achieved
- Minimum variance observed

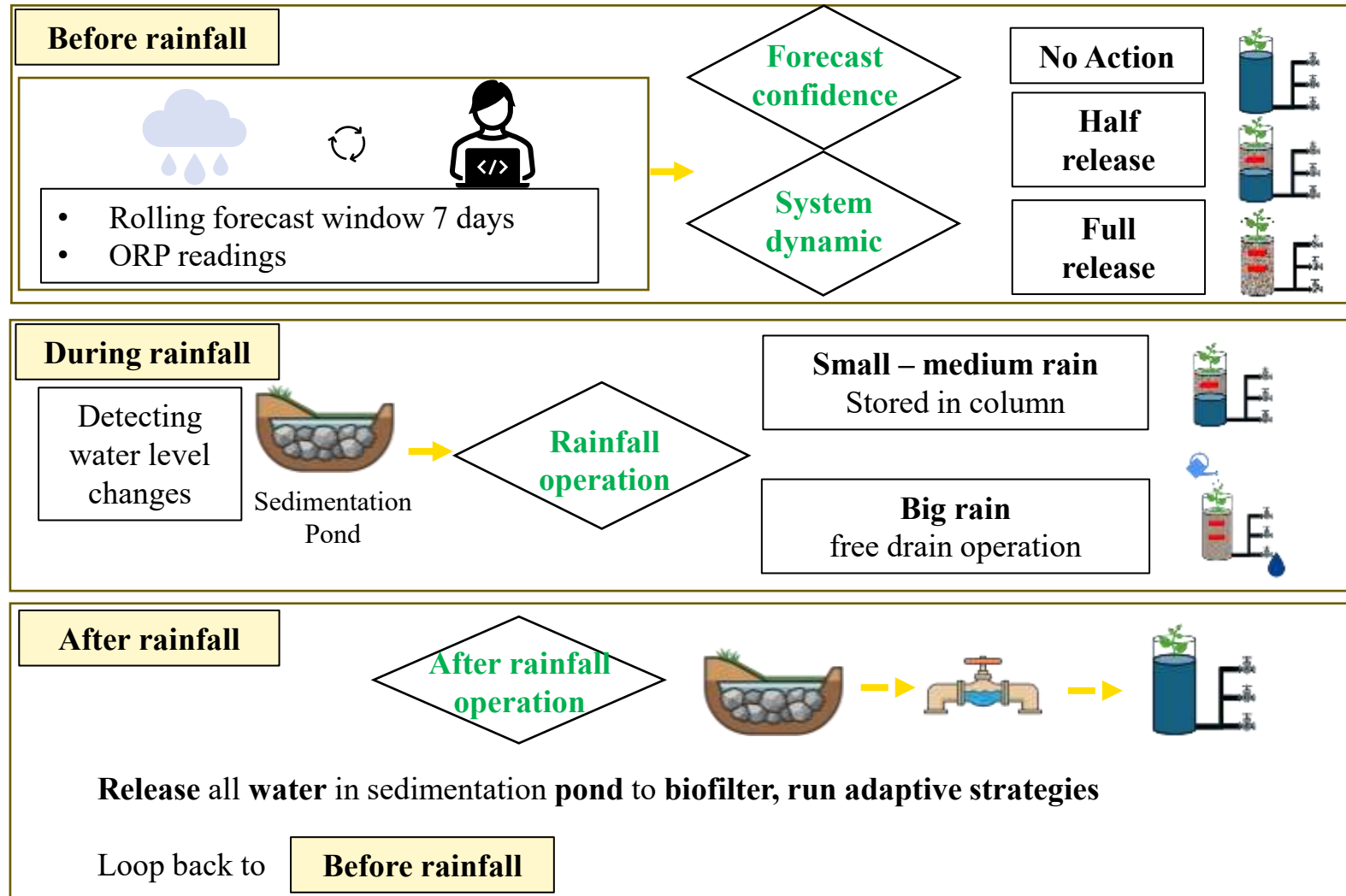
Redox potential (ORP) can be used for automatic operation



Why RTC performs better?

- Dynamic adjustments enhanced biodegradation efficiency

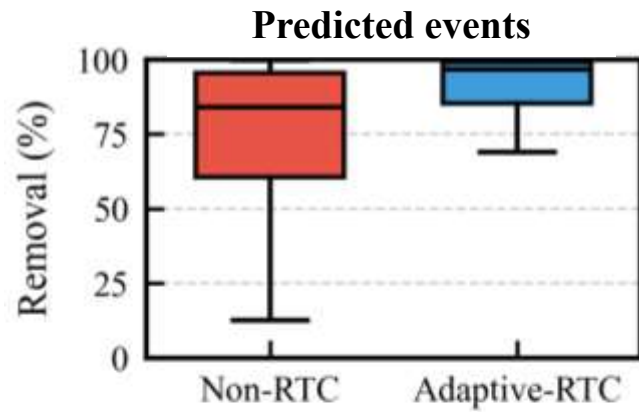
Adaptive RTC strategies under real rainfall



Operated under:

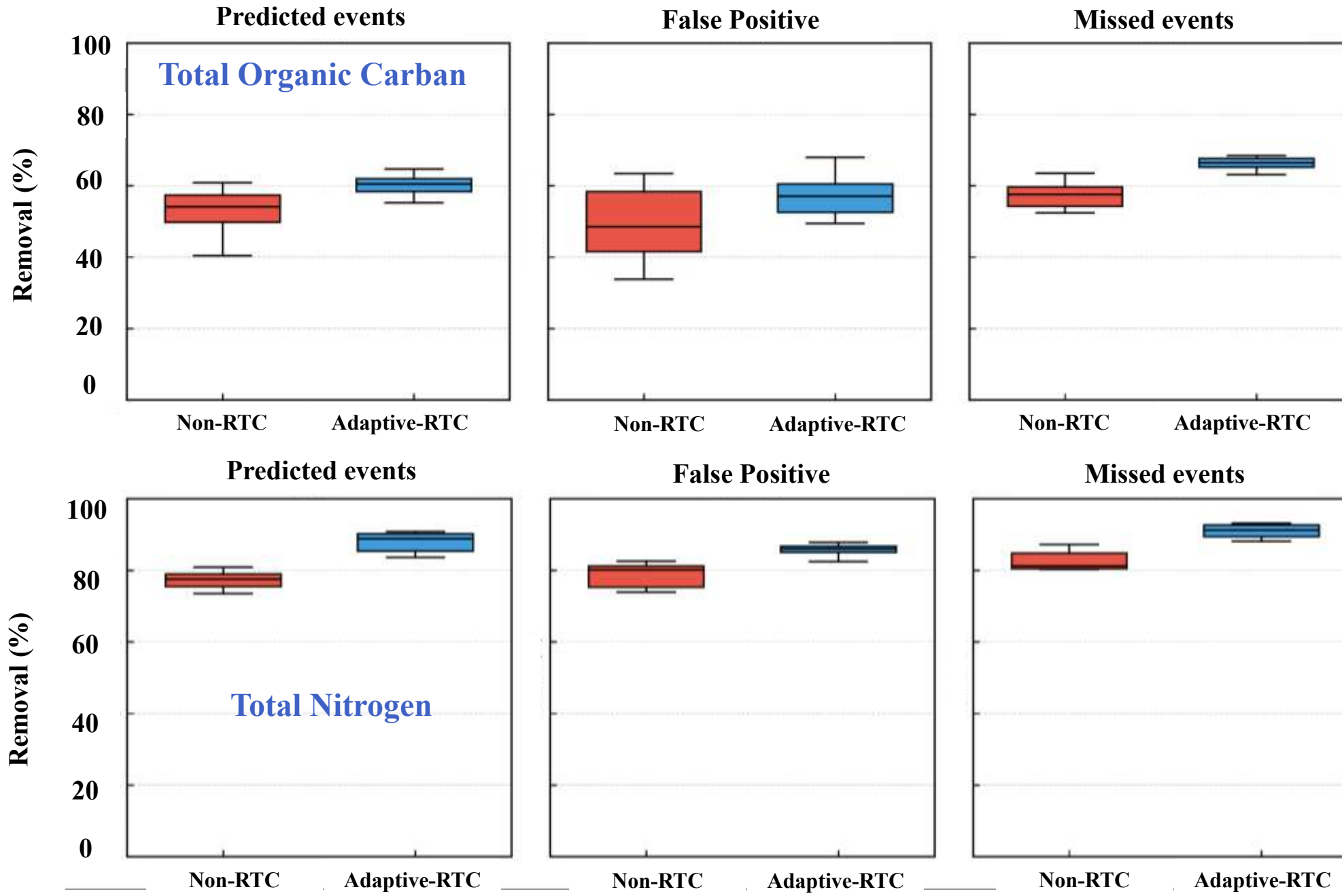
- Real rainfall events
- Real weather forecast

Adaptive RTC enhanced organic chemical removal

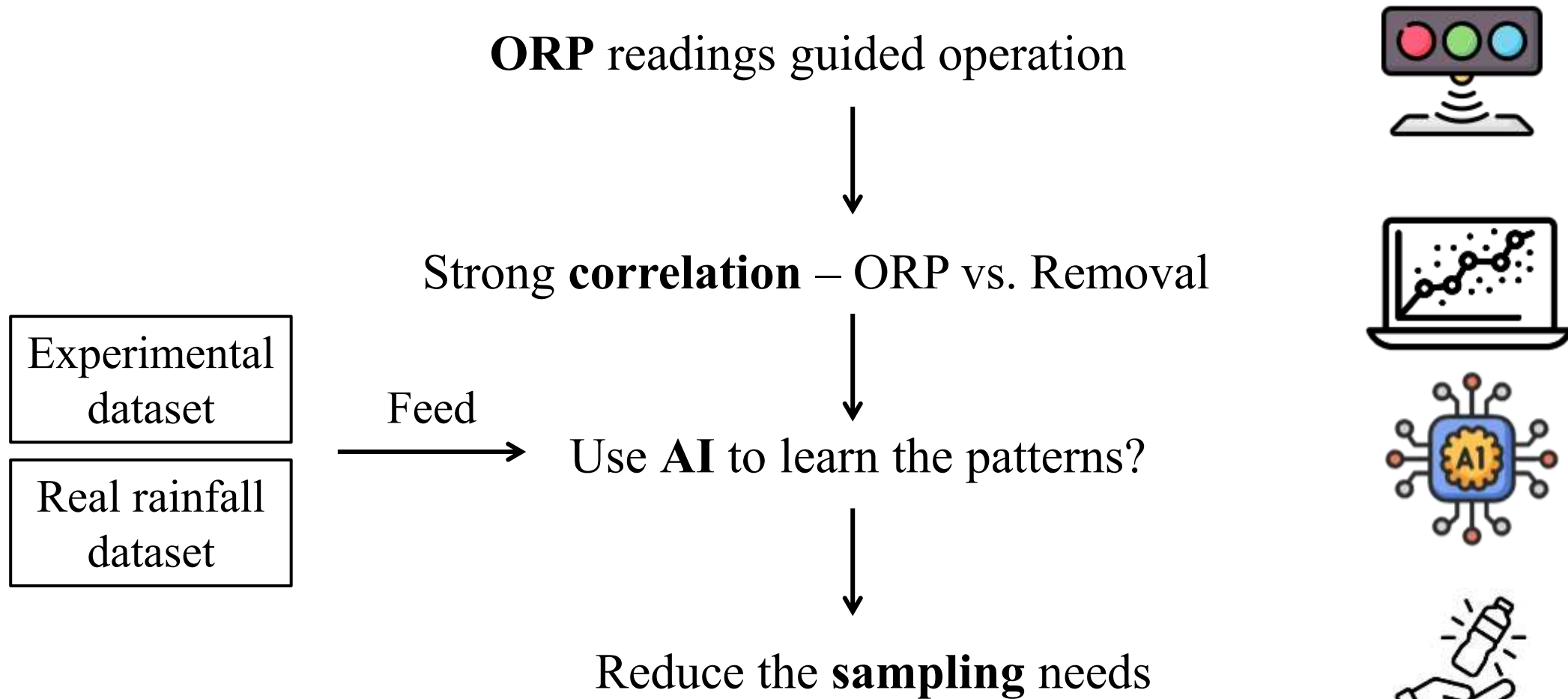


❖ **Adaptive-RTC** performed well under **predicted** events

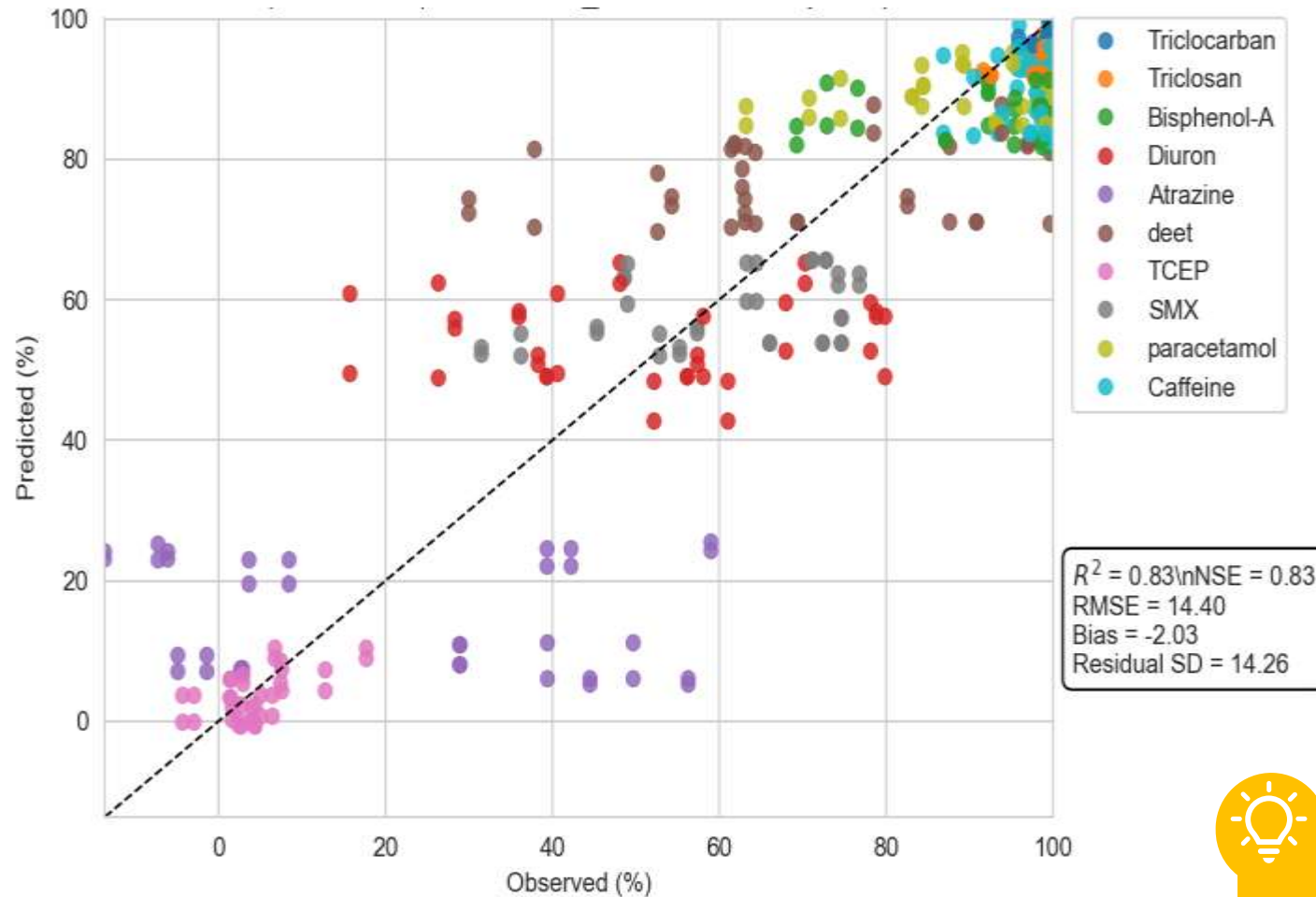
Adaptive RTC enhanced general pollutant removal



Using **Machine learning** to **predict** organic chemical removal



Using Machine learning can predict organic chemical removal



Use only sensor readings to train the model, prediction got:

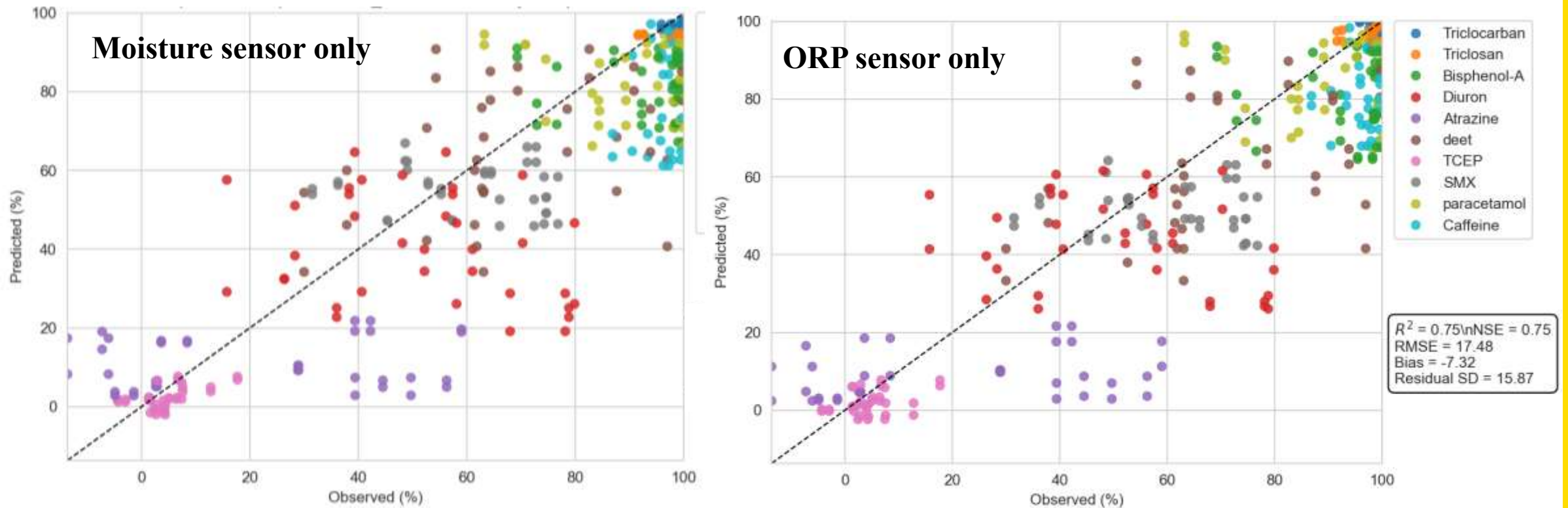
❖ 80% performance covered

❖ ~15% variance



❖ Less sensor, same job?

Using Machine learning can predict organic chemical removal



❖ 75% performance covered (dropped 5%)

❖ ~18% variance (increased 3%)

Conclusion and key messages

Overall aim



Establish a systematically way of implementing Real Time Control biofilters

Key messages:

- RTC strategies improve removal of organic chemicals.



Future work:





Thank You!



Australian Government

Australian Research Council

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