Modeling the photochemical removal of pharmaceutical compounds in planted constructed wetlands

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CSU Water Conference- Spring 2023

Introduction: PPCPs

- Pharmaceutical and personal care products (PPCPs) that end up in water systems pose environmental, and health risk.
- Most wastewater treatment plants lack the money and technology to specifically target these compounds using advanced treatment to achieve high level of removal.
- Research work has explored the use of post-polishing of conventional wastewater treatment effluent using various types of constructed wetlands to provide removal beyond conventional removal of PPCPs.

https://www.ysi.com/ysi-blog/water-blogged-blog/2018/12/pharmaceuticals-personal-care-products-water-treatment

Figure 1: Pharmaceutical and personal care products (PPCPs)

Introduction: Constructed Wetlands

- Constructed wetlands combine multiple mechanisms to transform and remove PPCPs.
  - Direct and ***indirect photolysis***
  - Biological removal
  - Adsorption based removal
  - Plant uptake (in case of planted wetlands)

Pho-chemical transformation pathways

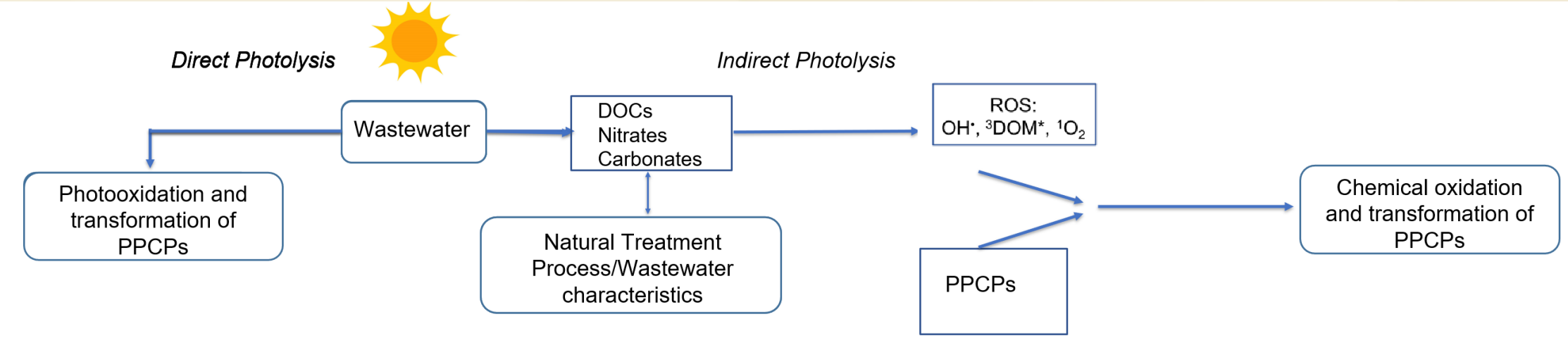


Figure 2: Schematics depicting photochemical based processes in constructed wetlands

Modeling Aspects to Consider

PPCPs Compound Specific	Wastewater Quality Changes	Reactive Oxygen Species Formation	Transport Aspects
Quantum Yields	DOC composition and concentration	Reaction between photosensitizers and photons	Hydraulic residence time
Molar absorption coefficient	Nutrient fluctuations	Depth of light penetration	Dispersion Parameters
pKa	Temperature Impacts	Available area	
Reaction constants with ROS species	Growth season impacts – from plants	Altitude and longitude	
Reaction rate with photons	pH	Season	

Arcata Wastewater Treatment Facility

- For this presentation we focus on the DOC transformation happening within the treatment train as that helps us identify the unique role of planted constructed wetlands
  - Determine how the DOC transformation affects the indirect ROS generation focusing on hydroxyl radicals

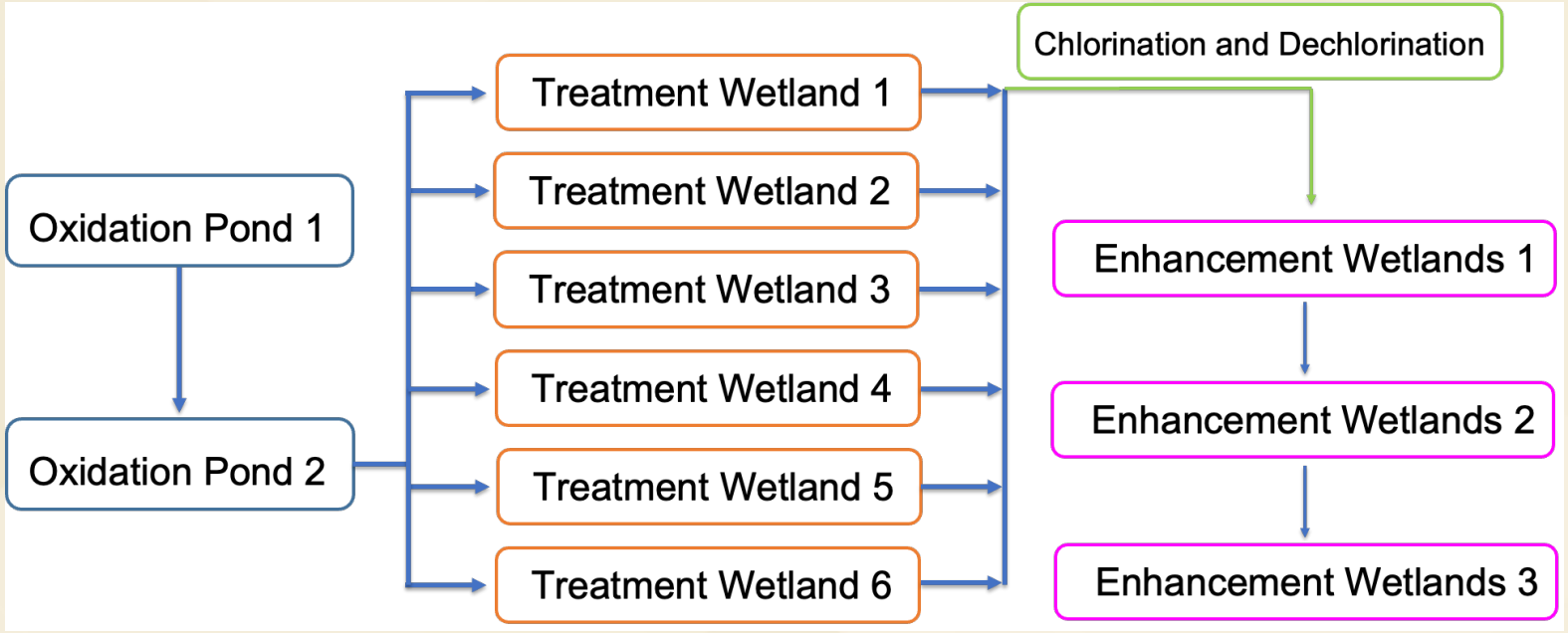


Figure 3: Wastewater flow path through the AWWTF

Site Details

- Oxidation pond effluent (OX 4-2)
- Treatment wetland effluent (TW 8-2)
- Chlorination effluent/Enhancement wetland influent (EW 11 influent)
- Enhancement wetland effluents (EW 12, EW 14, and EW 15)

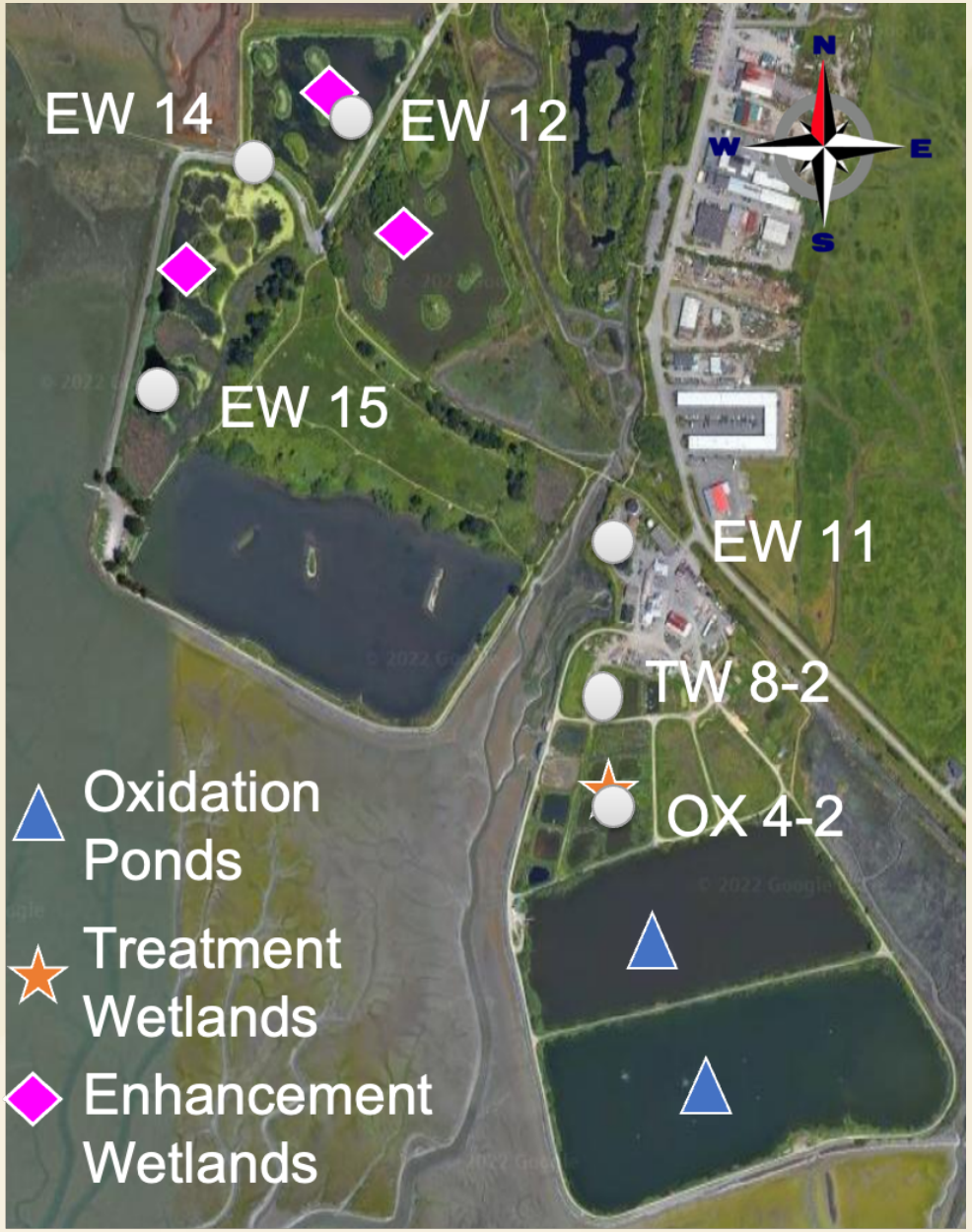


Figure 4: Satellite photo of AWWTF with sampling locations

Some results

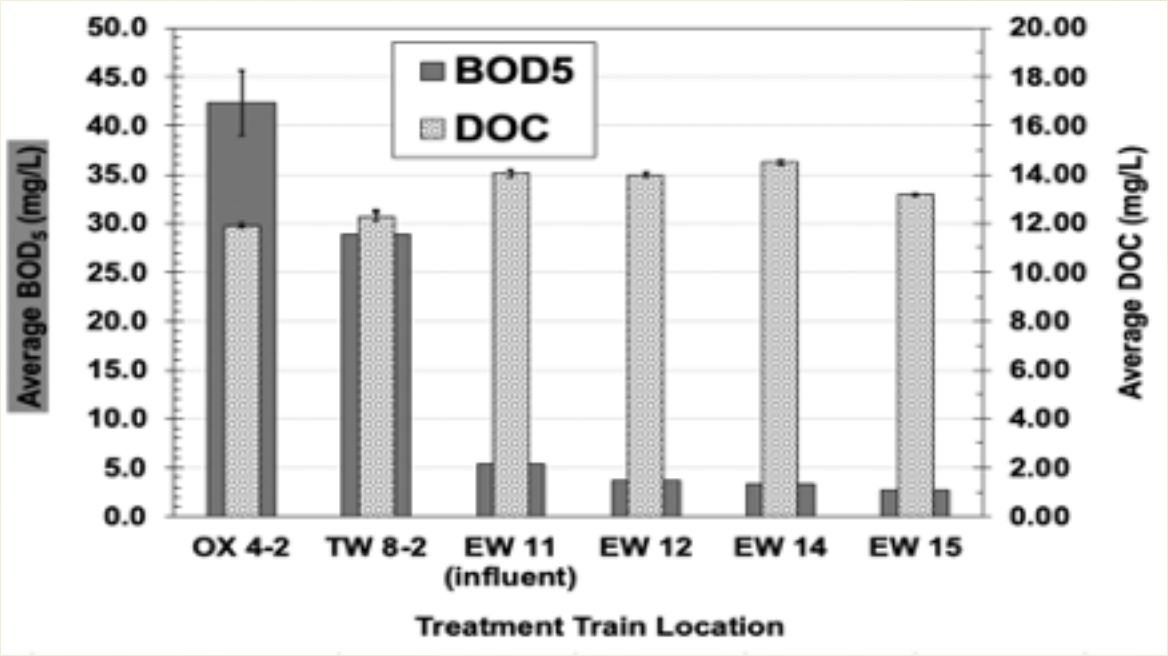


Figure 5: BOD_5 and DOC concentrations throughout the AWWTF

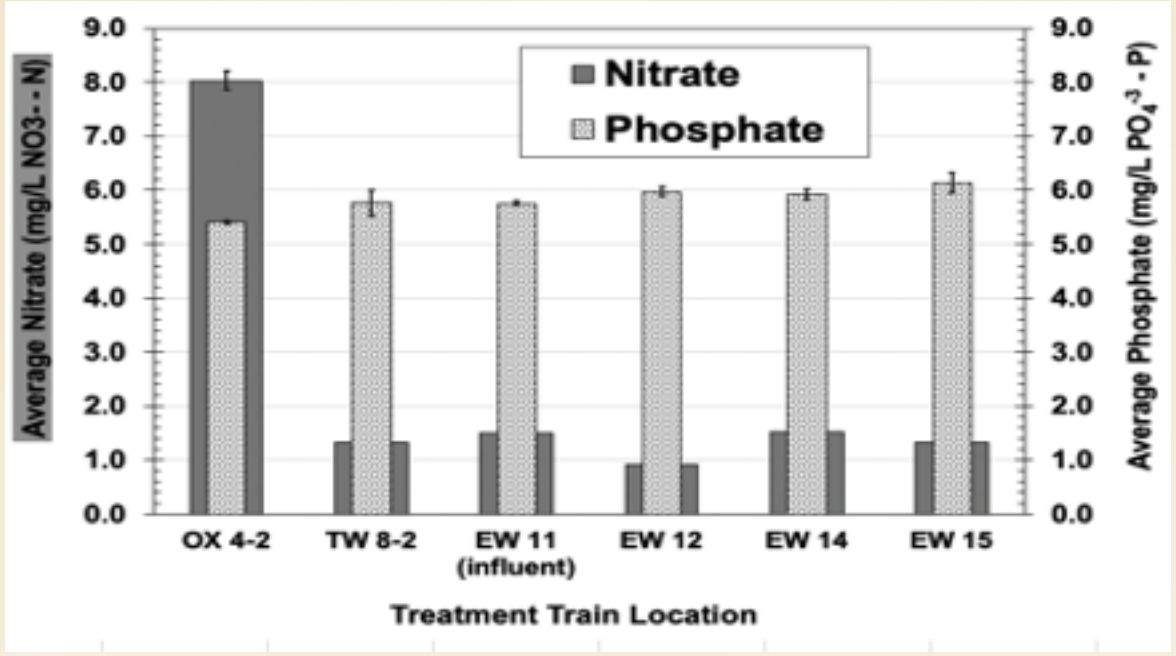


Figure 6: Dissolved nitrate and phosphate concentrations throughout the AWWTF

Some Results

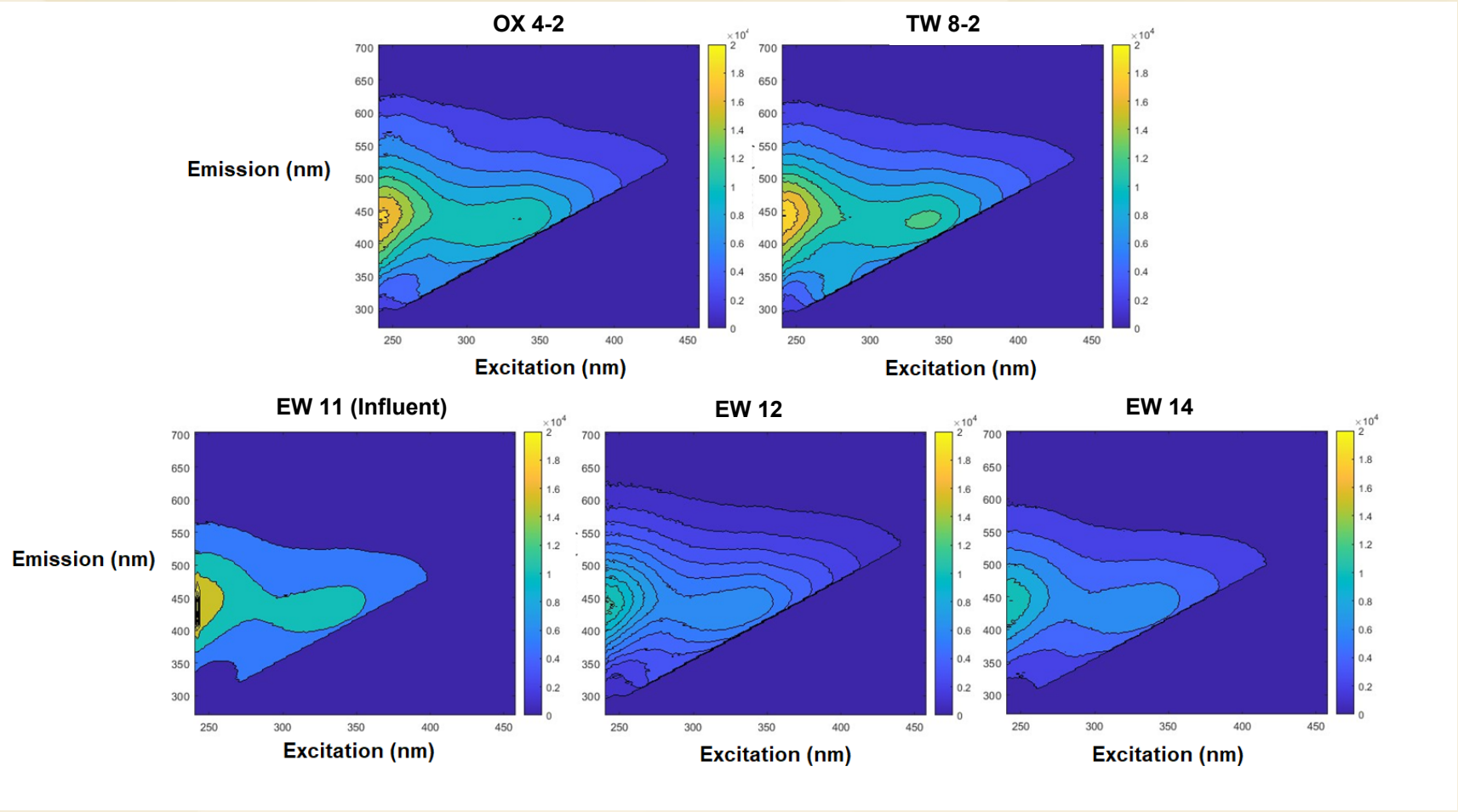


Figure 7: EEMS throughout the AWWTF. Z axis (color bar) is intensity in cps

Some Results

$$TA + \cdot OH \rightarrow 2HTA$$

- We saw an interesting effect of the treatment wetland on the hydroxyl radical formation
- Method details in Marty King's Poster

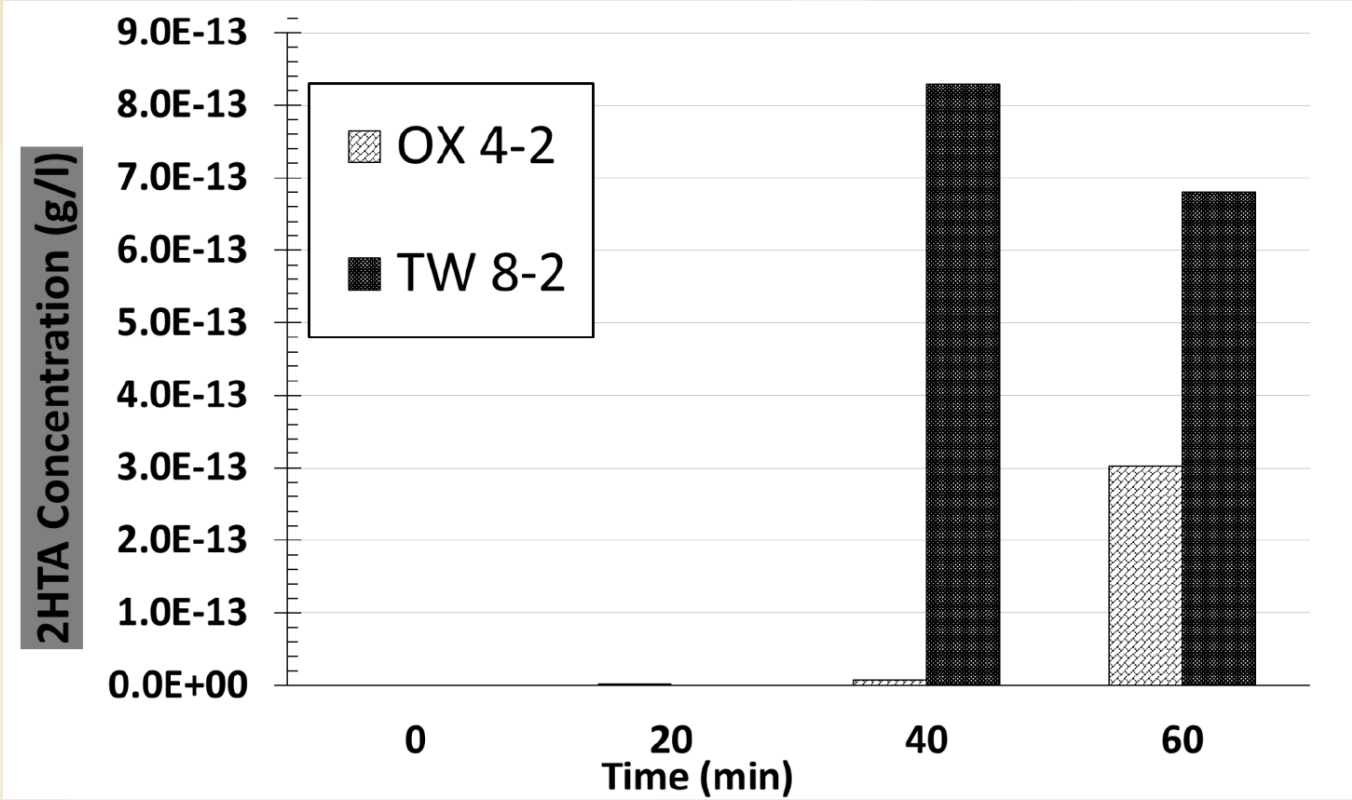


Figure 8: 2HTA concentrations of Oxidation Ponds (OX 4-2) and Treatment Wetlands (TW 8-2), taken at 20 min intervals during solar simulator experiment

Organization of Research

Claire Ingvoldsen

- DOC Characterization and Modeling Using Fluorescence

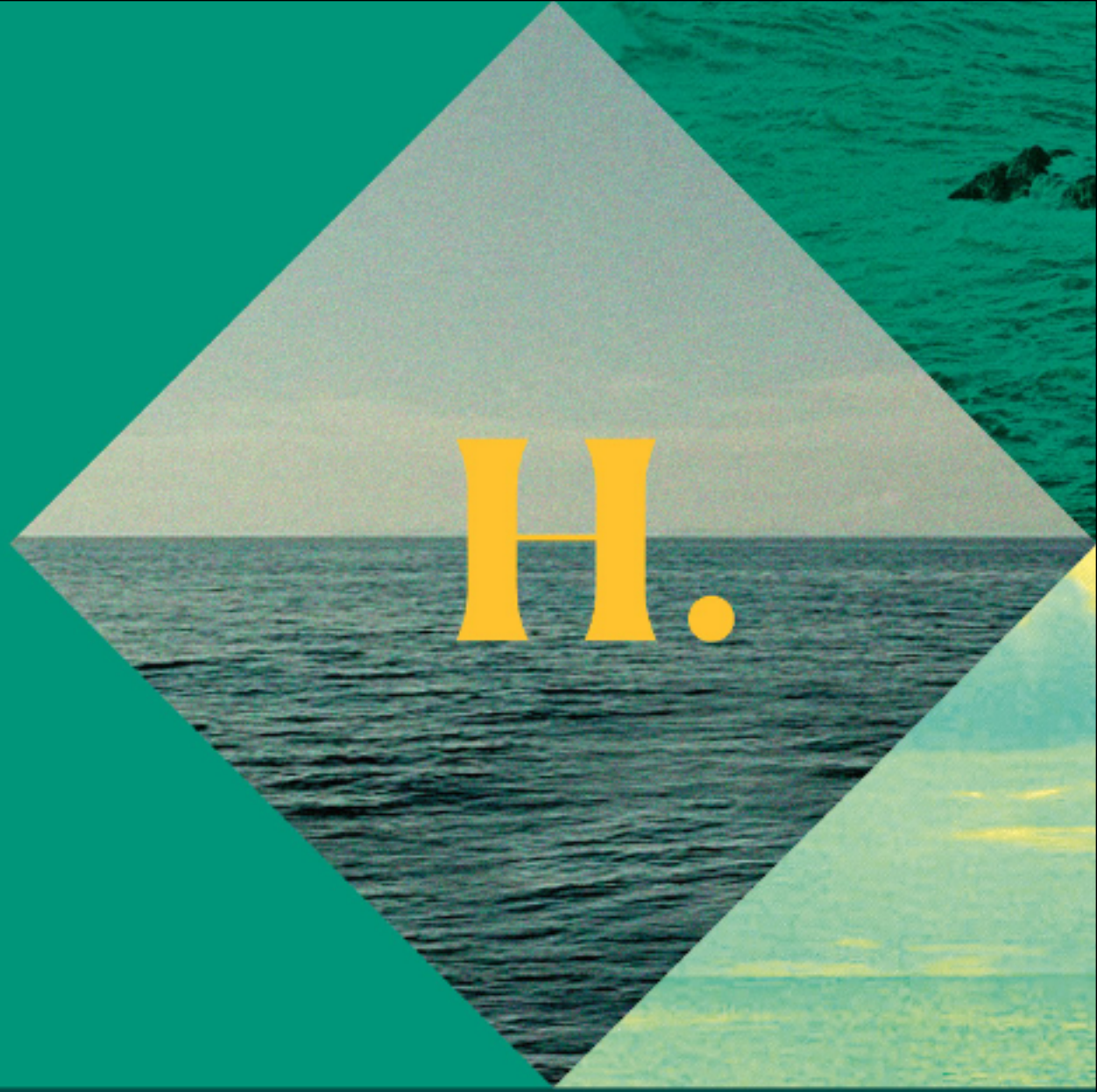
Angel Cortez Ramirez

- Water quality analysis and process modeling

Marty King

- ROS formation experiments

Acknowledgements and Questions



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Acknowledgements

- We recognize the land that is the focus of our research and the institutions that housed this project are located on the present and ancestral Homeland and unceded territory of the Wiyot Tribe. Tribes and Nations in Humboldt County include Hupa, Karuk, Mattole, Tolowa, Wailaki, Wiyot, Yurok. Donation to the Wiyot Tribe honor tax: http://www.honortax.org/index.html
- Indian Natural Resources Science & Engineering Program
- NSF LSAMP (grant number HRD-1826490, NSF Native FEWS (grant number HRD 2120001)
- Yacob Startup Fund (Cal Poly Humboldt)
- AMRI is Arcata Marsh Research Institute, City of Arcata's Wastewater Treatment Plant, https://arcatamarsh.wordpress.com/
- Dr. Matthew Hurst: Provided training and access to Shimadzu TOC Analyzer
- Dr. Jorge Monteiro: Provided training and access to the Edinburgh FS5 Spectrofluorometer
- Brandon Wilcox: Helped with the development of HPLC methodology and provided training
- Colin Wingfield: Provided Laboratory training in both Water Quality testing and safety
- Michelle Dostal: Logistical Assistance
- Schatz Energy Research CenterElizabeth Van Skike& Kayleigh Vincent-Welling: Provided training and assistance on Oriell® Sol3ATM CLASS AAA Solar Simulator

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