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The treatment and use of oilfield produced water in Kern County.

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Physics and Engineering

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Outline

- Produced Water in Kern County
- Electrochemical oxidation of produced water
- Irrigation of forages with treated produced water
- Collaborative project on risk assessment

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Produced Water in Kern County

- Water that is brought to the surface when oil is extracted from the ground.
- A production of 7-15 barrels of water per barrel of oil in Kern County.
- Some of if is very low in salt, some of it is saltier than seawater (TDS can range from below 1000 ppm to above 100,000 ppm) .
- Besides oil and salt, this water may contain boron, and other inorganic elements, such as heavy metals.

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Produced Water in Kern County

What they do with it?

- Underground injection into disposal wells;
- Reinjection for enhanced oil recovery (EOR) - water flooding or steam injection (about ¼);
- Irrigation.
- Some disposal into unlined pits.

No disposal=no oil production

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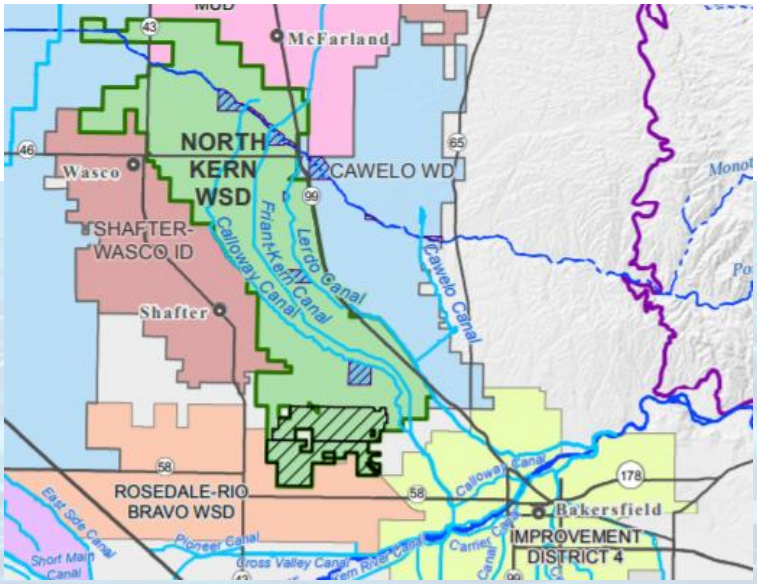
Produced Water in Kern County

- Agriculture in Kern County uses around 2.3 million acre-feet per year (around 50 million barrels per day).
- Around 5 million barrels per day of produced water are extracted.
- Most of agricultural use of produced water (43,300 ac-ft/yr) is in 2 districts: Cawelo (30,000 ac-ft) and North-Kern (11,000 ac-ft.)



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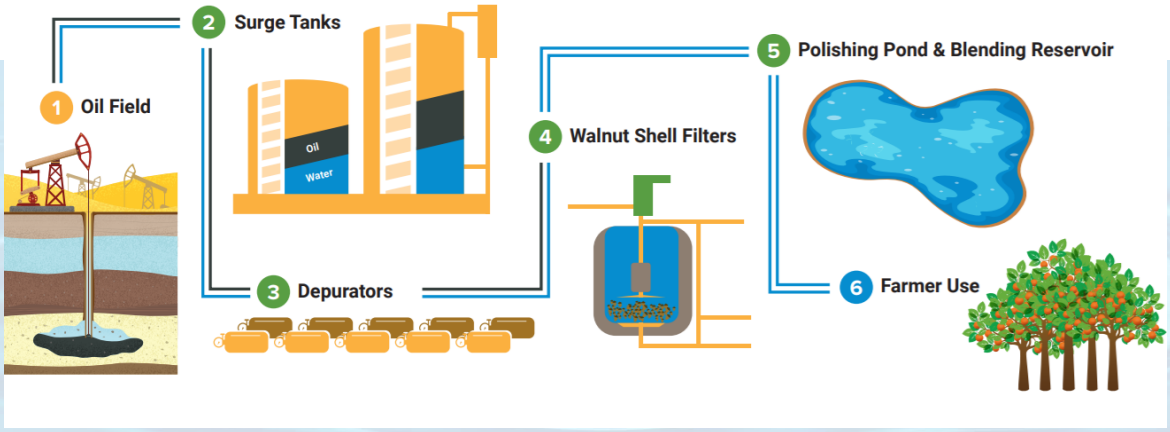
❖How is this water cleaned?

- Separate suspended oil. Induced air flotation.
- Walnut shell filters are used to absorb some of remaining oil.
- For steam generation: reduce the hardness by ion exchange.
- For further reduction of TDS: Reverse osmosis. Expensive.



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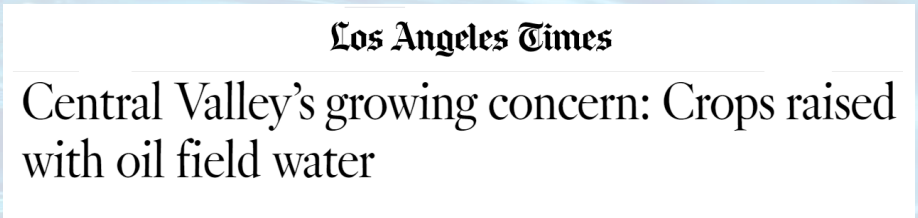
❖How is regulated?

- California regional water boards regulate the reuse of this water.
- Every reuse project is required to acquire a permit and testing of the water is done at regular intervals.
- About 5 years ago, there was a strong movement towards limiting the use of produced water in agriculture.
- Food Safety Expert panel is currently working on evaluating the practice of agricultural irrigation with produced water.


ENVIRONMENT JULY 24, 2015

These Popular Fruit and Veggie Brands May be Grown With Oil Wastewater

The practice is gaining popularity in drought-plagued California, but is it safe?


Los Angeles Times

Central Valley's growing concern: Crops raised with oil field water

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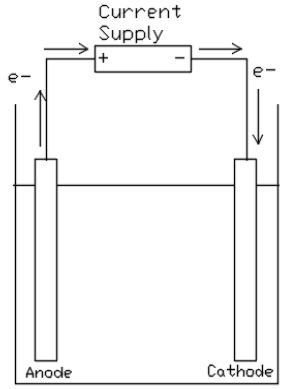
Electrochemical oxidation of produced water

- Electrochemical reaction: caused by the passage of an electric current and involving in most cases the transfer of electrons.
- Electrochemical reactions in produced water have been used mostly as “electrocoagulation” by the use of aluminum electrodes.
- Electrode materials: Iron, Aluminum, and mixed metal oxides (MMO) which are a titanium substrate with a coating of Iridium, Ruthenium or Platinum oxides.
- Generation of reactive species :hydroxyl, active chlorine, hydrogen, oxygen.



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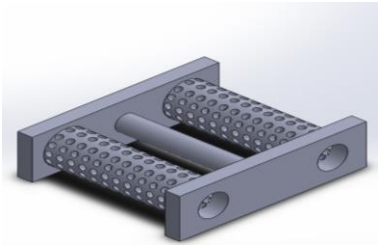
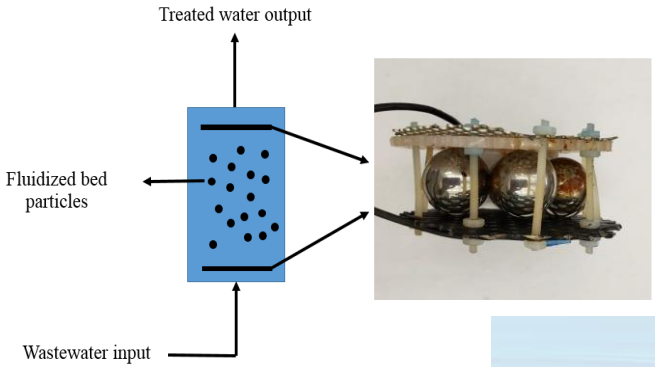
Electrochemical oxidation of produced water

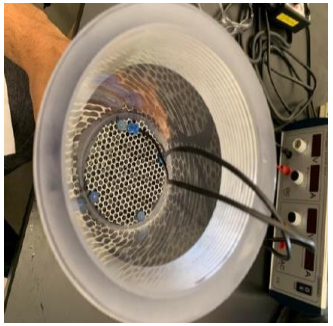
Different configurations:

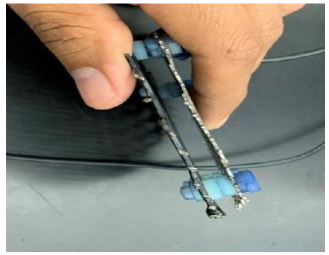
Concentric tubes:



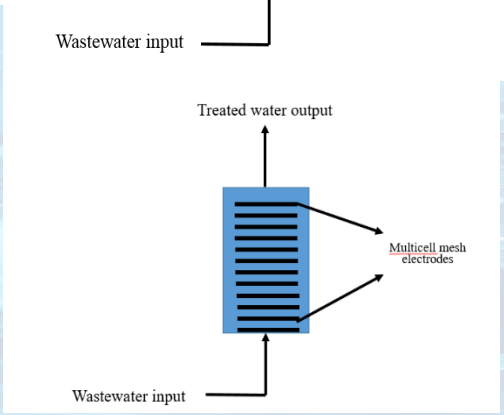
Fluidized bed:

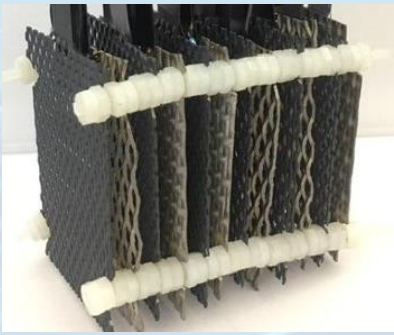






Multicell:





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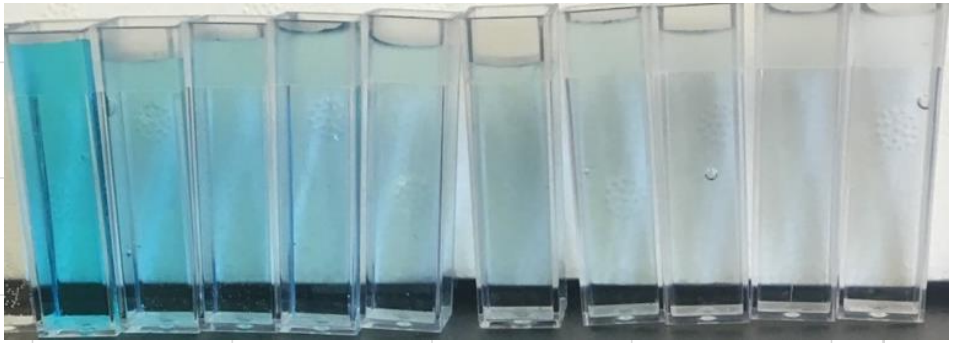
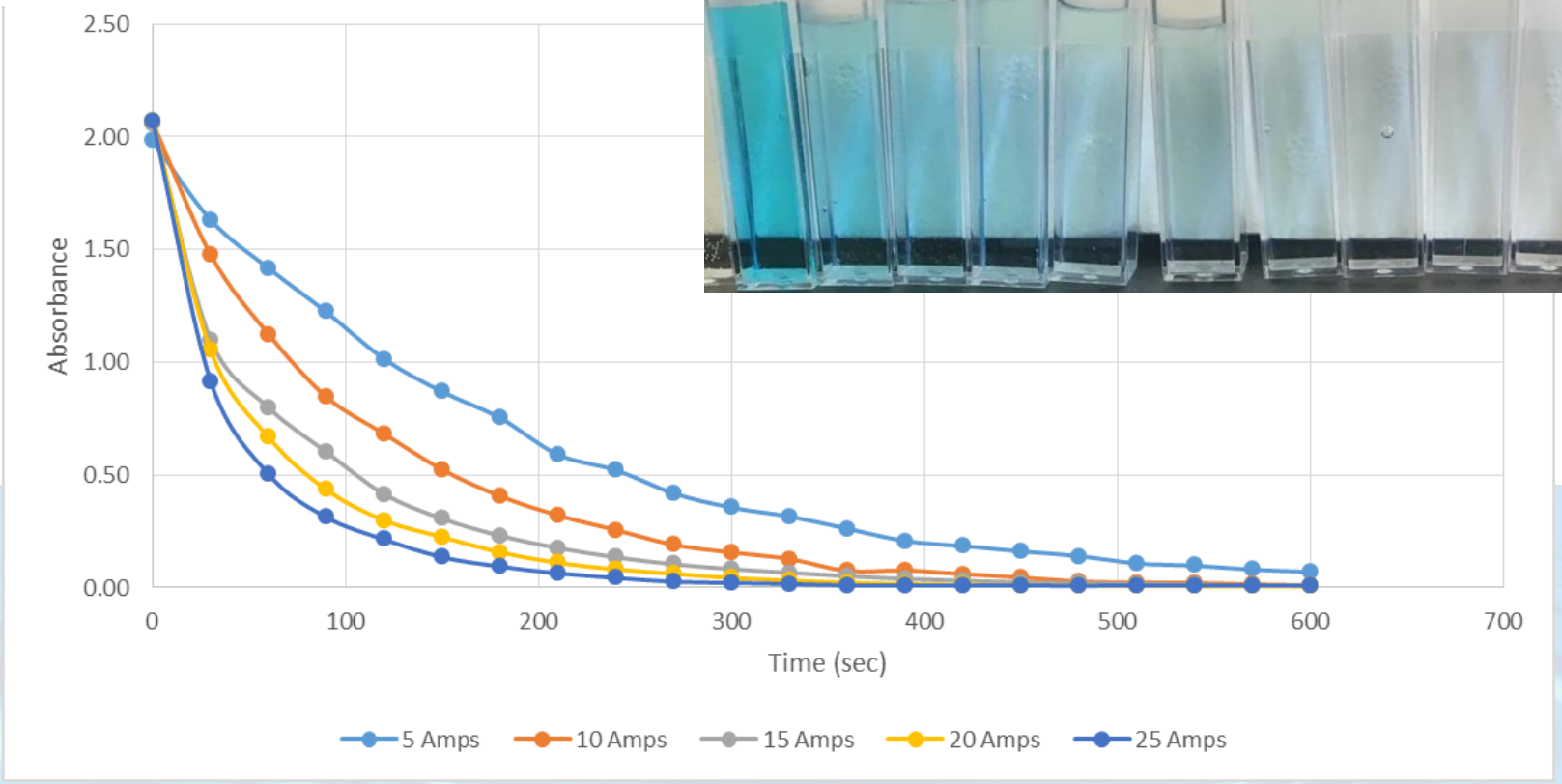
Measuring efficiency of design





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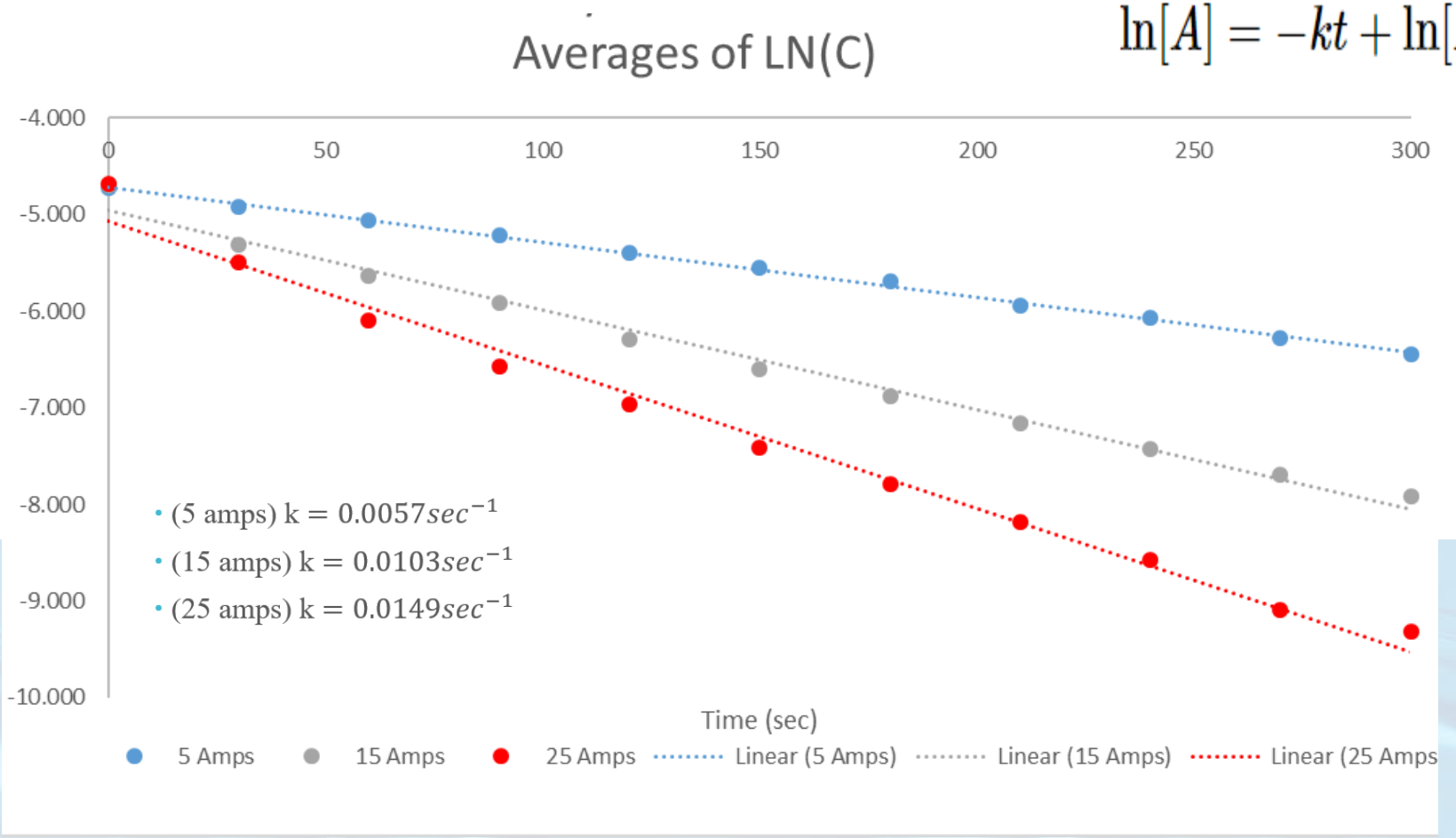
Measuring efficiency of design

$$\ln[A] = -kt + \ln[A]_o$$



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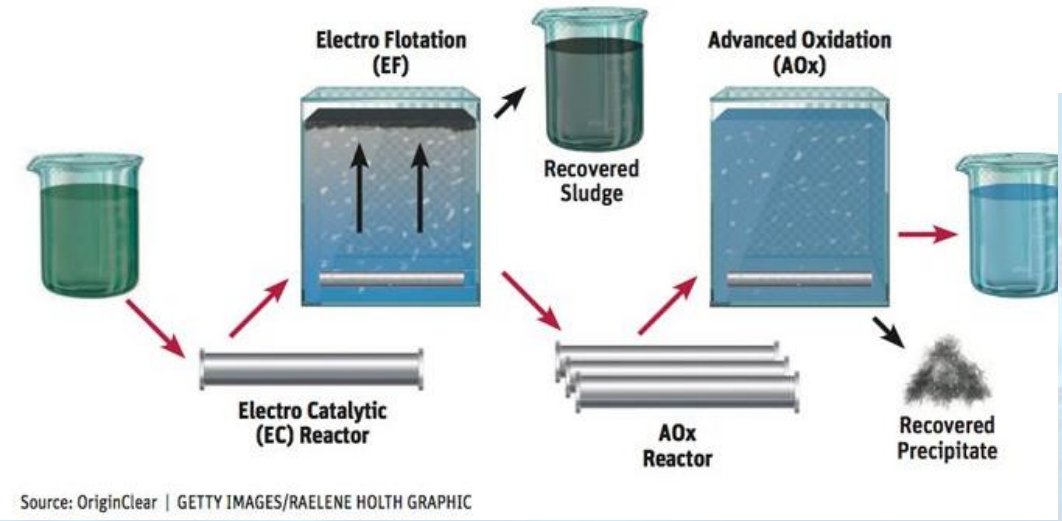
Electrochemical oxidation of produced water

Two stage Originclear process, same MMO anodes:

- 1) Electroflotation: Production of oxygen and hydrogen bubbles induce the floatation of suspended oil droplets. Similar to induced air flotation, no mechanical parts.

- 2) Electroxidation: The reduction in COD is caused by the reaction of reactive species with hydrocarbons.



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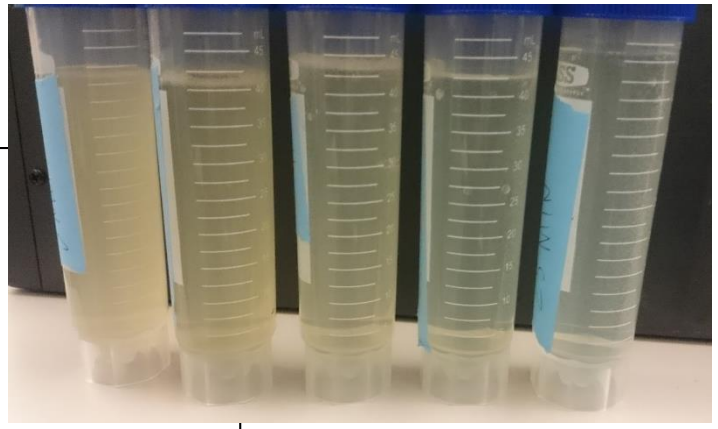
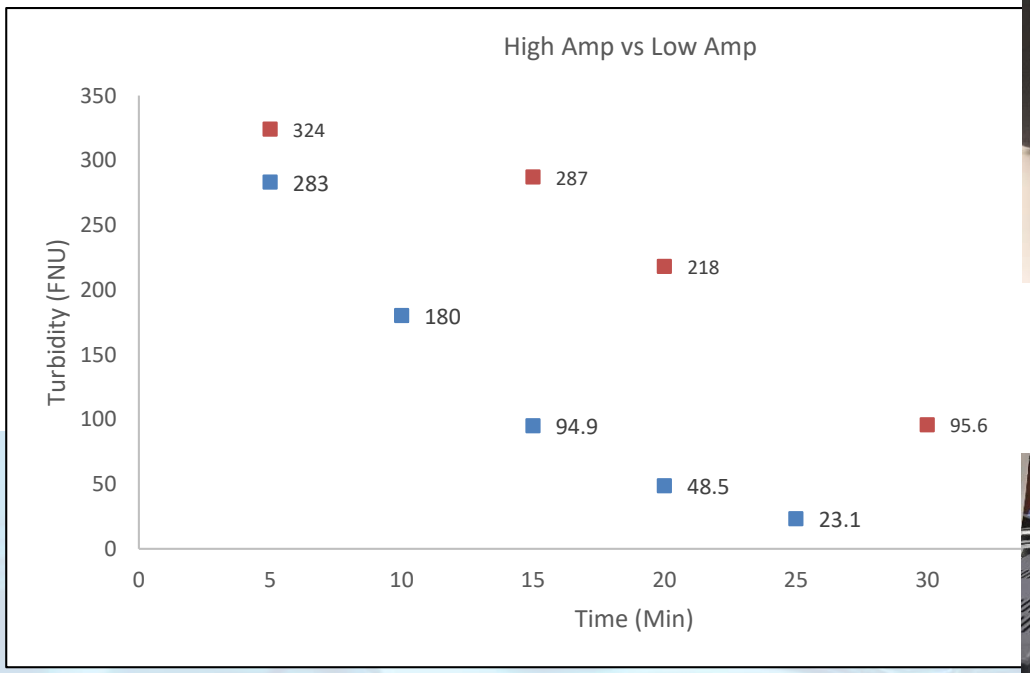
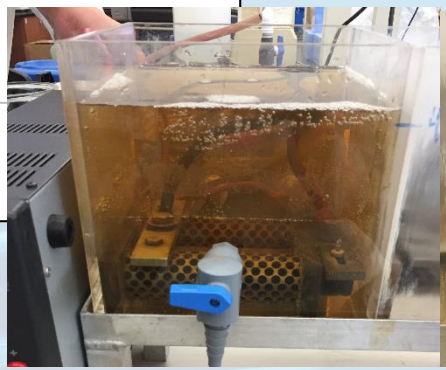
Electrochemical oxidation of produced water

- Electroflotation:







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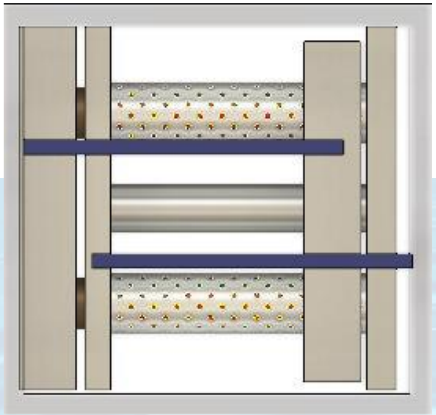
Electrochemical oxidation of produced water

	COD	COD	COD	COD
Initial	130	121	56	50
EF	35	26	16	20
EO1	10	12	8	6
EO2	0	0	0	1
Flow rate EO	1.5 l/min			
Residence time EF: 4 minutes				



- Around 500 gallons of produced water was treated and used for greenhouse experiments.

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Electrochemical oxidation of produced water, field study

- I

Constituent	Limitation	Units
Electrical Conductivity (EC):	1000	micromhos per centimeter (µmhos/cm)
Chloride:	200	milligrams per liter (mg/L)
Boron:	1	mg/L

- Water characteristics
- 1960 micromhos per centimeter
- Salinity : Cl 483 mg/l
- Boron: 1.6 mg/l

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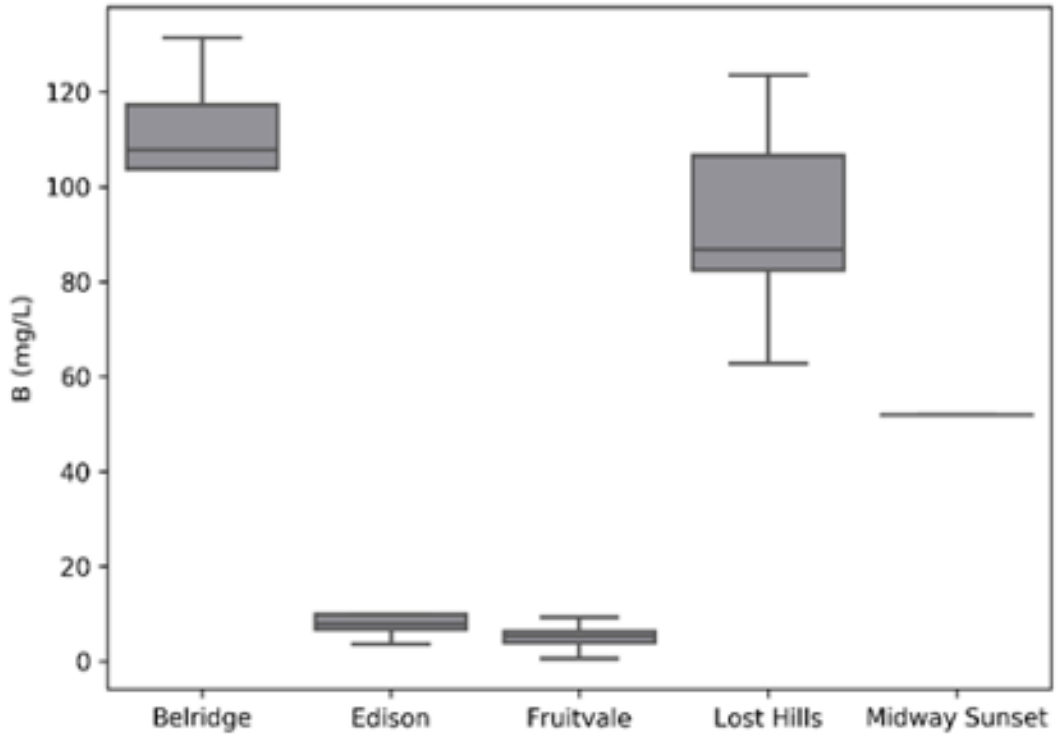
Electrochemical oxidation of produced water, field study

- Boron can be very high in some formations



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- Small oil producer: 1000- 2000 barrels per day, only 15 of oil

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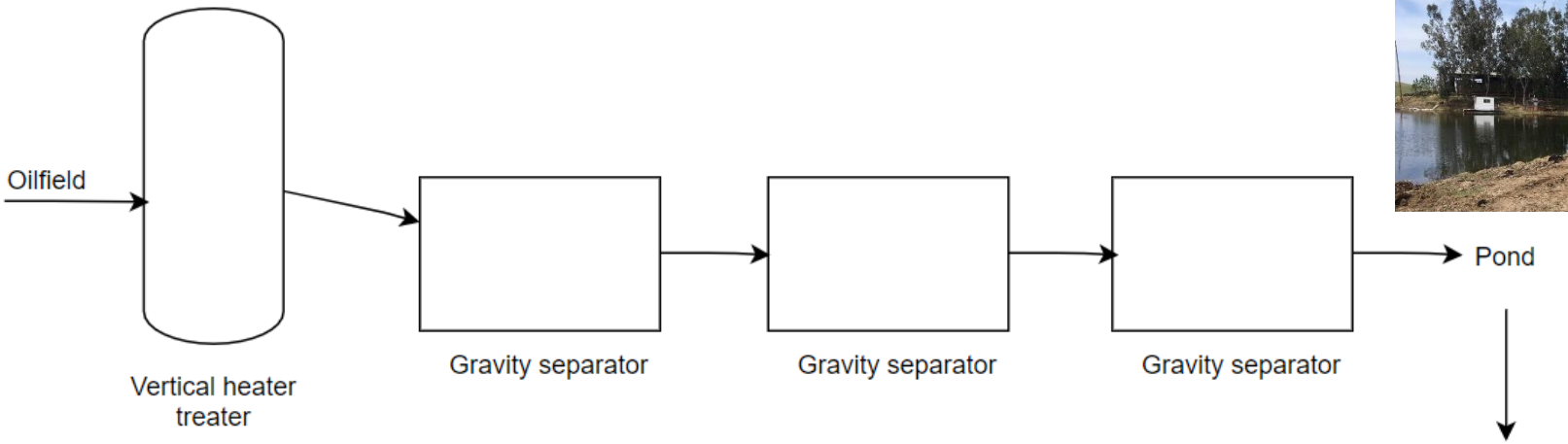
- Produced water is separated from oil by gravity separators and coagulants.



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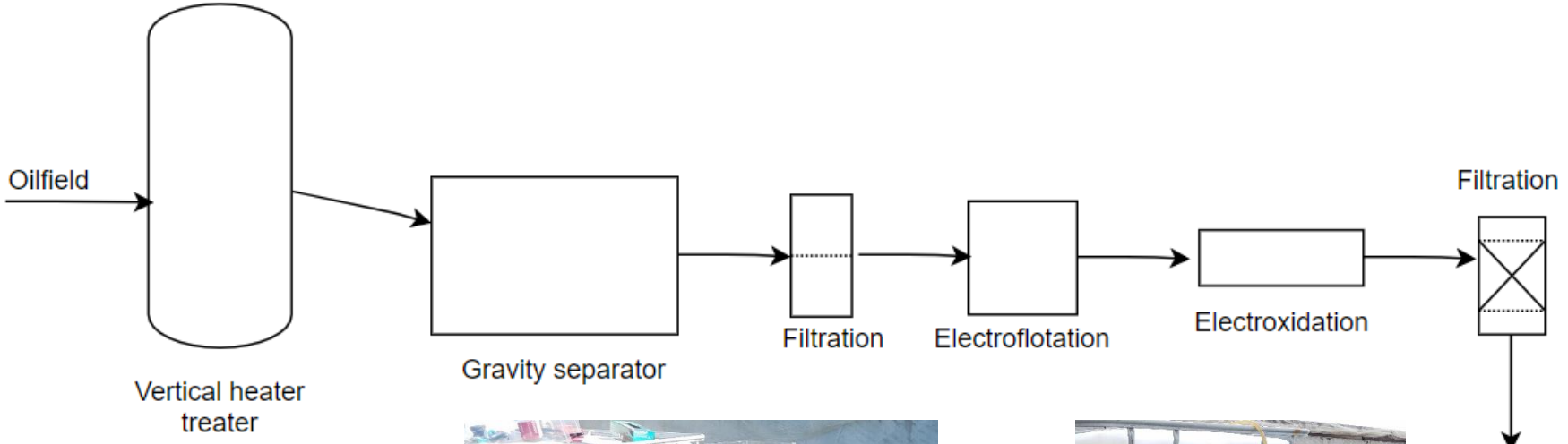
- Produced water is treated by filtration, electroflotation, and electrochemical oxidation.



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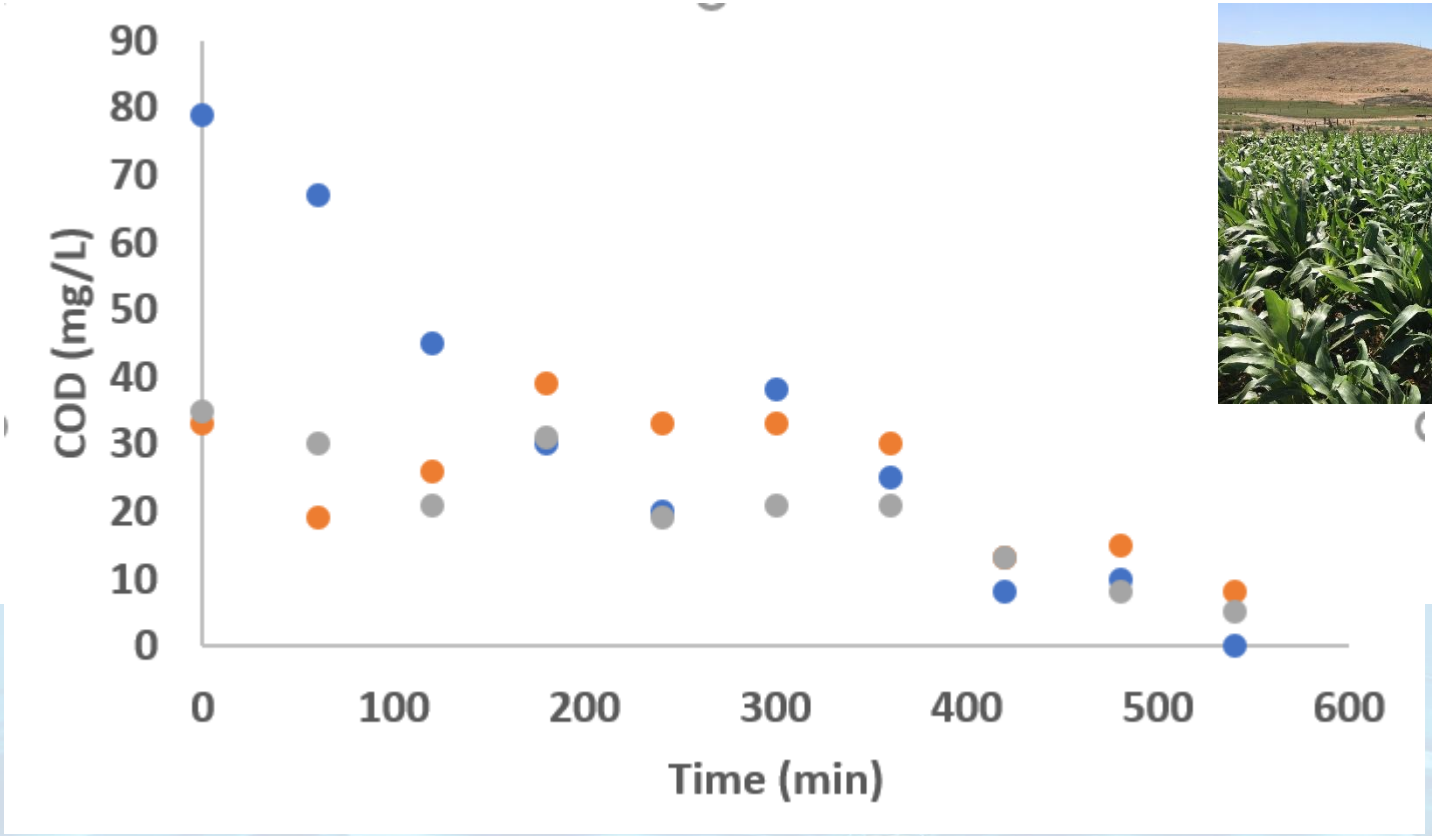
Electrochemical oxidation of produced water



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

The impact of using low-saline oilfield produced water for irrigation on water and soil quality in California

Andrew J Kondash [a,b], Jennifer Hoponick Redmon [b], Elisabetta Lambertini [b], Laura Feinstein [c], Erika Weinthal [a], Luis Cabrales [d], Avner Vengosh [a,*]

- This study indicates that blended low-saline OPW provided by the Cawelo Water District of Kern County in the southern San Joaquin Valley of California is of comparable quality to the local low-saline groundwater.

- Salts and metal concentrations in the low-saline OPW in the Cawelo Water District do not exceed the irrigation and drinking water standards, except for arsenic.

- A small sampling test showed no metals and As enrichment in pistachios grown in the CaweloWater District when compared with other regions.

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Risk Analysis, Vol. 0, No. 0, 2020 DOI: 10.1111/risa.13641

Is Food Irrigated with Oilfield-Produced Water in the California Central Valley Safe to Eat? A Probabilistic Human Health Risk Assessment Evaluating Trace Metals Exposure

Jennifer Hoponick Redmon,[1,*] Andrew John Kondash,[1] Donna Womack,[1] Ted Lillys,[1] Laura Feinstein,[2] Luis Cabrales,[3] Erika Weinthal,[4] and Avner Vengosh[4]

- Very conservative study.
- Greatest risk is for a vegetarian person consuming only food irrigated everyday with produced water, but still very low.
- Assuming maximum concentration of arsenic in the irrigation water.
- Blended produced water had an average 7 times lower concentration than the maximum.
- No other inorganic constituents accumulated enough in crops and soil to pose significant risks to human health.

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❖Acknowledgments

Collaborators: Florence Cassel (Fresno State), Avner Vengosh (Duke), Jennifer Redmon (RTI International), Laura Feinstein (Pacific Institute), Jean Louis Kindler and Nick Eckelberry (Originclear).
Students: Jesus Banuelos, Karli Cordova, Brooke Mioni, Catalina Rivera, Julian Arellano, Silvia Zavala, Manuel Ochoa, Antony Hernandez, Hector Gutierrez, Sergio Gonzalez,Bryan Karunwi, and many others.

- USDA-NIFA“Assessing Potential Human Health Impacts Associated with the Use of Oilfield Produced Water for Crop Irrigation”, #2017-68007-26308.
- USDA-NIFA, “Investigate the use of treated unconventional water for potential agricultural applications”. 2016-38422-25544
- ARI CSU, “Physiological performance and nutritional quality of forages irrigated with oilfield waters”. #17-01-003
- Water Resources Policy Institute CSU Internships, “Investigation of Produced Water”.
- Metropolitan Water District, “Designing and building an electroxidation fluidized bed reactor” , #179948
- CERC CSUB, ““Electrochemical oxidation of organic compounds in water”.

Questions?