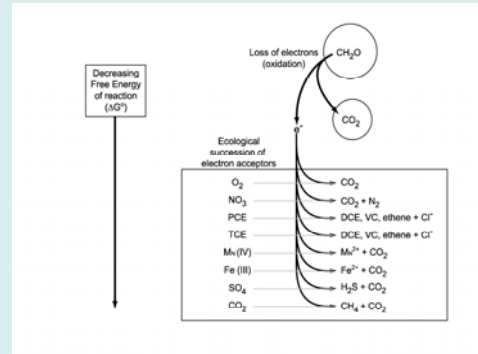


# Bioavailability of Dissolved Organic Carbon in Agriculturally Impacted Groundwater systems

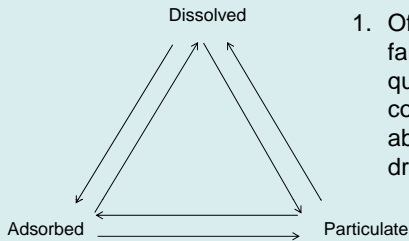
Francis H. Chapelle, Paul M. Bradley, and Peter B. McMahon



While understanding the behavior of electron acceptors in groundwater is straightforward, the behavior of electron donors (org C) is not:

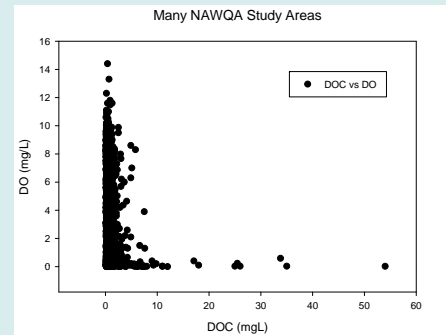


## Pools of Organic Carbon in groundwater systems



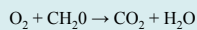
1. Of these pools, DOC is by far the smallest. So the question is, what are DOC concentrations telling us about the potential for driving redox reactions?

## DOC vs. DO, many NAWQA Study Units



## Origin of hyperbolic relationship

Begin with the irreversible chemical reaction:



Concentrations of the various constituents are related by a kinetic parameter:

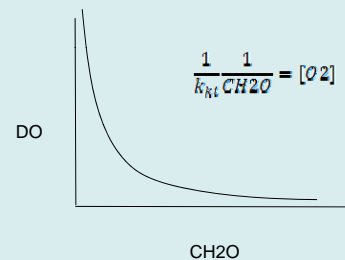
$$\frac{[CO_2][H_2O]}{[O_2][CH_2O]} = k_{kt}$$

or

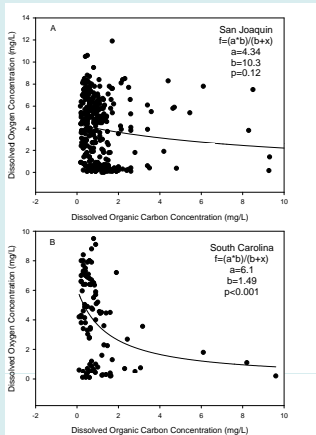
$$\frac{1}{k_{kt}} \frac{1}{CH_2O} = [O_2]$$

This is a hyperbolic algebraic expression

The degree of curvature is given by  $1/k$ . The greater the value of  $k$  (the faster the reaction), the smaller the value of  $1/k$ , giving a more pronounced curve



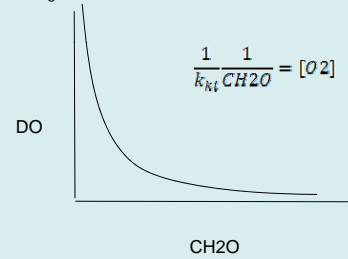
## DOC vs. DO, San Joaquin and South Carolina



69

This suggests the hypothesis that the bioavailability of DOC in SC is greater than that of San Joaquin

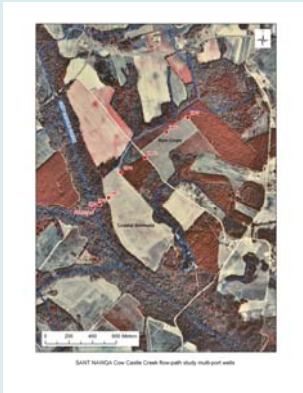
- ▶  $O_2 + CH_2O \rightarrow CO_2 + H_2O$
- ▶  $k$  in this reaction is greater for SC than for CA



How can we test this?

70

## Cow Castle Creek, South Carolina



71

## San Joaquin, CA near Modesto



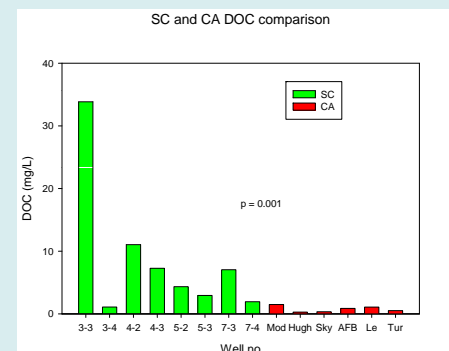
72

We collected water samples from Cow Castle Creek, SC and San Joaquin, CA and analyzed for various indicators of DOC bioavailability

- DOC concentrations (high vs. low)
- Carbohydrate content of DOC (high vs. low)
- Amino acid content of DOC (high vs. low)
- Microbial abundance (high vs. low)
- Microbial growth (high vs. low)
- Specific UV absorption (aromaticity of DOC)
- Bioassays of  $CO_2$  production/consumption

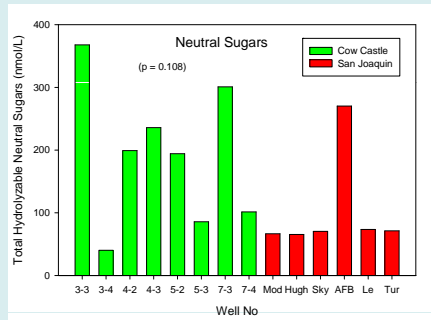
73

## DOC concentrations



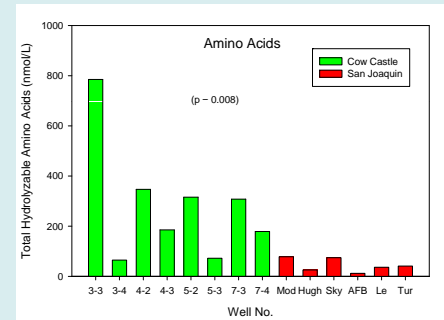
74

## Total Hydrolyzable Neutral Sugars



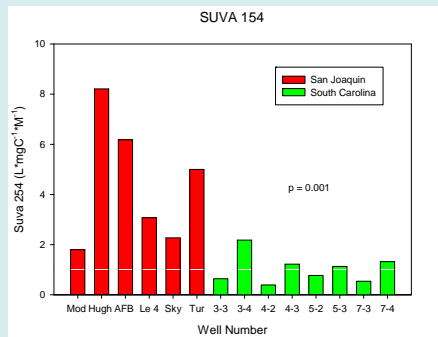
75

## Total Hydrolyzable Amino Acids



76

## SUVA



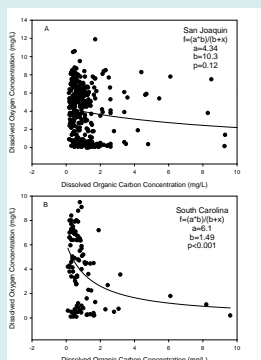
77

## Summary Comparison

Bioavailability Indicator	Comparison of San Joaquin and South Carolina (p value)
DOC (mg/L)	0.001 (passed criteria (p<0.05))
THNS (nmole/L)	0.108 (no)
THNS yield (%)	0.008 (yes)
THAA (nmole/L)	0.008 (yes)
THAA yield (%)	0.66 (no)
Initial cell count (cells/ml x 10 <sup>4</sup> )	0.003 (yes)
Final cell count (cells/ml x 10 <sup>4</sup> )	0.228 (no)
SUVA 254	0.001 (yes)
SUVA 280	0.001 (yes)
Bioassay CO <sub>2</sub> change with incubation	0.004 (yes)

78

So there are several lines of evidence consistent with the hypothesis that SC DOC is more bioavailable than San Joaquin DOC



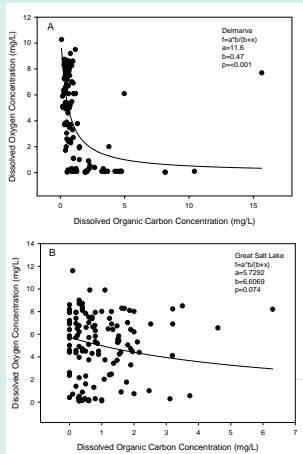
79

This suggests a method to compare the bioavailability of DOC from place to place using DO and DOC measurements



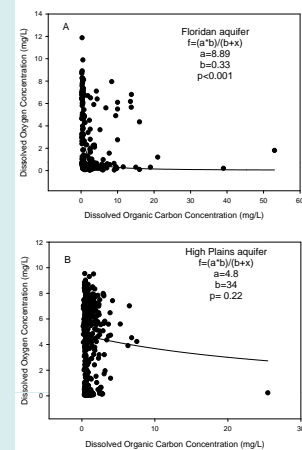
80

## Delmarva (MD, VA) and Great Salt Lake



81

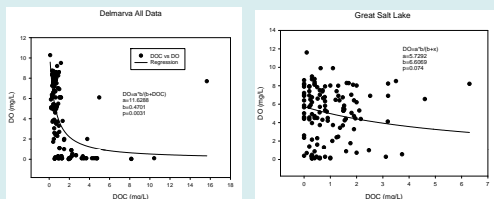
## Floridan aquifer, High Plains aquifer



82

NAWQA has generated a large data base (~10,000) containing DOC and DO concentrations measured in groundwater underlying agricultural land use

- ▶ This method may allow us to interpret this data in the context of redox process-driving bioavailable carbon.



83