SPATIAL AND TEMPORAL MODELING OF DOC TRANSPORT PROCESSES FROM AGRICULTURAL LANDSCAPES TO RIVERS: A CASE STUDY OF THE CHIPPEWA RIVER USING SWAT ANALYSIS

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Background

Dissolved Organic Carbon (DOC) is an essential part of the carbon cycle (Figure 1) and a water quality parameter is measured for a multitude of reasons. DOCs interfere with disinfection processes, like UV, ozone and chlorination (Figure 2). In processed water, residual DOCs can increase bacterial growth and make the water visually unappealing. "Regulations for DOC are specific to each country, with aesthetic objective in drinking water being approximately 5 mg/L. " (RealTech Water)

The known controls on Dissolved Organic Carbons (DOCs) are: Hydrology, precipitation, water flow rates, temperature, soil acidity, land use change, In-Lake and In-Stream Removal (an effect of human intervention), nitrogen enrichment, atmospheric CO2 enrichment, Net Primary Production, and soil type.

DOCs are the basis for biological productivity, providing nutrients for primary producers and microbial life.

Research Objectives

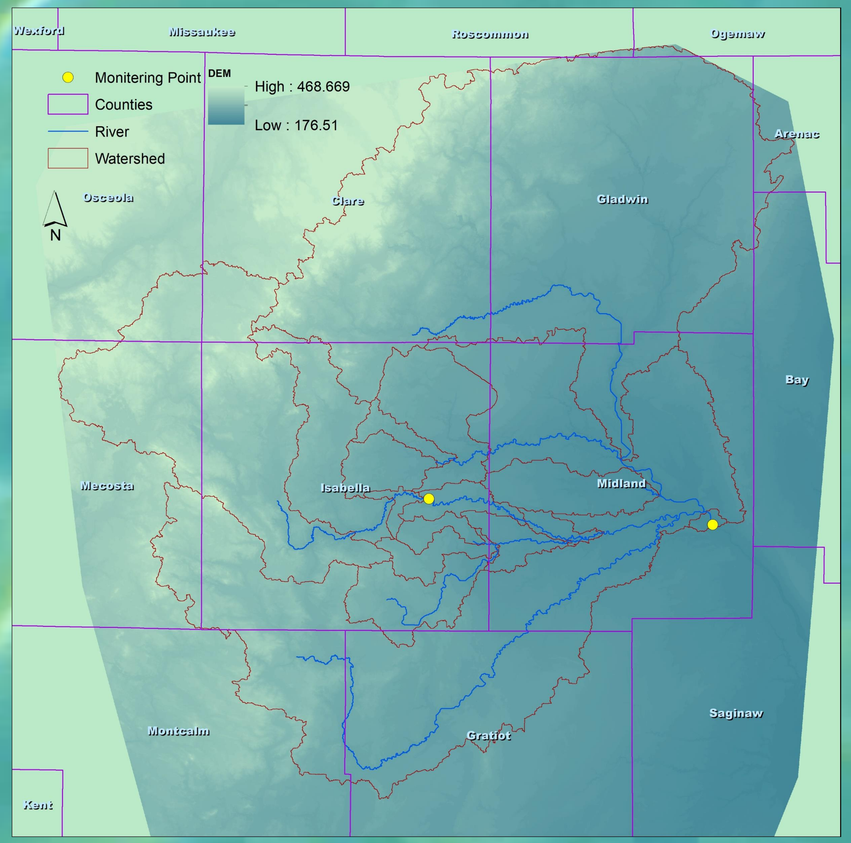
This study aims to address the question of how agricultural land use effects DOC flux from terrestrial ecosystem to aquatic environment. Especially, we will explore how flow capacity effects the DOC concentrations at sub-basin scales, with the hypothesis that higher flow capacity will dilute the DOC concentrations but increasing flux.

Approach

Hydrological characters at each basin will be estimated for daily by using Soil Water Assessment Tool (SWAT). Hydrological modelling will be based on the most important update to the methodological data. The SWAT model will be able to predict the flow capacity and rates of specific sub-basins where we have monthly field measurements on DOC concentrations.

The area of study is the Chippewa River of Michigan, as shown in the center of the poster. The area is dominated by agricultural land uses (Figure 3). The river stretches into five counties; Midland, Isabella, Mecosta, Osceola, and Clare. The river is a tributary of the Tittabawassee River, and a part of the Saginaw River basin. The Chippewa river runs 91.8 miles, and crosses a large portion of the central lower peninsula of Michigan. The study site with rather flat landscape allows to understand the dynamics of DOC flux in a slow-paced river watershed. The river is prone to seasonal flooding, although human intervention has largely eliminated smaller floods. The river also has a large recreation base, although fishing is discouraged.

Site



DOCs in Everyday Life

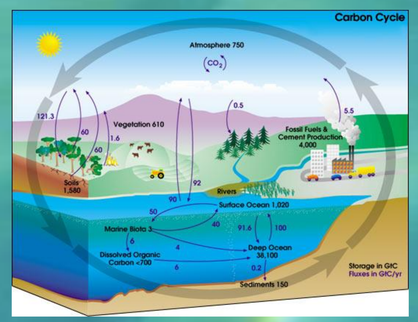


Figure 1. DOCs are an essential part of the carbon cycle.

Figure 2. (Notre Dame) A figure showing water with low, medium, and high DOC concentrations, and their lake of origin.

Land Cover

Landcover of Watershed Based on NLCD 2011

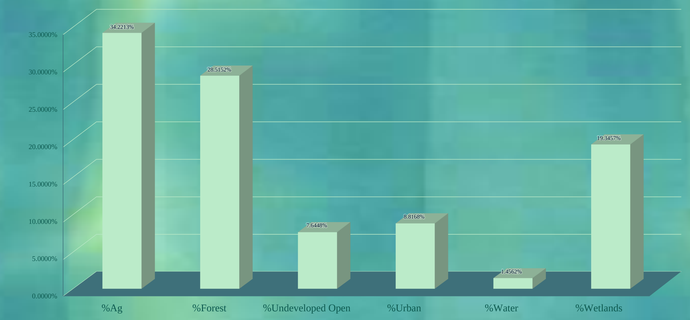


Figure 3. Code Key: Water = 11 Urban = 21, 22, 23, 24 Undeveloped open = 31, 52, 71 Forest = 41, 42, 43, Ag = 81, 82, Wetlands = 90, 95

Implications

We anticipate that DOC concentrations from agriculture landscape with easy topography are higher than that from forest watersheds due to high crop plant residual availability in soil. East topography also allows water to interact with plant residuals so that river flow is loaded with more DOC.

The SWAT model is an ideal system allowing to study terrestrial DOC transport processes from lands to waters. The model is able to link the DOC flux to variations of many other components, such as Urban Planning, Water Treatment, Recreation, Ecology, and Climatology. We also expect that statistical analysis results can estimate the possibility if climate change or extreme storm events would cause significant intolerable consequences of aquatic ecology due to excessive DOC loading from watersheds.

The study serves as a testbed for finding optimum mitigation solutions for balancing between natural environmental quality and agricultural productivity in response to climate change. The study meats the requirement of studying how human activities can impact on natural environment in positive or negative directions.

References

Results was based on the final project of a course taught by Dr. Yong Q. Tian
Figure 1 was from RealTech Water, 2017.
https://realtechwater.com/parameters/dissolved-organic-carbon/
Figure 2 was from a web-site from the Notre Dame University, 2018
https://science.nd.edu/undergraduate/minors/sustainability/capstone-projects/2014/elser/