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# Relationship between brownification and governing physical processes in Lake Bolmen, Sweden

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## Introduction

During the last decades brown color has increased in surface waters. This so called brownification is caused, mainly by humic substances leaching from nearby soils and being introduced into the water bodies.
Brown colored water minimizes the recreational attraction of rivers and lakes and has negative impacts on the ecosystem of this surface waters. Moreover, it constitutes a huge and increasing problem in water treatment plants, which might make it necessary in the near future to exploit new sources for a reliable water supply.
Most ongoing research on browning of surface waters involves a purely biological approach and the coupling with hydrology and hydrodynamics have hardly been investigated. The purpose of this research is to analyze the relationship between color and hydrological parameters.

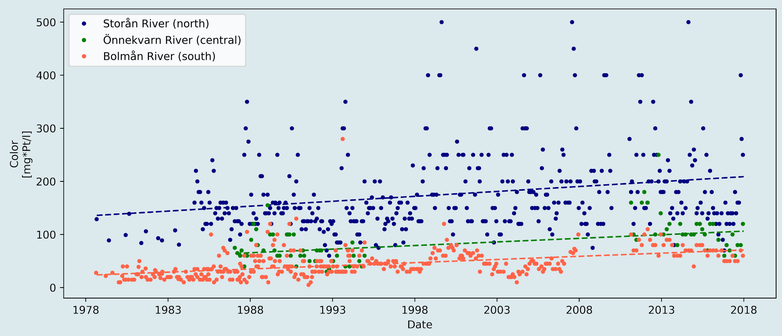


*Figure 1: Development of color in Lake Bolmen*

## Research Questions

- How is the color related to the season?
- How is the color distributed in space?
- Which parameter determine the color value?
- Will the water color reach a maximum or continue to increase?

## Research Area

Lake Bolmen, located in southern Sweden and covering an area of 184 km², constitutes Swedens 10th biggest lake. It is used as water resource for 12 municipalities in the most southern county of Sweden and provides drinking water for almost one million people (figure 2). Next to its high value as water supply resource the lake and its surroundings have important recreational value.
Bolmens watershed covers an area of 1650 km² and is dominated by forest and wetlands (figure 3).

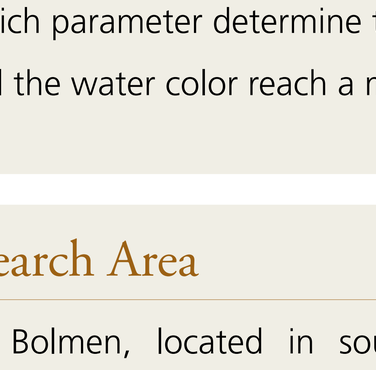


*Figure 3: Land use distribution inside the Bolemen catchment*


*Figure 2: Bolmentunnel and supplied municipalities*

## Methodology

Monthly observation data were compiled from the homepage of the local river basin organization of the Lagan river basin, Lagans Vattenråd. Meteorological data where retrieved from the Swedish Meteorological and Hydrological Institute (SMHI).
Data analysis and model prediction have been performed with Python 3 and the pandas library.

## Results

Northern parts of the lake show significant higher color values than the southern part, with one exception, Murån river in the south part of the lake. The higher color might result from the catchment properties of this river that is dominated by wetlands and coniferous forest.

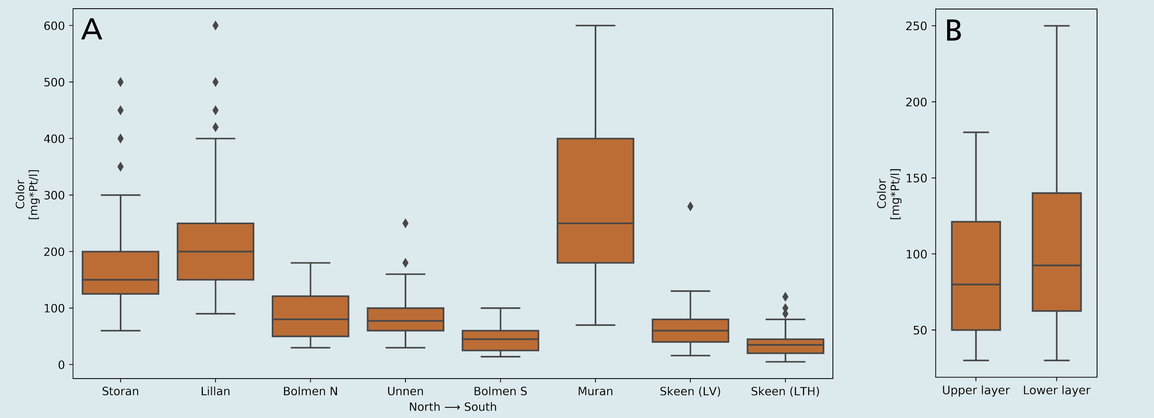


*Figure 4: Color variation inside the lake from north to south (A) and upper to lower layer (B)*

The seasonal changes in color in the lake and its tributaries vary quite significantly. For the northern parts high runoff drives the color and for the southern parts the highest color values occur during winter time (figures 5 and 6).

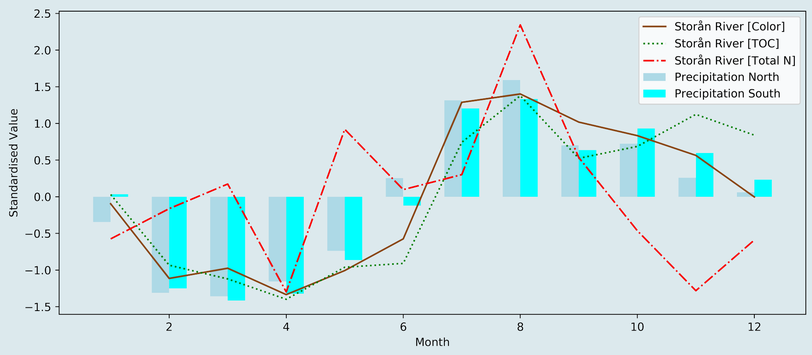


*Figure 5: Seasonal color variation in the northen catchment related to driving water parameters*

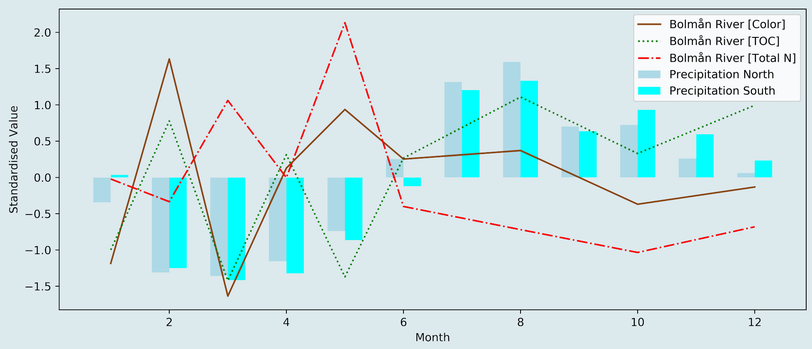


*Figure 6: Seasonal color variation in the southern catchment related to driving water parameters*

## Conclusion & Future Research

Performed analysis shows that the color in the lake is determined by different parameters, whereby TOC, Total N, land use and precipitation/runoff play a deterministic role.
More continuous measurements are needed to allow more defined predictions about the color in future research.
The obtained insights will be used in combination with a hydrodynamical model to gain information about the behavior of the colored water in time and space.

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