Inferring long-term trends in prairie reservoirs (Saskatchewan, Canada) through analysis of DNA in sediment cores

Tse, T. J.\textsuperscript{a,b}, Song, T.\textsuperscript{a}, Hecker, M.\textsuperscript{a,b}, Giesy, J. P.\textsuperscript{a,b,c}, Doig, L. E.\textsuperscript{a,b}, and Jones, P. D.\textsuperscript{a,b,d}

\textsuperscript{a}Toxicology Center, University of Saskatchewan, 44 Campus Drive, Saskatoon, SK, S7N 5B3, Canada
\textsuperscript{b}Global Institute for Water Security, University of Saskatchewan, 11 Innovation Boulevard, Saskatoon, SK, S7N 3H5, Canada
\textsuperscript{c}Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5B4, Canada
\textsuperscript{d}School of Environment and Sustainability, University of Saskatchewan, 117 Science Place, Saskatoon, SK, S7N 5C3, Canada
Introduction

• Lake Diefenbaker
  • Large multi-purpose reservoir (225-km long) located in southern Saskatchewan, Canada.
  • Provides water for 45% of Saskatchewan residences (WSA 2012).
  • Moderately eutrophic$^1$ up-reservoir to oligo-mesotrophic down-reservoir$^2$.

• Buffalo Pound Lake
  • Provides water for 25% of Saskatchewan residences (WSA 2014).
  • Naturally rich in nutrients
  • Eutrophic$^3$.

---


$^2$Dubourg et al. 2014. J. Great Lakes Res. (Submitted)

Introduction

• Residual or “environmental” DNA in the sediment can remain preserved over time and can possibly allow retrospective genetic monitoring of an aquatic system\(^5\).

• eDNA can be extracted from the sediments and can be used to identify the presence of organisms and changes in community composition.

• eDNA can provide insight regarding the emergence or presence of problematic or harmful organisms within an aquatic system (e.g. toxin-producing cyanobacteria).

Introduction

**Goal:** To reconstruct historical trends of the cyanobacterial community in two Saskatchewan reservoirs (Lake Diefenbaker and Buffalo Pound Lake).

- **Study objectives:**
  - Isolate DNA from sediment and amplify the 16S rRNA gene region to assemble cyanobacterial community composition and trends.
  - Identify potentially harmful cyanobacterial species.
  - Identify toxin producing genes if known toxin-producers are present.
Sample Sites

Figure 1: Map of sediment core locations from Lake Diefenbaker Gardiner arm (white), Qu’Appelle arm (yellow) and Buffalo Pound Lake (teal) in Saskatchewan, Canada.
Introduction

- Lake Diefenbaker Algal Pigments:
  - Algal pigments analysis suggested an increasing cyanobacterial presence in Gardiner arm⁶.
  - Myxoxanthophyll was present at only these two locations on Lake Diefenbaker.

Materials and Methods

• Genomic DNA (gDNA) was extracted from sediment using EZNA Soil DNA kits.
• PCR amplification was completed using cyanobacterial 16S rRNA primers modified from Nübel et al., 1997 with Illumina recommended overhangs.

• Sequencing was completed using a MiSeq Desktop Sequencer.
• Secondary analysis was completed using the MiSeq Reporter, and an Illumina-curated version of the Greengenes taxonomy database.

Results

DNA Concentration

DNA Purity

- DNA purity was relatively conserved in all sediment increments:
  - BPL \sim 1.8
  - LD: Gardiner arm \sim 1.8
  - LD: Qu’Appelle arm \sim 1.7
Comparisons Among Sites

Buffalo Pound Lake

Gardiner arm

Qu’Appelle arm

Order
- Chroococcales
- Nostocales
- Synechococcales
- Unclassified

Sample ID
Comparisons Among Sites and Depths
Abundance of Cyanobacteria – Buffalo Pound Lake
Abundance of Cyanobacteria – Gardiner arm
Abundance of Cyanobacteria – Qu’Appelle arm

Order
- Unclassified
- Synechococcales
- Stigonematales
- Pseudanabaenales
- Nostocales
- Chroococcales

Abundance of cyanobacteria sequences

Sample
- LDQA.001
- LDQA.002
- LDQA.003
- LDQA.004
- LDQA.005
- LDQA.006
- LDQA.007
- LDQA.008
- LDQA.009
- LDQA.010
- LDQA.011
- LDQA.012

October 5, 2015
Results Species – Buffalo Pound Lake

- 19 different species of cyanobacteria in BPL sediments.
- 5 species with strains known to produce toxins.
  1. *D. circinale*
  2. *D. lemmermannii*
  3. *D. mendotae*
  4. *M. novacekii*
  5. *M. panniformis*
Results Species – Lake Diefenbaker

- 8 different species of cyanobacteria in LD – Gardiner arm sediments
  - 3 species with strains known to produce toxins.
    1. *D. lemmermannii*
    2. *D. circinale*
    3. *D. mendotae*

- 6 different species of cyanobacteria in LD – Qu’Appelle arm sediments
  - 1 species with strains known to produce toxins.
    1. *D. lemmermanii*
Discussion

• eDNA in sediments are fairly well preserved and can be used to track historical changes in cyanobacterial community composition.

• Buffalo Pound Lake sediments had significantly higher abundance of cyanobacteria DNA compared to Lake Diefenbaker sediment cores (e.g. Gardiner and Qu’Appelle arm)
  • Potentially harmful cyanobacteria were identified at all three sites.

• Cyanobacteria DNA abundance was greater in recent (top) sediments compared to middle and bottom sediments in each sediment core.

• Useful in identifying arrival of invasive species.

• Useful in assessing changes in cyanobacterial community over time.
Future Work

- Identifying, quantifying and correlating algae toxin genes to cyanobacteria community composition.

- Correlating pigment data and other bio-geo-chemical datasets to cyanobacteria community composition.

http://www.biomedcentral.com/content/figures/1471-2148-9-115-1-l.jpg
Acknowledgements

Funding provided by:
• Global institute for Water Security (GIWS)

• Natural Sciences and Engineering Research Council (NSERC) of Canada

• Acknowledgements:
  • Allison Hill
  • Jon Doering
  • Shawn Beitel
  • Steve Wiseman
Questions?