MICROBIAL SOURCE TRACKING AND OTHER WATER QUALITY ISSUES IN UTAH

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WATER QUALITY

Physical Issues
Turbidity, temperature, color, odor

Chemical Issues
Nutrients, heavy metals, pH, DO and many more

Biological Issues
Bacteria, viruses, pathogens

All standards should be maintained for the water to be suitable for any particular use
WATER QUALITY IN UTAH

All three issues are prevalent

Biggest examples are the Utah Lake, Jordan River, Great Salt Lake and many other surface water bodies

Good news is that many efforts are in place to address the water quality issues in Utah
Biological Issues with the Emigration Creek as a model system

Chemical Issues with a specific example of the Jordan River
Biological Contamination of Water Bodies

Sources of Bacterial Contamination include:
- Runoff and discharge from different sources
- Leaking of septic tanks
- Wastewater effluents

Development of proper TMDLs require the determination of:
- Type of bacterial contamination
- Magnitude of contamination
- Sources of contamination
SOURCES OF FECAL CONTAMINATION IN WATER

HUMAN

DOMESTIC

WILDLIFE
TRADITIONAL METHODS TO MONITOR FECAL CONTAMINATION

Human health standards are based on exposure to **Fecal Indicator Bacteria (FIB)**, such as **fecal coliforms**, **E coli**, **fecal streptococci** and **fecal enterococci** in drinking, recreational, and shellfish waters.

**INDICATOR BACTERIA DO NOT IDENTIFY THE SOURCE OF THE CONTAMINATION**
WHAT IS MICROBIAL SOURCE TRACKING (MST)?

- A novel technique used in diagnosing the sources of fecal contamination in water

Perform MST to identify the dog as the culprit

Fecal matter from dog flows into a water body

Unknown fecal contamination found

Match microbes from a polluted site and an animal source to suggest the origin of the fecal pollution
WHY MICROBIAL SOURCE TRACKING?

Feces production in the United States (rough estimates) = $1 \times 10^{12}$ kg/year by humans and domestic animals

Source: US EPA
Large number of water bodies in the United States are considered impaired on the basis of microbial quality.

Diseases are transmitted through feces contaminated water.

Remediation requires knowing the “source” of the problem and investigating high levels of fecal indicator bacteria.

Science-based procedures are needed to assist in source identification.

Identifying TMDL violations.
MICROBIAL SOURCE TRACKING

Method Classification

- Library Dependant
- Library Independent
MICROBIAL SOURCE TRACKING

Method Classification

- **Library Dependant**: Host specific *E. coli* isolates (library) are needed
- **Water Body**: Obtain *E. coli* isolates from the water body
- **Match with the library**: Match with the library
- **The method is laborious, expensive and time consuming**
- **Requires expertise in *E. coli* isolation**
- **Has geographic limitations**
MICROBIAL SOURCE TRACKING

Method Classification

- Library Independent

- No time and space restraints
- They are based on nucleic acid techniques arising from the field of molecular ecology, such as developing host-specific strains that can be used to identify host-specific markers
MICROBIAL SOURCE TRACKING

Method Classification

Library Dependant

EXAMPLES:

- ARA (Antibiotic Resistance Analysis)
- CUP (Carbon Utilization Profile)
- RFLP (Restricted Fragment Length Polymorphism)
- AFLP (Amplified Fragment Length Polymorphism)
- Rep-PCR (repetitive extragenic palindromic - PCR)

Library Independent

EXAMPLES:

- Phage typing (serotypic or genotypic)
- Gene specific PCR
- Total Community Analysis
- Host--specific PCR
WHAT WE CHOSE TO DO?

Library Independent Method

Host-Specific Polymerase Chain Reaction (PCR) targeting 16S rRNA gene of genus *Bacteroides*

- Genus *Bacteroides* are more abundant in the feces of warm-blooded animals than *E.coli*
- They are more likely to predict fecal contamination being obligate anaerobes. Enterococci and *E. coli* are facultative anaerobes
- High degree of host specificity that reflects differences in host digestive systems
- Primer sets that discriminate between human and non-human fecal pollution
POLYMERASE CHAIN REACTION

PCR is a technique that enables researchers to produce millions of copies of a specific DNA sequence in a short time.

16S rRNA region

94 °C
Denaturation

60 °C
Anneal with primers

72 °C
Elongation

Forward Primer

Reverse Primer

16S rRNA region
HOST-SPECIFIC PCR TARGETING BACTEROIDES

DNA Extraction from Water Column

*Bacteroides* 16S rRNA genes amplification from DNA extracts using HuBac (human cluster of *Bacteroides*)

HuBac566f, 5’-GGGTTTTAAAGGGAGCGTAGG-3
HuBac692r, 5-CTACACCACGAATTTCCGCCT-3
STUDY AREA – EMMIGRATION CREEK, SALT LAKE COUNTY, UTAH

SAMPLING DONE OVER A PERIOD OF 4 MONTHS
WHY EMIGRATION CREEK?

• Water quality in Emigration Canyon is considered to be the poorest of all the watersheds.

• Although Emigration Creek water is currently not used for culinary purposes, Salt Lake City owns two-thirds of the water rights and its use in the future remains an option.

• In 2002, a water quality assessment of Emigration Creek concluded high fecal coliform levels.
PCR RESULTS

MONTH OF JUNE

MONTH OF JULY

MONTH OF AUGUST

MONTH OF OCTOBER

POSITIVE AMPLIFICATION OF 16S rRNA BACTEROIDES GENE SPECIFIC TO HUMANS

THIS INDICATES PRESENCE OF HUMAN FECAL CONTAMINATION IN THE EMIGRATION CREEK
WHAT NEXT - FUTURE STUDIES

1. By performing PCR we can identify the presence or absence of human fecal contamination

2. Simultaneously identification and quantification of human fecal contamination

REAL TIME PCR or QPCR
THE JORDAN RIVER

- ~52 miles from Utah Lake to GSL
- Salt Lake, Davis and Utah Counties
- Pop. >900,000
- Land Use (Urban, Agriculture, Forest, Mining)
WATER QUALITY ISSUES OF THE JORDAN RIVER

• Parameters of Concern
  - Dissolved Oxygen
  - Temperature
  - Total Dissolved Solids
  - Nutrients
  - E. Coli
SOURCES OF POLLUTION

- Utah Lake
- Tributary Streams
- Permitted Discharge
- Storm water
- Direct Surface Runoff
- Groundwater

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CONCEPT ON SEDIMENT OXYGEN DEMAND (SOD)
SEDIMENT OXYGEN DEMAND

SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment-water interface.

Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the microbially facilitated nitrification of ammonia.

SOD several centimeters into the sediment is often dominated by the chemical oxidation.
How to Measure SOD?

\[ \text{DO}_T = \text{Sediments} + \text{Water column} \quad \text{DO}_W = \text{Water column only} \]

\[ \text{SOD} = \text{DO}_T - \text{DO}_W \]
SOD Chamber
SOD measurement in Jordan River

Chamber installation

Sampling for Nutrient flux-three chambers and six people

Someone is watching us (😊)
SOD- 2300S site

Slope of SOD 1 = 0.0065 mg/L-min
Slope of Control = 0.0005 mg/L-min
Net SOD = 0.0065 - 0.0005 = 0.0060 = 0.006 * 1.44 * 240
= 2.073 g/m²-day
THANK YOU!!

ANY QUESTIONS
NUTRIENTS DATA FROM DIFFERENT SAMPLING SITES OVER A PERIOD OF 4 MONTHS