North Dakota Water Resources Research Institute

Annual Technical Report

FY 2000

Introduction

This report deals with the activities of the North Dakota Water Resources Research Institute (ND WRRI) during the period March 2000 to February 2001, defined as FY 2000 by USGS.

During FY 2000, the bulk of the Institute's resources were allocated to its research and education functions through the mechanism of Graduate Research Fellowships.

This report is presented as four projects. Project B-01 gives an overview of the Graduate Research Fellowship program, and presents synopses of four of the seven Graduate Research Fellowships. These fellowships were of shorter duration, or had less than a half years support from the Institute. Research synopses for the other three fellowships, which were awarded to doctoral candidates and are of longer duration, are given as separate projects, numbered B-02 through B-04.

No stand-alone Information Transfer projects were operative during FY 2000. As noted in the Information Transfer section, IT is done through an annual newsletter, a website (www.nodak.edu/wrri) that is updated freqently, and presentations and publications and fellowship recipients and their associates.

Research Program

Basic Information

Title:	New Methods to Detect Chlorinated Organic Pollutants in Water
Project Number:	B-02
Start Date:	3/1/1998
End Date:	2/28/2002
Research Category:	Water Quality
Focus Category:	Water Quality, Toxic Substances, None
Descriptors:	Organic pollutants, PCBs, chemical analysis, spectrophotometry
Lead Institute:	North Dakota Water Resources Research Institute
Principal Investigators:	Andres D. Campiglia

Publication

1. A. F. Arruda and A. D. Campiglia. 2000. Screening potential of solid-phase extraction room temperature phosphorimetry for the analysis of polychlorinated dibenzofurans in water samples. Environ. Sci. Technol., 34(23), 4982-4988.

New Methods to Detect Chlorinated Organic Pollutants in Water

Andrea F. Arruda (Graduate Research Fellow) and
Andres D. Campiglia (Assistant Professor of Chemistry)

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Polychlorinated biphenyls (PCB) and polychlorinated dibenzofurans (PCDF) are organic pollutants that can occur in surface, ground and drinking water.

The initial objective of this project was to provide a rapid, simple and cost effective screening method for determining total PCBs and PCDFs in water samples. The objective was accomplished coupling solid-liquid extraction (SLE) and room temperature phosphorimetry (RTP). The method includes a three-step sample procedure, namely water extraction, application of phosphorescence enhancers to the extraction membrane, and direct RTP detection on the extracting substrate. The water sample (10-100 mL) is processed through an octadecyl extraction membrane with a syringe. The excess of water is removed from the membrane applying positive pressure to the syringe. 5 mL of phosphorescence enhancer is applied to the extracting substrate previous to phosphorescence detection. RTP is performed with a commercial spectrophosphorimeter under a nitrogen flow. Total analysis time varies from 8 to 10 minutes per sample. Limits of detection with 100mL of water sample were estimated at the parts-per-trillion level (10^{-12}g.mL^{-1}). Lower limits of detection are obtainable with larger water volumes. Environmental pollutants commonly encountered in water samples do not interfere with the screening method.

As an alternative to achieve specific compound identification, time-resolved laser-excited Shpol'skii spectrometry is being investigated. PCB and PCDBF are eluted from the extraction membrane using an n-alkane, which is frozen by sample vial immersion into liquid nitrogen (77K) or liquid helium (4.2K). The spectroscopy is directly performed from the frozen matrix using a fiber optic probe. This approach provides excellent reproducibility of measurements (2-5%) and relies on a rapid and simple experimental procedure. Promising preliminary results indicate the potential for specific compound identification at the parts-per-trillion level with no matrix interference.

Publications

A. F. Arruda and A. D. Campiglia. 2000. Screening potential of solid-phase extraction room temperature phosphorimetry for the analysis of polychlorinated dibenzofurans in water samples. *Environ. Sci. Technol.*, 34(23), 4982-4988.

Basic Information

Title:	The Periphyton in the Sheyenne River, North Dakota
Project Number:	B-03
Start Date:	3/1/1998
End Date:	5/31/2002
Research Category:	Water Quality
Focus Category:	Water Quality, Surface Water, None
Descriptors:	Biological indicators, water quality, algae,
Lead Institute:	North Dakota Water Resources Research Institute
Principal Investigators:	Marvin W. Fawley, Karen Anne Phillips

Publication

1. Phillips, K.A., M.A. Jaskowiak, and M.W. Fawley. 2000. An Analysis of the algal communities of the Sheyenne River, North Dakota, potentially affected by the Devils Lake emergency outlet. Report submitted to the U. S. Army Corps of Engineers (available form M.W. Fawley, Department of Biological Sciences, NDSU, Fargo ND 58105).

Project Number B-03

The Periphyton in the Sheyenne River, North Dakota

Megan A. Jaskowiak (Graduate Research Fellow), Marvin W. Fawley (Professor of Biological Sciences) and Karen A. Phillips (Research Associate)

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Devils Lake in Northeastern North Dakota is presently a closed basin, but rising, lake. Its size has been increasing for more than a decade, and if the rise continues there will be an uncontrolled flow into the Sheyenne River at some time in the future. An engineered outlet is being considered in order to provide a more controlled flow and reduce physical damage and water quality degradation that would come from an uncontrolled flow.

This research began as part of the environmental impact statement for the Army Corps of Engineers Devils Lake outlet project. In the first part of this study, periphytic algae were collected using artificial substrates at several sites along the Sheyenne River. The major goal of this study was to relate the periphyton communities to environmental factors that could potentially be affected by a Devils Lake outlet.

The relative abundance data for species of periphytic algae and environmental data were used for the assessment. This analysis was completed using canonical correspondence analysis (CCA). The environmental variables which explained the most variance in the periphyton communities were pH, orthophosphate, hardness, arsenic, sulfate and nitrite+nitrate. This analysis included all species identified. An analysis was repeated after the species which are considered to be phytoplanktonic were removed. This evaluation showed different environmental variables which explained the most variance. These environmental variables were percent sodium, calcium, pH, arsenic, and sulfate. This analysis proved to be more statistically significant. The phytoplankton species are not really part of the periphyton community and therefore, the variation seen in these species is coincidental. Therefore, the removal of these species makes the analysis more precise. These results were presented in a poster presentation at the 2000 North American Benthological Society meeting in Keystone, CO, and as a report to the Corps of Engineers.

The research that has been completed also includes a comparison of the natural substrates and artificial substrates and a comparison of the use of presence/absence data versus relative abundance data in CCA. Natural substrate communities appear to be quite different than the artificial substrate communities. These differences include several species which were not found at all on the artificial substrates. An example of these additional species is the diatom, *Navicula mutica*. The statistical analysis of the presence/absence and natural versus artificial substrates will be completed in the summer 2001.

Research that will also be completed this year includes the examination of three new possible species of *Nitzschia* (Hassall). The preliminary results from the new species will be presented at the Phycological Society Meeting in June 2001. The survey of the periphyton in the Sheyenne River is being prepared for publication. The results from studies completed in 2000-2001 will be prepared for publication.

Publication

Phillips, K. A., Jaskowiak, M. A. and M. W. Fawley. 2000. An Analysis of the algal communities of the Sheyenne River, North Dakota, potentially affected by the Devils Lake emergency outlet. A report submitted to the U. S. Army Corps of Engineers.

Focus Categories
WATER QUALITY and SURFACE WATER

Descriptors
Biological indicators, water quality, algae,

Basic Information

Title:	Effects of Fathead Minnows and Drainage History on Prairie Wetland Ecosystems
Project Number:	B-04
Start Date:	3/1/1998
End Date:	5/31/2001
Research Category:	Water Quality
Focus Category:	Wetlands, Water Quality, Surface Water
Descriptors:	Wetlands, Prairie Potholes, Biological Indicators, Freshwater Fish
Lead Institute:	North Dakota Water Resources Research Institute
Principal Investigators:	

Publication

1. Hanson, M.A., C.C. Roy, N.H. Euliss, K.D. Zimmer, M.R. Riggs, and M.G. Butler, 2000, A surface activity trap to capture water surface and aquatic invertebrates in wetlands, Wetlands, 20, 205&#64979;211.
2. Zimmer, K.D., M.A. Hanson, and M.G. Butler, 2000, Factors influencing invertebrate communities in prairie wetlands: a multivariate approach, Canadian Journal of Fisheries and Aquatic Sciences, 57, 76&#64979;85.
3. Zimmer, K.D., Effects of Fathead Minnows and Drainage on Wetland Ecosystems, Ph.D. Dissertation, Department of Zoology, North Dakota State University, Fargo, May 2001.

Project Number B-04

Effects of Fathead Minnows and Drainage History on Prairie Wetland Ecosystems

Kyle D. Zimmer (Graduate Research Fellow), Malcolm Butler (Professor of Biological Sciences), Mark A. Hanson (Adjunct Professor Zoology)

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Dissertation Abstract. Many studies have shown that fish can influence the structure and processes of aquatic ecosystems, but studies with replication at the ecosystem level are rare, as are studies involving wetlands. Some wetlands of the Prairie Pothole Region of North America support fish communities dominated by fathead minnows while others are fishless, providing an opportunity to assess the influence of these fish on wetland ecosystems. Additionally, extensive drainage of prairie wetlands has led to restoration of thousands of basins, but the success of these efforts is poorly known.

I assessed the effects of fathead minnows and prior drainage on characteristics of prairie wetlands by studying 20 semipermanent wetlands in Minnesota from 1996-1999. I used a 2x2 factorial design to examine the effects of minnows (presence/absence) and drainage (restored/non-drained) on the abundances of aquatic invertebrates, aquatic macrophytes, and amphibians, as well as water-column levels of chlorophyll *a*, total phosphorus, total nitrogen, and turbidity. Results showed that presence/absence of fathead minnows is an important determinant of many biotic and abiotic characteristics of prairie wetlands. Wetlands with minnows had significantly fewer aquatic insects, large and small-bodied cladocerans, calanoid copepods, ostracods, and larval tiger salamanders, as well as a higher abundance of corixids and higher levels of turbidity and chlorophyll *a*. In contrast, higher concentrations of phosphorus in restored basins was the only consistent history effect, and no consistent fish-x-history interactions were detected.

Additional research showed that the ecological characteristics of prairie wetlands can change rapidly in response to both minnow colonization and elimination. Thus, temporal variability in minnow presence/absence may be a source of temporal variability in other ecosystem components. Abiotic variables influence prairie wetlands, but this research indicates that these ecosystems may also be strongly influenced by the presence/absence of minnows. Inter-basin and inter-annual variability in minnow presence may be important for maintaining diverse assemblages of species at the landscape level, with fishless basins favoring certain assemblages of organisms and basins with minnows favoring others.

From a management perspective, these effects should be considered prior to landscape manipulations that alter the regional proportion of basins supporting fathead minnow populations.

Publications

Articles in Refereed Scientific Journal

Hanson, M.A., C.C. Roy, N.H. Euliss, K.D. Zimmer, M.R. Riggs, and M.G. Butler, 2000, A surface activity trap to capture water surface and aquatic invertebrates in wetlands, Wetlands, 20, 205-211.

Zimmer, K.D., M.A. Hanson, and M.G. Butler, 2000, Factors influencing invertebrate communities in prairie wetlands: a multivariate approach, Canadian Journal of Fisheries and Aquatic Sciences, 57, 76-85.

Dissertation

Zimmer, K.D., Effects of Fathead Minnows and Drainage on Wetland Ecosystems, Ph.D. Dissertation, Department of Zoology, North Dakota State University, Fargo, May 2001.

Focus Categories
WETLANDS, WATER QUALITY and SURFACE WATER

Descriptors
Wetlands, Prairie Potholes, Biological Indicators, Freshwater Fish

Basic Information

Title:	Graduate Research Fellowships
Project Number:	B-01
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Not Applicable
Focus Category:	Water Quality, Wetlands, Nutrients
Descriptors:	bioindicators, denitrification, ecosystems, ground-water quality, heavy metals, nutrients, phosphorus, pollutants, rivers, suspended sediments, urban water systems, water quality, water treatment, wetlands
Lead Institute:	North Dakota Water Resources Research Institute
Principal Investigators:	Gregory J. McCarthy

Publication

1. Nustad, Rochelle A., Determination of the Factors Causing Elevated Phosphorus Levels in a Natural Wetland and Methods for Remediation. M.S. Thesis, Department of Civil Engineering, North Dakota State University, Fargo, December 2000.
2. Tescher, Melani L., An Analysis of Mercury in Mallards from Kellys Slough National Wildlife Refuge in Grand Forks County, North Dakota, M.S. Thesis, Department of Biology, University of North Dakota, Grand Forks, August 2001.
3. Zimmer, K.D., Effects of Fathead Minnows and Drainage on Wetland Ecosystems, Ph.D. Dissertation, Department of Zoology, North Dakota State University, Fargo, May 2001.

Project Number B-01

Graduate Research Fellowships

Gregory J. McCarthy, ND WRRI Director, North Dakota State University, Fargo

Focus Category: WATER QUALITY, WETLANDS, and ECOLOGY

Descriptors:
bioindicators, denitrification, ecosystems, ground-water quality, heavy metals, nutrients, phosphorus, pollutants, rivers, suspended sediments, urban water systems, water quality, water treatment, wetlands

One objective of the Section 104b Program is to ensure the future availability of water resources research professionals. Graduate education/training is currently the major activity of the ND WRRI through a competitive Graduate Research Fellowships (GRF) awarded to students in a degree program on a topic directly related to water resources. Each fellowship is a research project will result in a thesis or dissertation and a new water resources research professional.

During FY 2000, the direct support of graduate student research through the GRF program accounted for 83% of the expenditures of funds provided by the Federal 104b allotment. Seven GRF projects were supported. Three are or were continuing projects with major support, and are listed as separate projects elsewhere in this report. Refer to these projects:

B-02: **New Methods to Detect Chlorinated Organic Pollutants in Water,** Andrea F. Arruda (Graduate Research Fellow) and Andres D. Campiglia (Assistant Professor of Chemistry), Department of Chemistry, North Dakota State University.

B-03: The Periphyton in the Sheyenne River, North Dakota, Megan A. Jaskowiak (Graduate Research Fellow), Marvin W. Fawley (Professor of Biological Sciences) and Karen A. Phillips (Research Associate), Department of Biological Sciences, North Dakota State University

B-04 Effects of Fathead Minnows and Drainage History on Prairie Wetland Ecosystems, Kyle D. Zimmer (Graduate Research Fellow), Malcolm Butler (Professor of Biological Sciences), Mark A. Hanson (Adjunct Professor Zoology), Department of Biological Sciences, North Dakota State University

In four of the seven fellowship projects, Federal and State agencies, and a local watershed board, provided co-funding or in-kind services such as water analyses:

- **Moorhead Water Treatment Plant**: Hurley/Lin, *An Investigation of Ozone Consumption Rates and By-Product Formation at the Moorhead Water Treatment Plant*
- **Pelican River (MN) Watershed District**: Nustad/Lin, *Determination of the Factors Causing Elevated Phosphorus Levels in a Natural Wetland and Methods for Remediation*.
- **ND Department of Health and ND State Water Commission**: Skubinna/Korom, *Modeling the Hydrogeochemistry of Denitrification in In-Situ Microcosms in the Elk Valley Aquifer*.

During FY 2000, three Graduate Research Fellows obtained their degrees:

- Kyle Zimmer, Ph.D. Now a post-doctoral researcher at the University of Minnesota, Minneapolis;
- Rochelle Nustad, M.S. Now a civil engineer with the U.S. Geological Survey, Water Resources Division, North Dakota District;
- Melani Tescher, M.S. Now a doctoral student at the University of Nevada Reno.

The remaining two students whose work is described in this section (Hurley and Skubbina) are near completion, and both should receive M.S. degrees in 2001.

Periodic updates of research progress are made to the web page of each GRF. See the Institute's website at ***www.nodak.edu/wrri*** and select the *2000 Fellows* link.

Synopses of the research progress or disquisition abstracts for the Hurley, Nustad, Skubinna, and Tescher projects follow.

An Investigation of Ozone Consumption Rates and By-Product Formation at the Moorhead Water Treatment Plant

Stuart Hurley (Graduate Research Fellow) and Wei Lin (Assistant Professor of Civil Engineering)

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The Moorhead Water Treatment Plant employs ozone for the purposes of disinfection and removal of taste and odor compounds. Ozone is a powerful oxidant that either completely oxidizes organic compounds into carbon dioxide and water, or partially oxidizes organics into simpler compounds also known as *disinfection by-products*. Some disinfection by products are of concern as drinking water pollutants.

The raw water or influent to the Moorhead water treatment facility consists of both well water and Red River water. The first stage of treatment is lime and soda ash softening which raises the pH of the water from about 8 to around 10.6-11.3. The water is then sent through the ozone contact chamber for primary disinfection. The ozone contact chamber consists of six cells. In the first cell the water is ozonated without any pH adjustment from the softening basins for oxidation of taste and odor compounds. In the third cell the water is ozonated and recarbonated with carbon dioxide to reduce the pH to around 9.5. In the fifth and sixth cells the water is ozonated again to meet disinfection requirements. From the ozone contact chamber the water is filtered then a chloramine secondary disinfectant is added to provide residual protection for the distribution system.

The purposes of this project are to identify as many of the DBPs produced by ozone oxidation as possible, to determine the operational conditions associated with the formation of these DBPs, and to investigate operational alternatives to improve ozonation efficiency.

A series of process sampling events and sample analyses were carried out to determine the extent of organic compound oxidation and ozonation by-product formation. Chemical oxygen demand (COD) and total organic carbon (TOC) were analyzed to determine the amount of oxidation and partial occurring across the ozone contact chamber. Decreased concentrations of TOC indicate complete oxidation of organic matter to inorganic products, while a COD reduction can be resulted from partial and complete oxidation of organic compounds. The results of this analysis showed a 10-35% COD reduction and generally less than a 10% TOC removal occurring in the ozone contact chamber indicating partial oxidation was taking place.

Two gas chromatograph mass spectrometer (GC/MS) procedures were developed to study the formation of ozonation by-products. The majority of ozone DBPs are oxygenated and polar in nature such as carbonyl compounds like aldehydes and ketones. An EPA purge and trap procedure was employed to identify volatile carbonyl compounds and another EPA derivatization procedure was used to quantify the carbonyl compounds produced through ozone oxidation.

Water samples have been taken and analyzed three times a week to quantify the disinfection by-products (DBPs) produced through ozone oxidation. Samples were drawn from (1) the ozone chamber influent, (2) after initial ozonation at high pH, (3) after recarbonation and pH adjustment, (4) after final ozonation for disinfection, and (5) after filtration. The first four sample points will provide information on what is occurring across the ozone contact chamber, and the filter effluent data will be used to assess the performance of the filters on removal of the DBPs as a result of biological oxidation occurring in the thin biofilm attached to the granular filter media.

The volatile analysis did not provide any conclusive evidence of volatile compounds produced through the ozonation process. There were very few compounds detected, and these were not produced on a consistent basis. The analytes that may be quantified by the carbonyl compound derivatization procedure are formaldehyde, acetaldehyde, propanal, butanal, crotonaldehyde, pentanal, hexanal, cyclohexanone, heptanal, octanal, benzaldehyde, nonanal, decanal, glyoxal, and methyl glyoxal. The major carbonyl compounds identified thus far are formaldehyde, acetaldehyde, butanal, glyoxal, and methyl glyoxal.

The total aldehyde concentration of the ozone contact chamber effluent is higher than the influent to the contact chamber indicating the formation of carbonyl compounds due to ozone oxidation. An important factor in the treatment process is the removal of these compounds. The filter effluent data provided in Figure 1 indicates the subsequent removal of the majority of these compounds before they actually reach the distribution system for domestic use. The removal of the aldehydes in the filters indicates that the filters are biologically active during this phase of the study.

Determination of the Factors Causing Elevated Phosphorus Levels in a Natural Wetland and Methods for Remediation

Rochelle A. Nustad (Graduate Research Fellow) and Wei Lin (Assistant Professor of Civil Engineering)

Environmental Engineering Program
Department of Civil Engineering
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Fargo, ND 58105

Thesis Abstract. Wetlands are known for their capacity to act as sinks or traps for nutrients and are often used for phosphorus and ammonia removal from wastewater streams and agricultural runoff. However, natural peat wetlands near Detroit Lakes, MN, appear to be releasing phosphorus into a drainage ditch. The ditch water running through the wetlands enters Lake Sallie, an important recreational lake. A field study was conducted to determine the factors causing the elevated phosphorus levels in the ditch and a bench scale aeration study was conducted to determine the feasibility of aeration within the ditch as a method to decrease phosphorus at the outlet of the ditch.

Results indicate that biological decomposition of organic matter in the wetland is resulting in the release of phosphate through mineralization. Microbial reactions may also be producing an environment that is favorable for the dissolution of metal-phosphates. These microbial reactions are resulting in high phosphorus concentrations in the wetland pore water. A hydraulic gradient exists in the wetland-complex with water moving from the wetland to the ditch. This gradient results in phosphate being transported from the wetland to the ditch. Results from the bench scale aeration study indicate that aeration is an ineffective method for reducing phosphate concentrations in the ditch. High dissolved oxygen conditions exist most of the year and based upon literature values, it is not possible to reduce phosphate concentrations below present levels.

Thesis

Nustad, Rochelle A., Determination of the Factors Causing Elevated Phosphorus Levels in a Natural Wetland and Methods for Remediation. M.S. Thesis, Department of Civil Engineering, North Dakota State University, Fargo, December 2000.

Modeling the Hydrogeochemistry of Denitrification in In-Situ Microcosms in the Elk Valley Aquifer

Paul A. Skubinna (Graduate Research Fellow) and Scott F. Korom (Associate Professor of Geology and Geological Engineering)

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Grand Forks, ND 58202

Nitrate is one of the most common groundwater contaminants observed in aquifers. In areas where agricultural activity is prominent, nitrate from fertilization may infiltrate and contaminate aquifers like the Elk Valley Aquifer (EVA) in Eastern North Dakota. The objective of this study is to gain a better understanding of the geochemical processes associated with the denitrification observed in the EVA. The research is focused on reaction paths, rates, products, denitrification capacities, and prediction of potential undesirable secondary products associated with the denitrification.

The methodology of this study has been to replicate the experiment done by Schlag and Korom using in-situ mesocosms (ISMs) located near Larimore, ND. The approach incorporates fieldwork and analytical lab work, with the addendum of computer modeling. The fieldwork consisted of amending groundwater contained within the ISMs with potassium nitrate and potassium bromide on October 8, 1998, followed by monthly sampling of the amended water using the protocol outlined by Standard Methods. Sample analyses for general anions, cations and other basic water parameters were performed by North Dakota Department of Health. Bromide analysis, along with duplicate analysis of dissolved carbon, nitrate-nitrogen, and sulfate, were performed at the UND Water Quality Lab.

Since October 8, 1998 the ISMs have been sampled fifteen times on an approximate monthly schedule. Sample analysis indicated a decrease of 5-10 mg/L NO_3^-– N per month. As of February 19, 2000 nitrate-nitrogen concentration in the R-ISM had been totally degraded to an effective concentration of 0 mg/L. The initial nitrate value was approximately 105mg/L. Bromide concentration in the R-ISM remained approximately 45 mg/L at that time. In the ISM amended with KBr only (referred to as the C-ISM), the Br^- concentration, which began the study at approximately 720mg/L, was approximately 600mg/L. Bromide observations in both ISMs indicate its effectiveness as a relatively conservative tracer.

Sulfate concentrations in the R-ISM increased to approximately seven times the initial concentration at the end of denitrification while the sulfate concentration in the C-ISM remained roughly constant. Comparatively, dissolved inorganic carbon (DIC) concentrations displayed little fluctuation in either the C-ISM or the R-ISM. This suggests that denitrification by sulfide minerals is the prominent process in this groundwater system. However, dilution accounted for, sulfate production in the R-ISM does not stoichiometrically account for all missing nitrate. Though sulfide minerals may be thermodynamically favorable electron donor, it appears organic carbon (OC) is also participating in the denitrification process. Possibly, denitrification sourced DIC is being offset by a secondary DIC sink reaction resulting in no net observable increase.

Comparing the data set of the second tracer test to that of the first tracer test performed by Schlag, the following conclusions are apparent: (1) Denitrification rates in the second tracer test are about half of those observed in the first tracer test. (2) Percent of denitrification by sulfide minerals, accounted for by sulfate production, decreased in the second tracer test to 48 – 73% vs. 61-89% in the first tracer test. (3) Nitrogen isotope fractionation analyses suggests a more electron donor deficient environment in the second tracer test than first tracer test.

Extensive hydrogeochemical modeling with PHREEQC-2 has been done to improve the understanding of the synthesis of processes and secondary reactions associated with the denitrification. Current efforts have the following objectives: to model the observed state of geochemical thermodynamic disequilibrium within the ISMs during the tracer test; to gain more substantiated evidence of OC's role as an electron donor to the observed denitrification; and to gain insights and propose a possible scenario of major geochemical reactions associated with study methodology, naturally occurring processes and observed redox.
The latest modeling methodology has substantiated pyrite as a major electron donor to denitrification, suggested the formation of iron oxy-hydroxides as a product of denitrification by pyrite, and provided a more substantiated line of evidence that OC is simultaneously active as a second major electron donor to denitrification.

Presentations

Korom, S. F., A. E. Kammer, A. J. Schlag, and P. A. Skubinna, In-situ study of denitrification in the Elk Valley Aquifer, North Dakota, EOS, Transactions, American Geophysical Union/Supplement, 82(20), S168, 2001 (Abstract)

Skubinna, P. A., and S. F. Korom, In-situ study of denitrification in the Elk Valley Aquifer: Second tracer test, EOS, Transactions, American Geophysical Union/Supplement, 82(20), S168, 2001 (Abstract).

An Analysis of Mercury in Mallards from Kellys Slough National Wildlife Refuge in Grand Forks County, North Dakota

Melani L. Tescher (Graduate Research Fellow) and Sally Pyle, Assistant Professor of Biology

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Thesis Abstract. Although, methylmercury contributes only a small fraction to the total mercury pool in aquatic ecosystems, it is an increasingly common pollutant around the world. It is believed that contaminants like methylmercury are responsible for declines many avian populations through the reduction in habitat, food quality and quantity, reproductive impairment and low nesting success. Kellys Slough is a National Wildlife Refuge with a main purpose of waterfowl production and therefore makes a prime test system because it surrounded by land that has been cultivated for generations. The purpose of this study was to examine methylmercury bioaccumulation in waterfowl raised on Kellys Slough National Wildlife Refuge in Grand Forks County, North Dakota. To better understand the dynamics of bioaccumulation, baseline total mercury concentrations were assessed in the sediments. Environmental variables such as pH, dissolved oxygen, microorganisms and sediment clay content was also assessed. These variables aid or hinder the transformation of mercury to methylmercury. The food sources for the ducklings (macroinvertebrates and vegetation) for the young mallards were also studied. Sediment analysis showed total mercury concentration ranged from 24.70 ng/g-86.50 ng/g with a mean concentration of 42.12 ng/g ± SD 25.44. These levels are below the EPA standard (0.1-0.2 μg/g) for freshwater systems. Vegetation and macroinvertebrates were analyzed for total mercury content. The levels ranged form 4.94 ng/g to 86.50 ng/g ($x = 45.65 \pm 20.034s$) in the vegetation and 4.16 ng/g-10.50 ng/g ($x = 7.59 \pm 2.702$) for the invertebrates. Liver tissue was analyzed for inorganic and methylmercury. The reason behind the dual analysis was to determine the amount of inorganic mercury crossing the gut and the body. Due to the assumption that inorganic mercury does not cross the gut, the muscle tissue was analyzed only for methylmercury. Levels for each tissue showed ranged form 88.90 ng/g to 238.0 ng/g methylmercury ($x = 138.79$ ng/g ± 40.573) and 10.00 ng/g to 24.91ng/g inorganic mercury ($x = 24.91$ ng/g ± 16.682) in the liver and 44.40 ng/g to 107.0 ng/g ($x = 73.05$ ng/g ± 22.629) in muscle tissue. Regression analysis showed a positive correlation between total mercury concentration of sediment and vegetation. However, a negative correlation was seen between sediment and invertebrates, and vegetation and invertebrates. No significant difference was measured between the means of any of the groups. Methylmercury concentrations found from liver and muscle tissue were analyzed with a Paired t-test. There was a significance

difference between the means for these to tissues (<0.001). We also saw a correlation factor 0.780. Paired differences showed a mean of 65.74 ± SE 8.524 (t-value = 7.712, df = 9, sig. 0.000). The data collected were conclusive in determining differences in the bioaccumulation of methylmercury concentrations between the liver and muscle tissue.

Thesis

Tescher, Melani L., An Analysis of Mercury in Mallards from Kellys Slough National Wildlife Refuge in Grand Forks County, North Dakota, M.S. Thesis, Department of Biology, University of North Dakota, Grand Forks, August 2001.

Information Transfer Program

Basic Information

Title:	ND WRRI Information Transfer Program
Start Date:	3/1/2000
End Date:	2/28/2000
Descriptors:	Newsletter, website
Lead Institute:	North Dakota Water Resources Research Institute
Principal Investigators:	Gregory J. McCarthy

Publication

The Institute has a newsletter which is issued in December of each year. Copies of past newsletters can be obtained by writing to the Director. The Institute's website address is ***www.nodak.edu/wrri***.

The institute continued its modest support of the Biotic Resources Seminar Series at North Dakota State University.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	4	0	0	0	4
Ph.D.	3	0	0	0	3
Post-Doc.	0	0	0	0	0
Total	7	0	0	0	7

Notable Awards and Achievements

None

Publications from Prior Projects