This project was conducted in cooperation with the State of Georgia, Environmental Protection Division.

EPD Grant Number:
SFY2017 State Seed Grant
Contract Number: 751-170132

Project Title:

Bromide Concentrations in Surface Drinking Water Sources for Butts County

FINAL REPORT

Submitted by:
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Period of the Project:

08/31/2017 – 05/30/2021

Approved by: _____
First Last Name, Contract Administrator
NonPoint Source Program
Watershed Protection Branch

EXECUTIVE SUMMARY

Project Title

EPD Grant Number 751-170132

PROJECT START DATE: 08/31/2017

PROJECT COMPLETION DATE: 05/30/2021

FUNDING:

State amount allotted	$ 58,699
Match amount allotted	$ 44,095
Cash amount allotted	$ 12,420
Federal amount expended	$NA
Match amount expended	$48,370.06
Cash amount expended	$11,801.97

EXECUTIVE SUMMARY

The overall goal of this project was to support activities outlined in the Middle Ocmulgee Regional Water Plan (RWP) by initiating a watershed-based water quality monitoring program to identify the sources of increasing bromide and microplastic concentrations in the surface water source used for Butts County, et al. Water & Sewer Authority (Authority) public drinking water supply downstream of Jackson Lake on Ocmulgee River.

Concerns regarding levels of disinfection by-products also known as trihalomethanes (THMs) specifically byproduct THMs precursor levels of total organic carbon (TOC) and brominated based bromoform, in the treated drinking water as well as concerns regarding unregulated microplastic pollution in sources of drinking water prompted this project.

Data collected in this project supported University of Georgia (UGA) in refining the sampling program, develop a model bromide and microplastic water quality monitoring program, and develop resources and recommendations that could be used by other municipal drinking water facilities which may be experiencing increasing bromide concentrations and are concerned about microplastic pollution in source and treated drinking water.

Activities that were completed:

- We conducted a pilot bromide water monitoring program. Initial results indicated that bromide concentrations were relatively low and no longer presented a risk to drinking water quality. Sampling after March 2020 stopped due to the COVID-19 pandemic. The chemistry lab also ceased to analyze samples until April 2021.
- Sampling for TOC ceased after March 2020 stopped due to the COVID-19 pandemic. The chemistry lab also ceased to analyze samples until April 2021.
- Initiating a pilot program for microplastics analysis was much more time intensive and expensive that initially planned. These changes arose from significant changes in the way that microplastics are collected and analyzed. Therefore, the PI has invested and continues to invest funds outside of this project to support the work. Sampling for microplastics ceased between March and October 2020 stopped due to the COVID-19 pandemic. As the process is so time intensive, the samples collected between October 2020 and April 2021 continue to be analyzed.
- We developed the following resources for Georgia residents and water planning groups:
- Links to resources developed through this project are located here: https://drive.google.com/drive/folders/18yTB03NZC1wuwbbv8CJ1CAjT2Xnw2ta3?usp=sharing

- We created extensive resources to support greater understanding of bromide pollution in surface water. They include a website, a report (white paper), PowerPoint presentations, and videos. They can be found here: http://cappslab.ecology.uga.edu/additional-info/bromide-in-surface-water/
- We created extensive resources to support greater understanding of microplastic pollution in surface water. They include a website and a workshop on how to monitor microplastic pollution. These resources can be found here: http://cappslab.ecology.uga.edu/resources-to-support-microplastics-research/
- We also presented our work to the water quality information and project progress periodically to Regional Water Council stakeholders periodically.

1.0 INTRODUCTION

Disinfection By-Product Precursors

Disinfection by-products (DBP) are formed by the reaction of chemical disinfectants with by- product precursors. Natural organic matter (usually measured as Total Organic Carbon (TOC)) and inorganic matter (bromide) are the most significant DBP precursors. Initial bromide and TOC concentrations are a concern to municipal public drinking water facilities at the withdrawal intake of the drinking water supply source and can become a risk in the treated drinking water distribution system. High levels of bromide and TOC can react with pre- and post- chemical disinfection treatment (chlorine, chlorine dioxide, chloramines and ozone) in source water and create DBPs such as haloacetic acids (HAAs) and trihalomethanes (THMs).

Human health risks associated with products and by-products of reactions between bromide, TOC, and disinfection treatment chemicals in public drinking water sources are of concern. These disinfection by-products are regulated under the US EPA Safe Drinking Water Act (SDWA) and GAEPD under the Rules for Safe Drinking Water (Chapter 391-3-5-.04).

DBPs in public drinking waters are actively monitored in the distribution water lines and regulated as Total Trihalomethanes (TTHMs) with a maximum contaminant level (MCL) of 0.80 mg/L and Haloacetic acids (five) (HAA5) with a maximum contaminant level (MCL) or 0.60 mg/L.

Bromide

Bromide is a naturally occurring element in the Earth's crust. Typically, when elevated levels of bromide are found in surface water, it is most often associated with fossil fuel extraction and utilization, but other sources of bromide contamination include, but are not limited to, pharmaceuticals, drilling fluids for deep wells, and pesticides. However, bromide is not biologically reactive and it has little to no human health risks in recreational surface waters. Neither the US EPA water quality standards as administered by 40 CFR Part 131 or Section 303 of the Clean Water Act, nor the GAEPD under the Rules and Regulations for Water Quality Control (Chapter 391-3-6-.03) require monitoring bromide concentrations because it is naturally occurring in surface water and is not biologically reactive.

Some studies show that brominated DBPs may pose a higher risk to human health than other types of HAAs and THMs that do not contain bromide. So the grouping and the sum of the concentrations of DBPs could result in finished drinking water with high levels of brominated DBPs while still remaining under the limit for MCLs.

Bromate is also regulated at 0.10 mg/L. For lab monitoring purposes, disinfection by-products are grouped together for a sum of the concentrations in milligrams per liter and do not distinguish between brominated and non-brominate compounds.

Total Organic Carbon (TOC)

TOC also has no health effects. However, TOC provides a medium for the formation of DBPs. Public drinking water systems that use conventional filtration treatment are required to remove specific percentages of organic materials, measured as TOC, that may react with disinfectants to form DBPs. Removal must be achieved through a treatment technique (enhanced coagulation or enhanced softening) unless a system meets alternative criteria. Measurements of TOC removal after treatment are based on the alkalinity of the water. Target source water TOC removal (mg/L) for the Authority is > 2.0 to 4.0. The Authority's Consumer Confidence Report for 2018 reported the average TOC amounts to be 1.7 mg/L.

Microplastics

High concentrations of microplastics, or small pieces of plastic less than 5mm long, have been documented in aquatic systems throughout the globe. Research in marine environments has demonstrated the potential impacts of microplastic pollution on animal populations, food web ecology, and ecosystem processes. However, comparatively less work has been conducted in streams and rivers. Recent work comparing microplastic

concentrations in source and finished water in the US has demonstrated that microplastics can remain in water throughout the treatment process. Yet, more work is needed to understand the factors influencing the spatial and temporal distribution of microplastics in sources of drinking water.

Butts County Water and Sewer Authority

The Butts County, et al. Water & Sewer Authority (Authority) operates two public drinking water system facilities; Burford Water Treatment Plant, with a water withdrawal intake on the Ocmulgee River downstream of Jackson Lake dam, and the Stewart Water Treatment Plant, with a water withdrawal intake on the Towaliga River which does not drain to Jackson Lake. The Burford Water Treatment Plant is the primary drinking water source for the system.

As part of the Safe Drinking Water permit requirements, the Authority has been actively testing for disinfection by-products THMs in the finished drinking water from the system's distribution water lines. In December 2013, Authority staff first documented positive results for bromoform in THM data from the State of Georgia laboratory. These data were collected from multiple sites (Figure 3). This upward trend continued for two years, resulting in one violation close to the detection limit of the MCL for TTHM in September 2015. The Authority initiated additional treatment steps (through aeration of finished water within the distribution system), which reduced the higher trend in disinfection by-product compounds.

Additional samples tested by a private laboratory showed unusual higher levels of the THM bromoform in the water samples which prompted testing for bromide in the raw, untreated surface water sources. From August 2015 to September 2016, the raw water from the Ocmulgee River tested positive for bromide (range: 20 µg/L to 130 µg/L). Results showed the bromide concentrations in the Ocmulgee were significantly higher than bromide levels in the nearby Towaliga River (range 16 µg/L to 30 µg/L) (Figure 2A and 2B).

2.0 PROJECT OBJECTIVES, GOALS, AND ACTIVITIES

Project Activity #1: Enact a pilot bromide, total organic carbon, and microplastics monitoring program

Task 1: Collect and analyze water quality data

- Bromide will be sampled monthly in source water for 2 years at 12 field sites(Aug. 2017–Aug. 2019). After 2 years, bromide will be periodically sampled in limited basis until end of project May 31, 2021.
  We conducted a pilot bromide water monitoring program. Initial results indicated that bromide concentrations were relatively low and no longer presented a risk to drinking water quality. Sampling after March 2020 stopped due to the COVID-19 pandemic. The chemistry lab also ceased to analyze samples until April 2021. They had not processed our samples or charged us for the analysis of the remaining samples prior to lab closing down.
- TOC will be sampled monthly in source water for 7 months of 2-year period at 12 field sites (Jan. 2019 - July 2019). After 7 months, TOC will be periodically sampled in limited basis until end of project.
  Sampling for TOC ceased after March 2020 stopped due to the COVID-19 pandemic. The chemistry lab also ceased to analyze samples until April 2021. They had not processed our samples or charged us for the analysis prior to lab closing down.
- Microplastics will be sampled every two months in sediment and source water from October 2019 – April 2021 at a subset of the original 12 sites as well as in treated finished drinking water at the water treatment plant for remaining time of the project.
  Initiating a pilot program for microplastics analysis was much more time intensive and expensive that initially planned. These changes arose from significant changes in the way that microplastics are collected and analyzed. Due to extreme variation in the quality of microplastics analysis, the PI sent a graduate student to a lab in California in February 2020 (She used her own resources from other funds. The expenditures associated with this trip were not included in the cash match and are not reflected here. Sampling for microplastics ceased between March and October 2020 stopped due to the COVID-19 pandemic. As the process is so time intensive, the samples collected between October 2020 and April 2021 continue to be analyzed. Therefore, the PI has invested and will continue to invest funds outside of this project to support the work.

Task 2: Report water quality information to stakeholders

- Conduct quarterly presentations for the members of the Water Council and other interested stakeholders. Presentations will include site photos, the data that have been collected during the quarter, and historical data.
  The PI has presented informal updates to the collaborators in Butts County and to members of the Water Council multiple times throughout the project. Formal presentations were made twice during the project (2018 and 2021). Field work and reporting activities were negatively impacted by the COVID-19 pandemic.
- During the last meeting of the year, the presentations will be used to share the technical report described in Task 1.
  The PI has presented informal updates to the Water Council multiple times throughout the project. Formal presentations were made twice during the project (2018 and 2021). Field work and reporting activities were negatively impacted by the COVID-19 pandemic.

Project Activity #2: Develop resources and recommendations to provide information regarding bromide/bromoform, TOC, and microplastic impacts on drinking water Develop online resources which will be completed prior to the end of monitoring.

Tasks 3: Research state, federal, and international information available on bromide/bromoform, TOC, and microplastic impacts on drinking water

- Conduct an extensive literature and internet search to identify and summarize all of the bromide/bromoform, TOC, and microplastics case studies and monitoring programs.
  We conducted these reviews and created a summary report about bromide/bromoform and carbon interactions with water pollution. We also reviewed microplastics methods. During this review, we realized that there was a lot of debate about best practices in the collection and analysis of microplastics. Therefore, we contacted a microplastics expert in CA. We sent a graduate student to be trained in microplastics analysis and we organized a regional workshop (~65 people) for people in the southeast to be trained by experts in the field. We created online resources for all of these activities.

Tasks 4: Generate a white paper documenting recommendations for monitoring bromide in source water that can be incorporated into watershed plans or local water plans

- Collaborate with Butts County officials and use the data collected and the materials generated by this project to develop a set of recommended actions for monitoring bromide, TOC, and microplastics in source water.
  All of the data we have received has been shared with Butts County. Though we did not document the elevated concentrations of bromide during our surveillance, the county plans to continue to monitor Br concentrations in source water. Our microplastics analysis is still continuing.

Tasks 5: Create website in conjunction with Butts County and the Georgia EPD hosted by the River Basin Center at the University of Georgia

- Create a resource available for counties throughout the state of Georgia and to broadly distribute the products of this project.
- At the end of the project, the website will go live and will contain the information generated throughout the project.
  We created websites and a Google folder with all the information.

Project Activity #3: Reporting Requirements

Task 6: Submit Quarterly Reports and invoices to GAEPD Deliverables

Quarterly deliverables, data, invoices, supporting documentation, reporting progress on project and using template provided by GAEPD.

We completed these reports.

Task 7: Submit Final Invoice & Close-Out Report to GAEPD for review

We completed this report.

2.1 PLANNED AND ACTUAL MILESTONES, PRODUCTS, AND COMPLETION DATES

Milestones	Starting Dates	Completion Dates
Milestone 1 Bromide White Paper	08/17	06/19
Milestone 2 Bromide Website and Educational Materials	08/17	08/19
Milestone 3 Methods Development for Microplastics	08/19	05/21
Milestone 4 Online Workshop Development for Microplastics and Website Development	10/19	09/20

2.2. EVALUATION OF GOAL ACHIEVEMENT AND RELATIONSHIP TO THE REGIONAL WATER PLAN

The methods and data from this project were used to support the implementation of management measures from the RWP and enhance the technical resources available to monitor and assess bromide, TOC, and microplastic concentrations throughout the State of Georgia. RWP management measures include:

- WQ2 - Water Quality Management Practice: Adopt and Coordinate Statewide, Regional, and Local Water Quality Monitoring Programs (page 6-9). We enhanced local and regional water quality monitoring programs through an intensive pilot program monitoring of bromide and organic carbon concentrations in the Middle Ocmulgee River Watershed.
- WS1 - Water Supply Management Practice: Develop/Update Local Water Master Plans (page 6-7). Inform the update of the local water master plan for Butts County by generating technical products for the Butts County, et al. Water & Sewer Authority. We generated technical documents and new SOPs for Butts Co. and for the state. All of these resources are available online on the websites we created as part of this project.
- WS2 - Water Supply Management Practice: Investigate Impacts of Metro Area Discharges (page 6-8). Investigate the impacts of metro area discharge on bromide concentrations in the Middle Ocmulgee River and monitoring of additional parameters, such as emerging pollutants. We did not detect elevated Br concentrations during our sampling. Later samples have not been and will not be processed due to the shutdown of the laboratory and our inability to conduct field research during the COVID-19 pandemic.
- This project will also support progress on a Recommendation to the State (in Section 7.4 of the RWP) regarding the collection of "Additional Data (Water Quality)."
  We did collect new water data and have provided new resources to our collaborators and the water council.

2.3 SUPPLEMENT INFORMATION

All of the supplement information can be accessed here. Many of the resources are videos; therefore, hard copies cannot be generated.

- *Google Drive Folder of Data and Resources:*
  https://drive.google.com/drive/folders/18yTB03NZC1wuwbbv8CJ1CAjT2Xnw2ta3?usp=sharing

- *BROMIDE*
  - Full website to access videos, etc. http://cappslab.ecology.uga.edu/additional-info/bromide-in-surface-water/
  - Bromide Concentrations in Surface Drinking Water Sources summary https://www.youtube.com/watch?v=aCNupUI2hPE
  - Bromide Concentrations in Surface Drinking Water Source ANTHROPOGENIC SOURCES https://www.youtube.com/watch?v=dXRaVS5nfo4&t=3s
  - Bromide Concentrations in Surface Drinking Water Source DEALING WITH BROMIDE AND BROMINATED COMPOUND https://www.youtube.com/watch?v=0_R1T_ajhwM&t=5s
  - Bromide Concentrations in Surface Drinking Water Source DisinfectionByproducts https://www.youtube.com/watch?v=EfyLaUtH-SM&t=1s
  - Bromide Concentrations in Surface Drinking Water Source Natural Sources and Chem Interactions https://www.youtube.com/watch?v=FFXPoY5pp7I
  - Bromide Concentrations in Surface Drinking Water Source REGULATIONS GOVERNING BROMINATED COMPOUNDS https://www.youtube.com/watch?v=xdxTuFbgb6k
  - Bromide Report http://cappslab.ecology.uga.edu/wp-content/uploads/2019/04/Draft_Final-Report.pdf

- *MICROPLASTICS*
  - Website to access microplastics resources: http://cappslab.ecology.uga.edu/resources-to-support-microplastics-research/
  - New collection and analysis methods: https://drive.google.com/file/d/1YVI3gjVRbjmV0FrAlbGXwCgyNZU1vZj8/view?usp=sharing
  - Introduction to Microplastics Workshop: https://youtu.be/JwddxV0e3dE
  - Field and Laboratory Methods: https://youtu.be/yxJL-3dhZZU
  - Microplastics Resources Folder: https://drive.google.com/drive/folders/18yTB03NZC1wuwbbv8CJ1CAjT2Xnw2ta3?usp=sharing

3.0 LONG TERM RESULTS IN TERMS OF BEHAVIOR MODIFICATION, STREAM/LAKE QUALITY, GROUND WATER, AND/OR WATERSHED PROTECTION CHANGES

NA

4.0 BEST MANAGEMENT PRACTICES (BMPS) DEVELOPED AND/OR IMPLEMENTED

We developed a protocol for collecting and analyzing microplastic pollution. These methods have been uploaded into the Google Drive Folder.

5.0 MONITORING RESULTS (IF APPLICABLE)

All of the data that were analyzed prior to the end of the grant have been posted in the Google Drive folder.

6.0 PUBLIC INVOLVEMENT AND COORDINATION

6.1. STATE AGENCIES

GA EPD

6.2. FEDERAL AGENCIES

NA

6.3 LOCAL GOVERNMENTS, INDUSTRY, ENVIRONMENTAL, AND OTHER GROUPS, PUBLIC AT LARGE

Middle Ocmulgee Water Council

6.4. OTHER SOURCES OF FUNDS

The project was and will continue to be funded through start-up funds provided to the PI by the University of Georgia.

7.0 ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

This project was complicated as it was initially designed to monitor an emerging contaminant that was detected by the Butts County Water Authority. However, after monitoring for one year, we did not detect the contaminant. Fortunately, with the support of the Water Authority, the Water Council, and the EPD, we were able to pivot to monitor another emerging contaminant of concern, microplastics, for the Water Authority. However, once we began our work, we quickly realized that the methods used to collect and analyze microplastics were varied and some were questionable. Therefore, we began investigating best methods. In response, we delayed our field collection, and we sent a graduate student to California to receive training in February 2020. This trip was paid for from other funds in the lab and were not charged to this project. On March 8, UGA stopped all field work and lab work. Therefore, the chemistry labs where we analyzing our data were shut down and did not open again in full capacity until 2021. Hence, many of the samples we have collected were not able to be analyzed during the tenure of this grant. We also had to delay any field collection of samples until October 2020. We did develop new methods to analyze microplastic samples, but they are time intensive, and the samples are still being processed. We are still investing financial resources in supporting students who are processing the samples and for the regents needed to process the samples. We will share the data with the Water Authority and Water Council once they are analyzed. These data are expected by December 2021.

8.0 FUTURE ACTIVITY RECOMMENDATIONS

Being able to pivot and address new issues and shortcomings in out planned activities was wonderful. We presented our findings and ideas to first the Water Authority and then discussed other concerns that they had about their source water. With this information, we were able to pivot, develop an idea and approach the EPD. With the support to the EPD, we were able to present our data and idea about how to move forward to the Water Council and to representatives from the EPD. They were able to vote on the proposal and ended up extending the timeline of the grant and alter the project goals. This type of flexibility was unexpected, but wonderful.

8.1 INFORMATION AND EDUCATION OUTPUTS

Please see the above links for the links to the information. We created a set of educational resources and a report discussing bromide and brominated compounds. These resources include PowerPoint presentations and movies. We also designed and executed a workshop discussing the collection and analysis of microplastics in the environment. The workshop was recorded and we have posted videos of the training online. We also used this information to develop new field and lab methods. We have detailed these with citations and uploaded them into the Google Drive folder.

9.0 BUDGET

BUDGETED EXPENDITURES

Item	Object Class Category	State Grant Funds	Matching Funds	Cash	Total

A	Personnel	$54.754.00	$8,232.00		$62,986.00
B	Fringe Benefits	$3,045.00	$1,598.00		$4,643.00
C	Travel	$900.00		$1,000.00	$1,900.00
D	Equipment				$0
E	Supplies			$11,420.00	$11,420.00
F	Contractual				$0
G	Construction				$0
H	Other				$0
I	Total Direct Charges (Sum of A-H)	$58.699.00	$9,830.00	$12,420.00	$80,949.00
J	Indirect Charges		$34,265.00		$34,265.00
K	Total (Sum of I and J)	$58,699.00	$44,095.00	$12,420.00	$115,214.00

FINAL EXPENDITURES

Item	Object Class Category	State Grant Funds	Matching Funds	Cash	Total
A	Personnel	$42,072.75	$8,232		$50,304.75
B	Fringe Benefits	$1,020.81	$2,320.06		$3,340.87
C	Travel	$904.25		$1,066.79	$1,971.04
D	Equipment				$0
E	Supplies			$10,735.18	$10,735.18
F	Contractual				$0
G	Construction				$0
H	Other				$0
I	Total Direct Charges (Sum of A-H)	$43,997.81	$10,552.06	$11,801.97	$66,351.84
J	Indirect Charges		$37,818.00		$37,818.00
K	Total (Sum of I and J)	$43,997.81	$48,370.06	$11,801.97	$104,169.84

9.1 BUDGET JUSTIFICATION

Any discrepancies in budget were due to research and travel restrictions and laboratory shut-downs associated with the COVID-19 pandemic.

Minority Business Enterprise (MBE) and Women Business Enterprises (WBE) Utilization NA