

Sample SRP Application Environmental Sciences

Applicants Melissa Pasierb, Class of 2017, undeclared, Allison Brooks, Class of 2018, undeclared, Sarah Sojka, faculty, Environmental Studies and Science and Physics

Title of Project:

Evaluating contaminant trapping behind dams on the James River

Abstract:

Dams have a range of negative environmental impacts on rivers making dam removal an important environmental goal. However, dams can trap contaminants, such as heavy metals, that would be released if the dam is removed. The James River Association hopes to remove dams in the Lynchburg area on the James River, beginning with the RockTenn dam. Before this removal, they need to assess the pollutant levels behind the dam. In this project, we will sample sediment around the RockTenn dam and analyze it for heavy metals to determine if removal of the dam will negatively impact downstream water quality.

Project description

Introduction

Our proposed research project examines heavy metal content and sediment characteristics in ecosystems upstream and downstream from at least one dam along the James River. The dams are a topic of debate in the community, which is now encouraging the James River Association to enact procedures of dam removal. Our project will therefore be a preliminary assessment of the ecological risks pertaining to this decision specifically in terms of heavy metal toxicity. Our experiments will not only address local environment concerns, but will also contribute to the larger national question of dam infrastructure, since physical changes in the environment, both natural and man-made, have rendered many dams impractical or unnecessary around the country.

Background/ Studies

Dams are manmade structures that divert a river's natural flow so that the water can be used for human purposes and can cause substantial damage to river ecosystems. Removing unnecessary dams can be an efficient way of repairing the disturbed ecosystem around a dam and improving water quality. Removing a dam restores a river's natural flooding cycles, water temperature and evaporation rates, deposition and transportation of sediments, dissolved oxygen content, and fish passage (Bednarek,

2001). Often the water in the reservoir created by a dam has a larger difference in temperature with depth because the water has a slower velocity and does not mix as well as a fast-moving body of water (Higgs, 2002). This can lead to lower levels of dissolved oxygen than one would normally find in a river, causing a decline in water quality. When one observes a river over a short period of time, the river appears to be relatively constant and within the confines of the riverbed. This does not truly represent the life of a river as rivers have natural flooding cycles throughout the year as a result of precipitation and other climate factors. Rivers regularly flood the wetlands that surround them and reshape their borders through erosion and deposition of sediments. Often terrestrial ecosystems adjacent to riverbeds depend on these floods for nutrients and other functions. In some cases dams are removed specifically in the hope that it will improve the health of damaged floodplains or habitat adjacent to the river (Bednarek, 2001). Dams negatively impact organisms that migrate upstream for spawning or other purposes and more delicate species can be affected by the decline in water quality and changes in flow. Many studies have looked at specific fish species and their populations before and after dam removal as well as changes in overall species diversity and richness (Higgs, 2002).

While there are numerous studies that indicate that dam removal has many longstanding benefits, there are some short-term problems that need to be abated during the process of dam removal. Supersaturation, which occurs when rapidly moving water traps high levels of nitrogen, can kill aquatic organisms if the levels of the water behind the dam fall too quickly (Higgs, 2002). This process can be avoided by lowering the reservoir levels more slowly during removal. One of the more complex issues associated with dam removal is the issue of dealing with the quantity of sediments trapped behind the dam. Sudden release of the sediments can suffocate organisms and temporarily cause very high turbidity downstream (Higgs, 2002). A more dangerous and difficult to mitigate issue, however, is that the sediments from construction, waste, and industry, which had been trapped behind the dam for years, may contain heavy metals which could be very dangerous to aquatic organisms as well as ecosystem health downstream (Higgs, 2002). This could also be dangerous for anyone consuming fish from the James, as heavy metals bioaccumulate in larger fish.

We will address this issue of heavy metal contamination in our study. Heavy metal contamination in sediments behind dams has been found in Saudi Arabia (Ahmad et al, 2015), China (Zhao et al 2013), Turkey (Keskin 2012), and even Virginia (Odhiambo et al 2013). Before a dam can safely be removed the volume of sediment and the concentration of any contaminants in the sediment must be determined. This question is particularly interesting for the dams along the James River because little research has been done on the extent of sediment and contaminant trapping by small dams such as those in the Lynchburg area.

While there have been many studies conducted on dam removal in the past, many of them have looked specifically at the health of the organisms and biota affected by the removal of the dam and the increase in health of the ecosystem. Our study would analyze specifically the sediments, their potential toxicity, and the history of the area to make predictions and plans for actions to be taken before the removal of the dam.

Methods and Design



Figure 1 Location of the RockTenn dam. RockTenn is a paper company that no longer uses this dam.

Our study will begin focusing on the RockTenn dam near Concord Turnpike (Fig. 1). This dam is no longer in use and the James River Association has received provisional support for removing the dam. However, they must determine if the removal of the dam will release contaminated sediments downstream. To address this question, we will begin sampling near the RockTenn dam. Three sites upstream from the RockTenn dam and three downstream will be selected for sampling. The site will be mapped and transects will be established parallel to the dam at even intervals away from the dam. Five riverbed samples of equal volume will be taken at even points along each of the transects. We will also sample three transects on the other branch of the James River (across Percival's Island). At all sites, we will also locate the boundary of trapped sediment. This will likely be done by determining the depth of fine sediment (silt and mud). Mud layers are unusual in rivers because of the velocity of the water but are typical behind dams. Looking at the thickness of the mud layer will allow us to estimate the volume of sediment trapped by the dam. This overall sampling plan will allow us to examine the impact of the dam on heavy metal concentrations and sediment trapping. The sediments sampled will be analyzed for their heavy metal content on the flame atomic absorption spectrometer following a nitric acid digestion. This method requires

a specific lamp to analyze each heavy metal. Because of this, we are investigating previous industries in Lynchburg that produced heavy metals upstream from this point in the James River. This may require some assumptions and calculations about the movement of heavy metals and sediments through the environment. However, this preliminary research will give us an idea of what heavy metals to test for and allow us to make more accurate predictions about the depth of sediments with heavy metals. At a minimum, we will test for copper, lead and cadmium in all sediments. We will also analyze grain size and organic content for all sediments. If we find elevated levels of heavy metals, we will conduct desorption experiments to determine how much of this metal is likely to be released to the water of the James River. In these experiments, the sediment is shaken with water for a specified length of time then the metal concentration in the water is analyzed.

We will communicate with the James River Association throughout the course of the project and they have agreed to provide assistance in sampling (including boat use if necessary) and offering any needed information. The project will begin with the RockTenn dam but other dams which might be removed in the near future could be added to the project, materials and time permitting. We are confident that we will be able to characterize the RockTenn dam during the eight-week Summer Research Program. If we do not find elevated levels of heavy metals behind this dam, we should have time to investigate at least one more dam. The ultimate goal of the James River Association is removal of all of the dams along this section of the James River. We are beginning research on land use history around the dam this semester so that we will be ready to sample and analyze sediment once the Summer Research Program begins. While we hope that this research project will continue into the school year studying additional dams, we are not seeking a course release.

5. Dissemination goals

This project has the potential to result in a peer-reviewed publication and that is our ultimate goal. Journals such as Environmental Science and Technology or Environmental Monitoring and Assessment would be appropriate for this paper. In addition, we plan to present the results at the Geological Society of America annual meeting in Baltimore, MD in November, 2015. We will also participate in Marcus and the Randolph Symposium of Artists and Scholars. Finally, and perhaps most practically, we will share our results with the James River Association to guide decisions about dam removal along the James.

Past outcomes:

Sarah Sojka participated in the SRP in 2014 as a part of three projects. Two of these projects were presented at the American Geophysical Union fall meeting in December. Brianne Conrad and Ryan Mahon presented a poster on their research on sediment biofilms and Sarah Sojka presented a poster on rainwater quality research conducted with Dang Phung and Chris Hollingsworth. Hannah Edwards, the sole student on the third project, successfully completed her project and demonstrated the potential of native plants as phytoremediators.

External Funding: We are not currently seeking external funding.

Academic credit: none

Budgetary Needs

Sediment sampling equipment \$565

We will need equipment to safely sample river sediment for this project. Depending on water depth, we may be able to use a simple coring tube but deeper water will require more advanced equipment such as an Ekman grab (http://www.benmeadows.com/ekmanbottom-grab-samplingkit_s_223570/?searchterm=ekman%2bbottom#mainProductBottom).

Unfortunately, we are unable to adequately predict which sampling method we will need because it is highly dependent on the water level at the time of sampling.

Chemicals and sample containers \$250

We will need nitric acid for all of our digestions and may need additional material for standards. We will also need aluminum dishes to dry the sediment samples and containers such as whirl-pak bags to store the sediments until analysis.

Animal Research: none

Statement About Student Researchers:

Melissa Pasierb and Allison Brooks are both extraordinary students and the type of students who will embrace the summer research experience and really thrive in the SRP community. Both students are SUPER students and plan to major in environmental sciences. Each brings a different and vital set of skills to the project.

Melissa is a sophomore with strong experience in experimental design and sediment analysis techniques. She is also proficient in mapping, which will be crucial for this project. Melissa is incredibly conscientious. In my Environmental Research Methods class, Melissa was the only sophomore and she consistently submitted work that showed more thought and understanding than the juniors and seniors in the class. Her independent research project, looking at the impact of rainfall events on the quality of water in Blackwater Creek, was excellent. Unfortunately, Melissa is often less sure of her ability, which is one of the reasons why she is an excellent candidate for SRP. Melissa wrote the project description for this project with minimal editing by me (following an initial edit by Allison) showing initiative and a dedication to the project. Her commitment to the project is wonderful and I am really excited about the possibility of working with her this summer.

Allison is a first-year student who plans to spend four years at Randolph despite entering with many college credits. She has quickly made an impression on many of the faculty at Randolph. She is hard-working, friendly and very thoughtful. She began talking to me about the environmental impact of dams last semester and has already taken “ownership” of the project. Allison’s strong chemistry background will be a wonderful compliment to Melissa’s skills for this project. As a first year, Allison is already taking organic chemistry and her lab experience will be a great asset for this project. Allison is the type of student who excels at Randolph precisely because of opportunities like the Summer Research Program. Getting her involved in research this early in her career will be a huge benefit for Allison and Randolph.

Student Statements:

Allison Brooks

My name is Allison Brooks and I am currently a first year student. I am majoring in environmental science and chemistry and will perhaps add an economics minor in the near future. Upon completion at Randolph College I plan to continue on to graduate school for environmental chemistry or another environmental science specialty. During my junior year of high school I entered the dual enrollment program with Rochester Community and Technical College (RCTC). It was at this institution I realized my love of chemistry and environmental science and began to shape my future plans. In May 2014 at the age of 18 I graduated from RCTC with high honors and an Associate’s Degree in Liberal Arts and Sciences. At RCTC, I completed a variety of classes that gave me a strong environmental science and chemistry background, including Principles of Geoscience, Chemical Principles I and II, Concepts of Biology as well as Biomedical Ethics. I have completed a large variety of classes that had laboratory components at both the high school and college level and these laboratory class periods have really piqued an interest in research and lab work itself.

After RCTC I found Randolph College (Randolph) and I applied and was selected for the SUPER Program. Throughout the program I have learned about fantastic research opportunities with all of our advisors. I have discussed an interest in environmental research in the past with Dr. Sojka and last semester she approached me with this project. I have always been interested in water chemistry, heavy metal impacts and dam construction and removal, this project would really further my research experience as well as pursue these interests. I would really appreciate determining if contaminants are present and then developing a best course of action plan for the removal process. I hope to further my experience, and use this experience in my future endeavors as a Randolph College environmental science graduate.

Melissa Pasierb

My name is Melissa Pasierb and I am a second-year Environmental Science student at Randolph College. I am applying for a position in the Summer Research Program so that I can gain valuable research skills and because I have specific interest concerning local environmental issues and the research question posed in the proposal. My hope is that this research will be both informative and useful for future actions taken by the James River Association regarding dam removal.

I have numerous technical and laboratory qualifications towards student research; my skills include computer data analysis and mapping, sterile technique, micro pipetting, replica plating bacteria, agarose and polyacrylamide gel electrophoresis, preparing solutions and samples, DNA extraction, microscopes, and soil analysis. I also have working knowledge of wetland delineation, water quality parameter testing, and environmental sampling methodology.

I have formal schooling and laboratory experience in Environmental Science Methods, Chemistry, Geology, and Biology, with additional coursework in Quantitative Aspects of Global Environmental Problems, Environmental Policy, and Environmental Studies.

I am also currently engaged in semester research for credit working under Dr. Sojka.

One of the most relevant experiences that has prepared me to do research has been my semester project for my Environmental Methods class (fall semester 2014). I explored the impact of Lynchburg's combined sewer overflow system on local stream health by observing the water quality of Blackwater Creek, a James River tributary, before and after a rain event. My work for this project included measuring pH, dissolved oxygen, phosphate, nitrate, and analyzing Coliform bacteria levels in water samples. As a result of this research I am very comfortable using a light spectrometer, nutrient testing substances, and bacteria plating equipment. In addition, I am comfortable disseminating information and discussing my results with others. The most important thing that I gained from this experience, however, was the desire to be involved in more research projects. I valued the independence afforded to me in this project and that the project catered to my personal interests as a student. I found myself invested in the

outcome of the experiment in a new and exciting way and I have a similar enthusiasm regarding the research topic set out in this research proposal.

In light of all of my qualifications and coursework I believe I would make a good addition to the Summer Research Program this year. Thank you for considering my application.

Citations

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