Watershed Studies and Restoration

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Abstract

Students in a rural Illinois high school Earth and Space science class were challenged to consider how to better manage our land in central Illinois to positively impact water quality. The students learned about watersheds, their local Little Wabash River and how our land use choices affect all of the bodies of water it empties into. They mapped the watershed, determined its threats, and gained an understanding of the effects of different land uses on the Little Wabash and all the watersheds downstream to the Gulf of Mexico. Students collected and analyzed water quality samples. They also used online tools to determine how changing a specific land use practice could impact runoff, siltation, and nutrient pollution. Students proposed and implemented a tree planting project to reduce runoff from part of an agricultural field of a local landowner. Students prepared detailed reports and showed improvement from pretest to post-test about their knowledge of watersheds. Results from this project will be used with future classes as the tree planting matures.

Introduction

Water pollution is a global problem. Everyone has seen sad pictures of animals swimming around and ingesting plastics in the ocean, and many in coastal communities have been impacted by beach closures at various times. My students in central Illinois may have seen these things as well, but they don't feel personally connected to them. We live in the very center of the continent, far from the ocean. Some students live on or near a local lake, Lake Mattoon, and sometimes they will describe the water as polluted, or "gross," but when pressed to explain what that means, they do not have much knowledge about what could be polluting the lake. Students rarely consider the river that feeds the lake and drains our farmland and towns, the Little Wabash River. Water pollution is an everyone problem. We all produce sewage. We all eat the food and use the products produced by farming. We all want the rainwater to drain from our yards and properties as soon as possible, and not flood our homes. But we all also want clean water to drink. We want clean water for recreation.

And we don't often make any connection between our lifestyle and land use choices and the quality of our water.

Project Implementation

The challenge we attempted to address with a NOAA Planet Stewards grant was "How do our land use choices affect the Little Wabash River and all of the bodies of water it empties into, including its estuary, the Gulf of Mexico, and how can we better manage our land in central Illinois to positively impact water quality?" The impairments in the Little Wabash River can be attributed to grain and livestock farming, and sewage treatment by several small towns along its length. (Illinois Environmental Protection Agency, 2008) Siltation and excess nutrients are the primary concerns, and these are tied directly to stormwater runoff and the associated erosion of soil from agricultural lands. (NOAA, 2019) As the Little Wabash makes its way downstream into the Wabash River, the Ohio River, and the Mississippi River, these same pollutants continue, until they are released into the Gulf of Mexico, which develops a dead zone every year (NOAA, 2021). In 2019, NOAA predicted the yearly dead zone in the Gulf of Mexico to be one of the largest ever, due to excessive amounts of agricultural runoff associated with increased rainfall throughout the Mississippi watershed during the year. Spring is the most significant season for the increased nutrient load, and in 2019, the USGS was estimating that 156,000 metric tons of nitrate and 23,300 metric tons of phosphorous was being discharged into the Gulf in May alone (NOAA, 2019). Some of these nutrients are coming from the Little Wabash watershed and the farmland in our school district. On a small scale, this project showed students in the Neoga Community School District and their families and community that land use changes can have an impact not just on local water quality, but on global water quality because of the effect in the Gulf of Mexico. This project involved installing a riparian forest area on the edge of an agricultural field currently experiencing significant erosion.

Figure 1. Runoff from site of riparian restoration before tree planting. Photo credit: Amy Brown

This erosion is the result of stormwater runoff, which also carries agricultural chemicals into the adjacent creek. The goal of the tree planting was to reduce erosion and runoff from the agricultural field, and improve the quality of the stream) therefore improving the quality of all downstream waters in the process.

Figure 2. Creek on restoration site showing silt runoff. Photo credit: Amy Brown

Riparian restorations are valuable tools in maintaining or improving water quality, with the added benefit of removing carbon dioxide from the atmosphere. (Climate Literacy and Energy Awareness Network, 2016)

Students in Earth and Space science class were challenged to first learn about watersheds, in general. We spent time identifying our watershed, the Little Wabash River. Students researched information about the watershed and impairments to it, and drew detailed maps of the area. We learned about pervious and impervious surfaces, and the impact those might have on runoff and infiltration. We mapped our school property, and identified areas of runoff from the property, as well as where it leaves the property. We also mapped the site about 10 miles from school, where a landowner had asked to have a riparian forest planted.

Table 1. Water quality results from Wikiwatershed analysis

	Load, agricultural use (kg)	Load, forest cover (kg)	Average concentration, agricultural use (mg/l)	Average concentration, forest cover (mg/l)
Total suspended solids	42.215	4.098	203.3	42.4
Total Nitrogen	1.505	0.096	7.2	1.0
Total Phosphorus	0.209	0.012	1.0	0.1

Table 2. Runoff results from Wikiwatershed analysis

	Depth, agricultural use (cm)	Depth, forest cover (cm)	Volume, agricultural use (m^3)	Volume, forest cover (m^3)
Runoff	4.355	2.029	207.67	96.76
Evapotranspiration	0.605	0.526	28.83	25.07
Infiltration	3.04	5.445	144.95	259.62

Students used tools on Wikiwatershed Model my Watershed (Stroud Water Research Center, 2022) to calculate runoff, infiltration and nutrient loss from the approximately 2-acre site, and then used the tool to change the land use on the site, and compare the differences in all parameters before and after the tree planting. Results from this analysis are displayed in Tables 1 and 2. Load and concentration data refer to the amounts of those contaminants expected to be in the runoff as simulated in the Wikiwatershed tool. (Stroud Water Research Center, 2022) Runoff was simulated based on an 8cm precipitation event. The depth measurements show how much of the 8cm runs off, infiltrates, or gets processed by the plants to eventually evapotranspirate. The volume data refers to total volume of water for each outcome. This simulation showed a significant reduction in runoff and pollutants between the current agricultural land practice and forest land use.

Figure 3. (top left) Students planting trees on the pull behind tree planter. Photo credit: Amy Brown

Figure 4. (top right) Students sort and prepare trees for planting. Photo credit: Amy Brown

Figure 5. (left) Students and volunteers measure and plant tree seedlings. Photo credit: Amy Brown

Figure 6. (right) Student using a dibble bar. Photo credit: Amy Brown

On a cool spring day in March, 2021, a group of intrepid students and volunteers planted approximately 1800 trees and shrubs on the restoration site. We used dibble bars (hand-held tree spades) and a pull-behind tree planter. Conditions were very muddy, which made tree planting easier, but walking and carrying muddy equipment harder.

We also collected water quality samples from the creek on the tree planting site and another site further downstream.

These were analyzed for typical freshwater quality parameters, including dissolved oxygen, ammonia, nitrites, pH, carbon dioxide, chloride, hardness, and alkalinity.

Results from the analysis of these water samples is shown in Table 3. Future classes will use these results to compare future water quality as the trees in the planting mature.

Figure 7. Student collecting water quality samples in the creek below the field.

Photo credit: Amy Brown

Figure 8. Student conducting water quality analysis.

Photo credit: Amy Brown

Students were given a pretest before beginning the activities in the unit, and after completing the unit to find out their knowledge about watersheds, both in general as well as about their own specific watershed and its impairments. Students showed a 49.7% increase in scores after completing the unit, reflecting the learning about watersheds as a result of the lessons. Students also prepared detailed reports of the results of our watershed study. These reports included recommendations for further land use changes that could improve water quality, both in the Little Wabash River and in the Gulf of Mexico. Some of these recommendations included more riparian tree planting restorations, installing saturated buffer strips along agricultural fields, and bioreactors to absorb excess nitrogen and phosphorus from field runoff.

Table 3. Water quality test results

Test name	Clear creek downstream 10/20/2020	Emmerich Farm tree planting site 10/23/2020
Alkalinity (ppm $CaCo_3$)	200	200
Ammonia nitrogen (ppm NH_3)	1.8	2.4
Carbon dioxide (ppm)	26	17
Chloride (ppm)	0.10	0.3
Dissolved oxygen (ppm)	10	3.5
Hardness (ppm $CaCo_3$)	320	300
Nitrite nitrogen (ppm NO_2-)	0.06	0.1
pH	7.5	8.0
Turbidity (NTU)	120	120

Conclusion

Real world problems provide actionable phenomena for students to engage with science. This project introduced students to their local watershed and concerns with its quality. Students quantified the water quality concerns, and learned about methods to improve some of the land management practices causing pollution issues. Students then proposed and carried out a tree planting project on former agricultural row crop acreage. Students produced positive quantitative and qualitative results, and were able to articulate how the land use changes would positively impact not just their own watershed, but all those down-stream, as well. Students showed learning improvement through pre and post-test scores, as well as comprehensive lab reports that included detailed background information about the watershed, its impairments, and the improvements in water quality the land use changes would provide.

References

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About the Author

Amy Brown is a high school biology and earth science teacher at Neoga Jr/Sr High School, in Neoga, IL. She has taught junior high and high school there since 2004. Amy earned her Bachelor of Science degree in Zoology (Wildlife Biology) from Southern Illinois University at Carbondale, and worked for the Illinois EPA for a few years in the early 1990's. She then spent a few years as an independent contractor contacting riparian landowners along the Embarrass, Salt Fork and Spoon Rivers in Illinois to promote healthy riparian management. Amy received her teacher certification through Eastern Illinois University, and later completed a Master of Science program at the same institution. For the past few years, Amy has also been part of a team working on writing NGSS storyline units with Dr. Barabara Hug of the University of Illinois at Urbana/Champaign College of Education. Amy is very interested in ecology and conservation, and has always strived to bring real world issues into her classroom. She can be reached at abrown@neogacusd3.net.