A longitudinal study utilizing citizen science to assess the presence of atrazine within the Mississippi River watershed.

Monica Blaser, Krystal Herrmann, Dr. Alan Kolok

Nebraska Watershed Network, Department of Biology, University of Nebraska at Omaha, Omaha, NE 68182

Introduction

Atrazine, a commonly used herbicide on corn and soy bean crops in the Midwest, can easily migrate to surface waters from agricultural fields. This occurs mostly due to the timing of application of the herbicide. Atrazine is typically applied during the early to mid portions of the growing season which coincides with late spring when rainstorms are a general occurrence (Ali and Kolok 2015; Kolok et al. 2014; Lerch et al. 2011a). The greatest concerns associated with atrazine run-off are the potential threats to human health and the environment. Previous studies suggest that atrazine is an endocrine disruptor meaning it has the ability to interfere with the natural hormonal system (Hayes et al., 2011). Scientists have recorded adverse affects on the reproductive systems of aquatic wildlife in the presence of atrazine. Specifically, accounts of feminization and defeminization have been documented in fathead minnows and Northern leopard frogs, respectively, who reside in waterways contaminated with atrazine (Hayes et al., 2002; Hayes et al., 2006).

Research projects that encompass a large geographic scale, watersheds being a prime example, can present a research with obstacles as they relate to data collection. Thus, a project of this proportion substantial benefits from the participation of citizen scientists. However, the use of citizen scientists has not been a widely accepted practice within the scientific community, largely due to concerns of reliability in measurement. As the US Environmental Protection Agency (USEPA) has verified the accuracy of many of the commercial available rapid assessment water quality tools, the concerns of reliability then fall upon common perceptions and perhaps biases against citizen scientists. With adequate training and support citizen scientists can provide valid and defensible data comparable to experienced scientists (Ali et al., 2016)

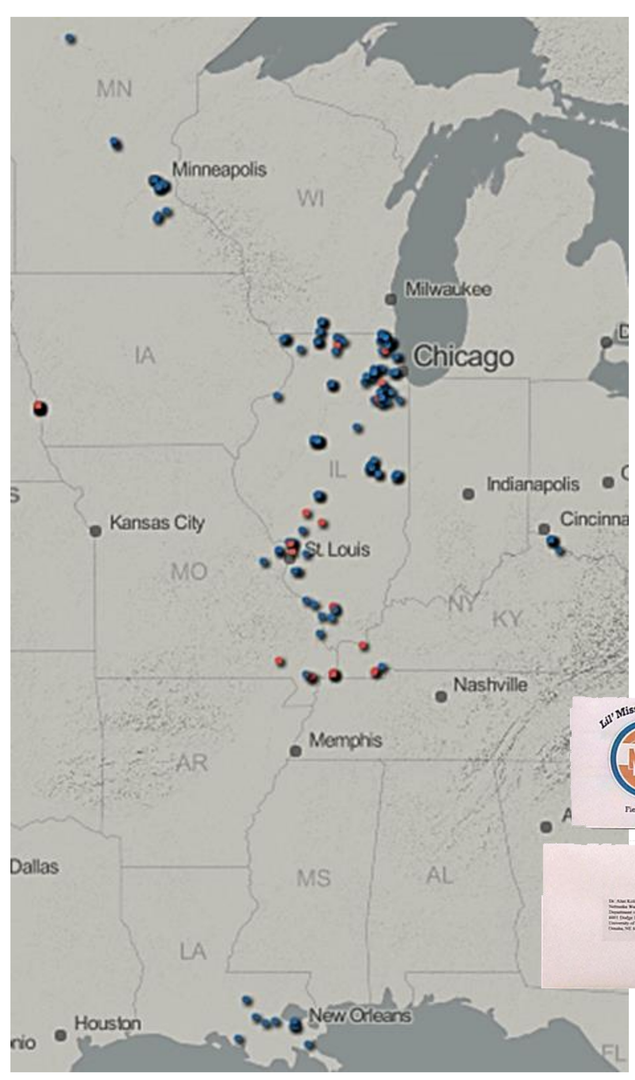
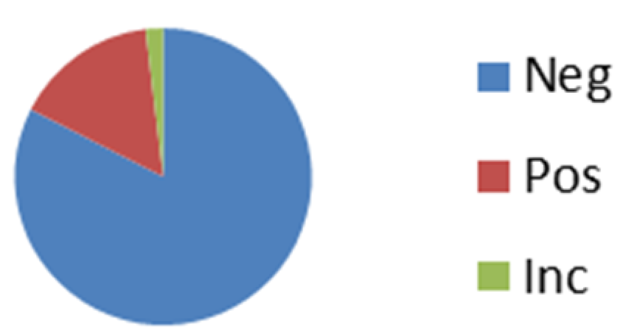
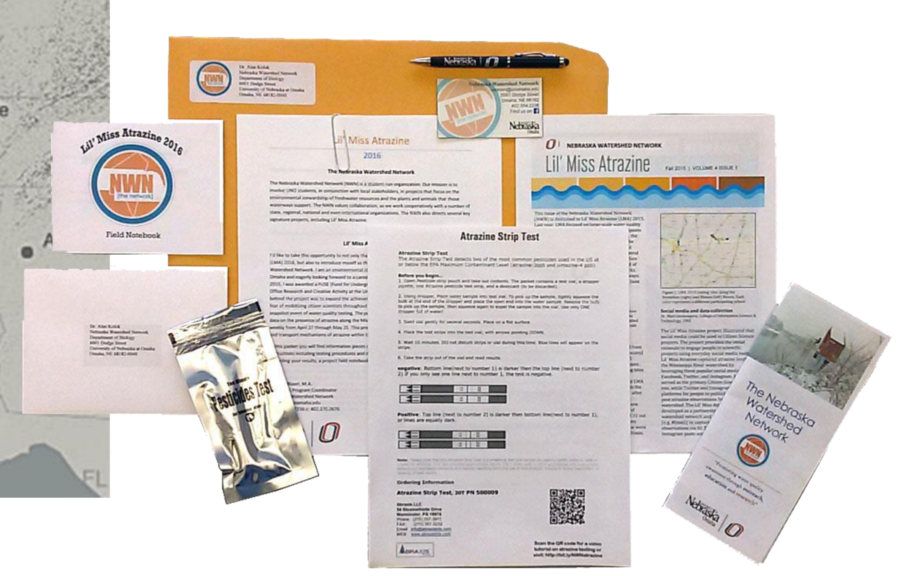


Figure 1a. Results from *Lil' Miss Atrazine 2014*. Negative responses are in blue, positive in red.

Figure 1b. Percentage breakdown of the results of LMA 2014.





Lil' Miss Atrazine 2014

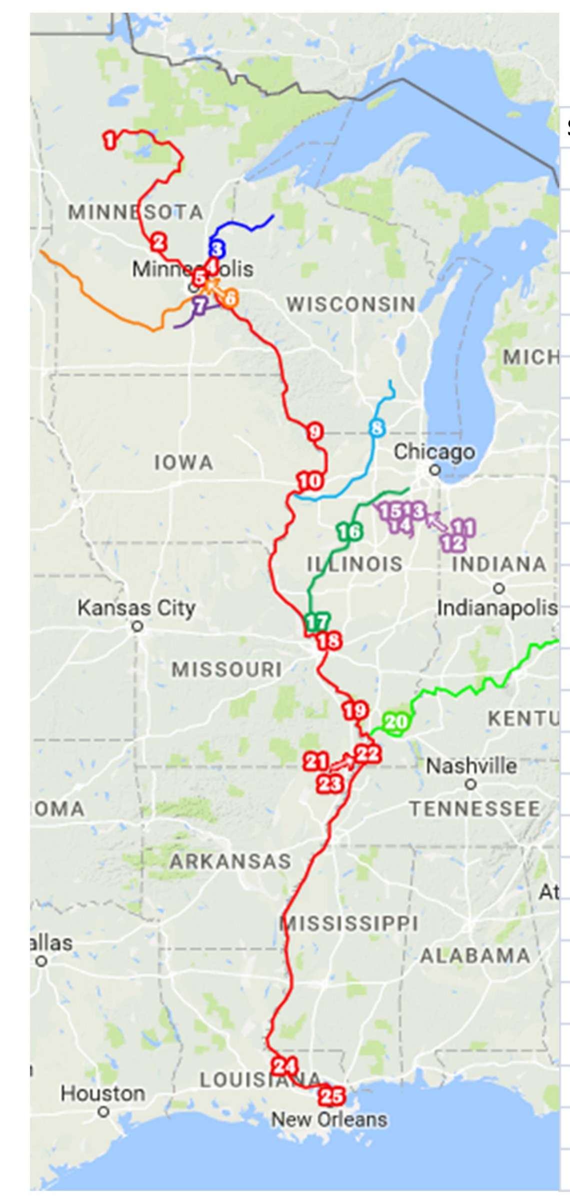
In 2014, Roni McClellen conducted a feasibility test of crowd sourcing scientific data utilizing citizen scientists to test for atrazine in the Mississippi River watershed. The project became known as Lil' Miss Atrazine (now known by the Nebraska Watershed Network as the Mississippi River Project 2014) and it sought to determine if citizen scientists could collect valuable scientific data on a large geographic scale. The project capitalized on a large number of citizen scientists collecting atrazine data in their local watersheds for one day, June 7, 2014. During Lil' Miss Atrazine 2014, data was collected for a 24-hour period encapsulating a snapshot or an abridged version of events occurring within the watershed. While the results of Lil' Miss Atrazine showed collecting data on atrazine within the watershed utilizing citizen scientists was a feasible collection method, more importantly the study revealed a majority of atrazine-positive data points were collected around the St. Louis area within the study's 24-hours. By the end of the 24-hour test period, more than 200 useable data points were compiled from 7 states. The results were generally negative, with the majority of data points coming from Illinois.

Lil' Miss Atrazine 2016

The 2016 project, expanded on the one-day snapshot model with an overall goal of seeing if the atrazine-positive results collected in the 2014 iteration of Lil' Miss Atrazine were constantly positive for the presence of atrazine over time. Eighteen trained volunteer citizen scientists from six states monitored 25 sites along the Mississippi River and six of its direct tributaries weekly from April 24 to May 28, 2016. Volunteers were provided with Abraxis testing strips. The test strips are a first-tier screening step in which the data provided by the strips indicates levels of atrazine equal to or greater than the U.S. EPA Maximum Contaminant Level of three parts per billion (ppb). These testing strips are lateral flow assays that use antibodies to detect atrazine at the given level making their use uncomplicated, requiring no need for costly of specialized equipment.

Results

From the study, we found 26.4% of the tests indicated a positive result for the presence of atrazine at the U.S. EPA drinking water standard of three parts per billion or greater, while 73.6% of tests results were negative. Just as in the one-day water quality event in 2014, this project also saw an increased incident of positive atrazine test results in the middle region along the Mississippi River around the St. Louis area with 68.2% of the positive test results being from this region. We were able to conclude that the atrazine-positive test results in the previous study in 2014 do not remain constant in any given location over time. Thus, the presence of atrazine within the Mississippi changes over time within the planting/growing season (between April 24 and May 28, 2016).



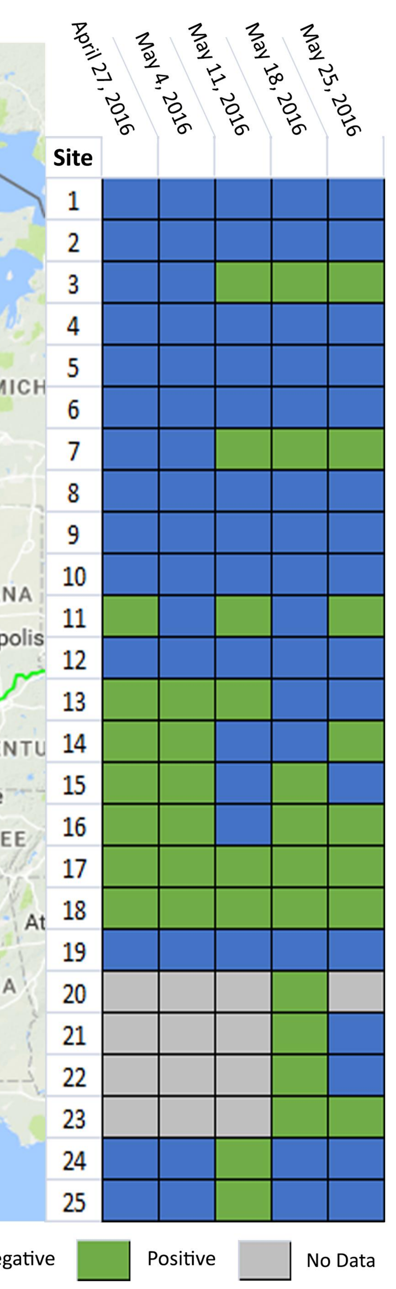


Figure 2a. Map of testing sites from LMA 2016. The colors represent the different watersheds that were part of the study.

Figure 2b. Visual breakdown of the results of LMA 2016. Negative responses are in blue, positive in green

Conclusion and Future Directions

This project provides evidence that atrazine presence within the Mississippi River Watershed fluctuates over time throughout the planting and/or growing seasons. This could imply that atrazine is introduced in spike events instead of constant flow. It is highly plausible that precipitation events within the growing season at key application times is the main driver behind the changes in the presence of atrazine and accounts for the lack of continual hotspots. Future research should include the collection of additional data points pertaining to rainfall dates and quantity, and if possible, estimated atrazine application amounts.

References

Ali, J., & Kolok, A.S. (2015). On-site, serial exposure of female fathead minnows to the Elkhorn River, Nebraska, USA, spring agrichemical pulse. *Environmental Toxicology and Chemistry, 34*(6), 1354-1361.

Ali, J.M., Herrmann, K., Rakestraw , M., & Kolok, A.S. (2016). Citizen-based scientific data collection: Fact or fiction? Learned Discourse: *Integrated Environmental Assessment and Management, 12*(2), 400-402.

Hayes, T.B., Anderson, L., Beasley, V., de Solla, S., Iguchi, T., Ingraham, H., …& Willingham, E. (2011). Demasculinization and feminization of male gonads by atrazine: Consistent effects across vertebrate classes. *Journal of Steroid Biochemistry and Molecular Biology, 127*(1), 64-73.

Hayes, T.B., Case, P., Chui, S., Chung, D., Haeffele, C., Haston, K., ... & Tsui, M. (2006). Pesticide mixtures, endocrine disruption, and amphibian declines: Are we underestimating the impact?. *Environmental Health Perspectives, 114*, 40.

Hayes, T.B., Collins, A., Lee, M., Mendoza, M., Noriega, N., Stuart, A.A., & Vonk, A. (2002). Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. *Proceedings of the National Academy of Sciences, 99*(8), 5476-5480.

Kolok, A.S., Sellin Jeffries, M.K., Knight, L.A., Snow, D.D., & Bartelt-Hunt S. (2014). The hourglass: A conceptual framework for the transport of biologically active compounds from agricultural landscapes. *Journal of the American Water Resources Association, 50*(2), 266-274.

Lerch, R.N., Sadler, E.J., Sudduth, K.A., Baffaut, C., & Kitchen, N.R. (2011a). Herbicide Transport in Goodwater Creek Experimental Watershed: I. Long-Term Research on Atrazine. *Journal of the American Water Resources Association, 47*(2), 209-223.

University of Nebraska Omaha