Assessment of atmospheric deposition of nutrients in Minnesota

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1. Goals and Objectives

The primary goal of this research to monitor atmospheric deposition of nutrients in selected sites. Over the last few years many of the studies being conducted to evaluate crop response to added N fertilizer are showing a decrease in the amount of N required to reach the economic optimum nitrogen rate, in certain parts of the state. One possible explanation is that more N is coming down with rainwater and snow during the winter and being stored in the soil. During the growing season, the plant can then utilize this N in addition to any other N that was applied in the fertilizer form. It is therefore, important to assess the distribution of N being deposited from atmospheric rain and snow fall throughout the state so that better N management practices can developed and implemented.

The main objective of this study is to: i) monitor atmospheric deposition of nutrients in five of the University of Minnesota Research and Outreach Centers.

2. Results

We have installed rainwater/snow collection stations at five of the University of Minnesota Research and Outreach Centers in Crookston (NWROC), Cloquet forest center (CFC), Becker, Lamberton (SWROC), and Waseca (SROC). Water sampling started in the Spring between April and May and was collected continuously until the end of March 2021. Water pH, nitrate-N, ammonium-N, and nutrient concentration (including K, Ca, Mg, and Al) analysis was done in all of the samples from events which had enough water to be collected. However, events with less than 0.1" were not sampled because of the low amount of water collected in the gauge meter. Rain and snow melt pH were the extremely alkaline, unlike pristine rainfall which has a pH of 5.5. Becker had the lowest rainwater and snow melt pH ranging between 5.5 and 7.7 in the 2020 season, very similar to what was observed in 2019 (pH range 5.3 and 7.2). At Crookston rainwater and snow melt pH in the 2020 season ranged between 5.6 and 8.0, also very similar to values observed in 2019 (pH range 5.0 to 8.0). At Lamberton rainwater and snow melt pH in the 2020 season ranged between (6.3 and 8.9), values slightly higher than what was observed in the 2019 season (pH range 5.5 and 8.5). At Waseca rainwater and snow melt pH in the 2020 season ranged between 5.9 and 8.2, values within the range of what was observed in 2019 (pH range 5.5 and 8.5). At the CFC rainwater and snow melt pH in the 2020 season ranged between 5.0 and 8.5; there is no previous year data for this location since this is the first year the study is being conducted at the CFC.

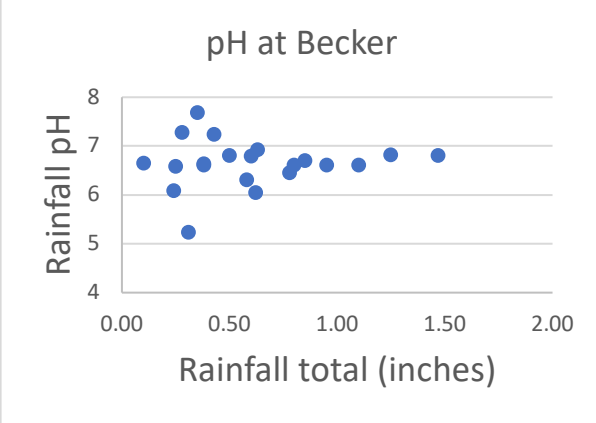
The results from the first season showed a significant variation in the concentration of N in the rainwater and snow. We found that ammonium-N concentration ranged from 0.01 ppm

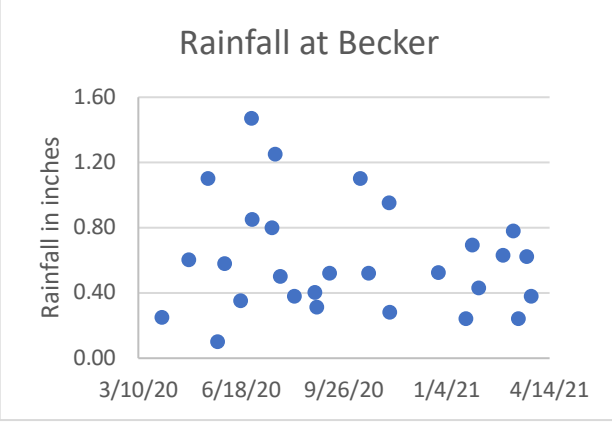
and was as high as 16.6 ppm in one particular event, and nitrate-N concentration ranged from 0.01 ppm to 1.4 throughout the state. However, most of the time the ammonium-N and nitrate-N concentrations were below 6 and 1 ppm, for ammonium-N and nitrate-N, respectively. The total amount of ammonium-N measured between April 2019 to March 2020 was 4.7, 1.4, 7.1, 9.7, and 10.1 lb ac^{-1} at Becker, CFC, SROC, SWROC, and NWROC respectively. The total amount of nitrate-N was much less and was about 1 lb ac^{-1} at all locations. Total N measured at all locations was 8.2, 8.0, 8.5, 22.1, 25.4 lb ac^{-1} at Becker, CFC, SROC, SWROC, and NWROC, respectively.

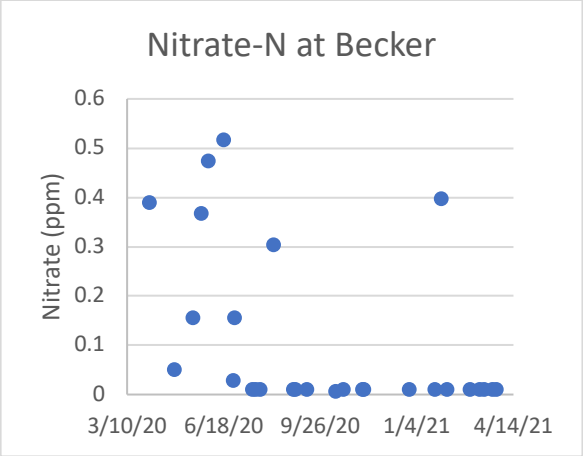
Ammonium-N and nitrate-N seasonal behavior were specific to each nutrient. Ammonium-N concentrations tended to be highest in the winter and early spring. In contrast, nitrate-N concentrations tended to be higher in the late spring and early summer.

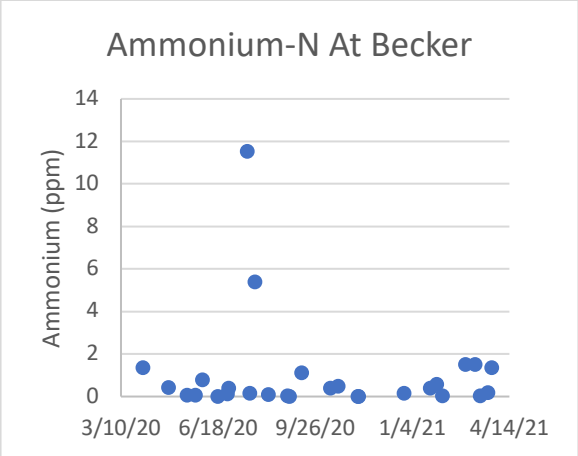
Becker

Rainfall total reported at Becker was 17" from April 2020 to March 2021. Rainfall water pH has been found to be highly variable and on rainfall below 0.5", the pH fluctuated between 5.2 and 7.7. Whereas in events with more than 0.5" of rainfall the pH tends to be below 6.0, or more alkaline. The amount of rainfall in each event was evenly distributed throughout the year with very few events greater than 1". Nitrate-N concentration in the rainwater was very low and ranged between 0.01 ppm to 0.51 ppm. Ammonium-N was more concentrated and ranged between 0.02 to 11.5 ppm. There was no relationship between N concentration in the water and amount of precipitation.



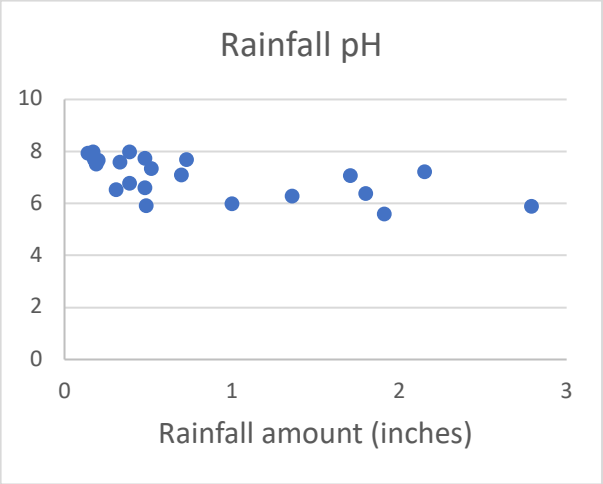


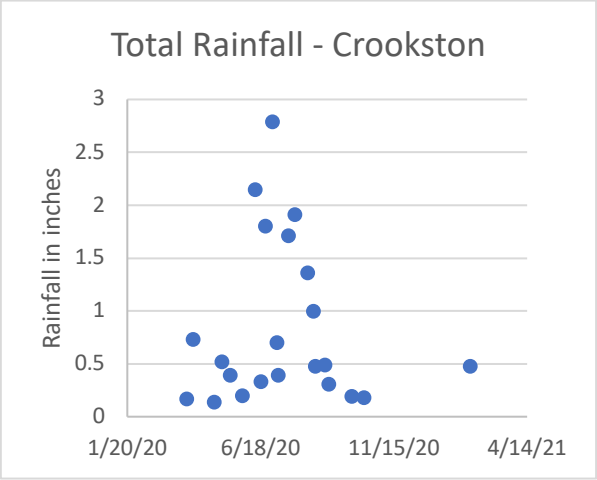


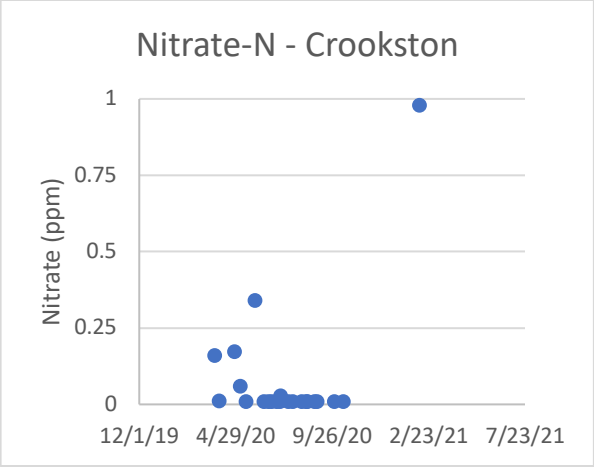


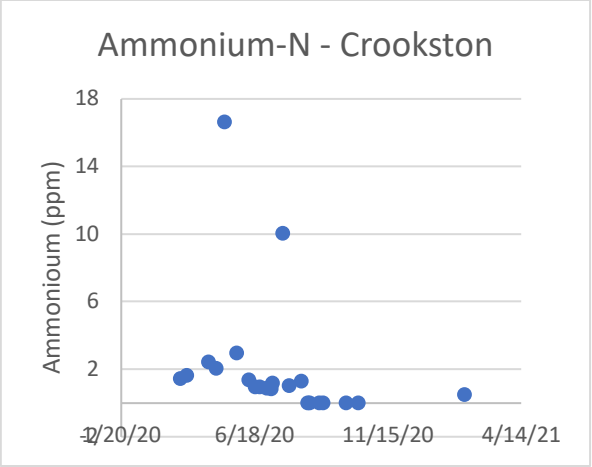
Crookston

Rainfall total reported at Crookston was 18" from April 2020 to March 2021. Rainfall water pH was highly variable; however, the pH was higher than what was observed at Becker. At Crookston rainwater pH was always above 6.0 (ranging between 6.0 and 8.0) in all events except one. The amount of rainfall in each event was evenly distributed throughout the year with very several events higher than 1", 2.7" being the highest. The majority ranged between 0.1 and 1". Nitrate-N concentration in the rainwater was very low and ranged between 0.01 ppm to 0.95 ppm. Ammonium-N had higher concentrations than nitrate-N and ranged between 0.06 and 16.6 ppm (very likely that the 16.6 ppm value is an outlier). Ammonium-N concentration tended to be higher in rainfall events that were below 1".



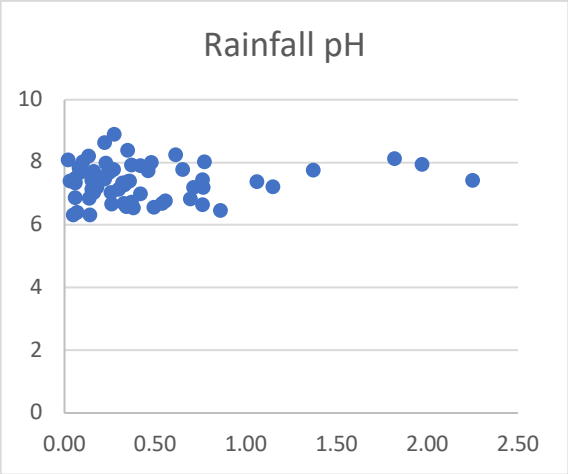


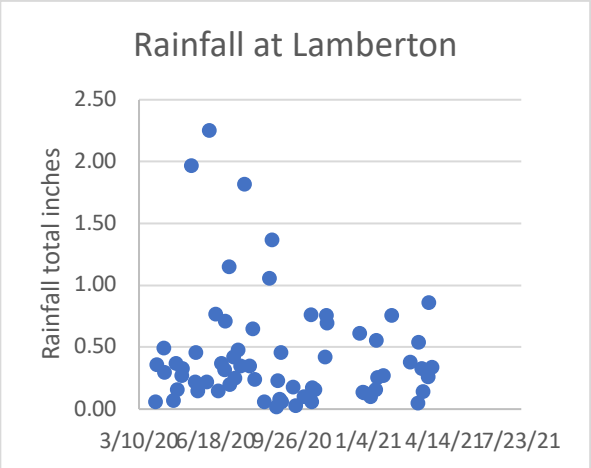


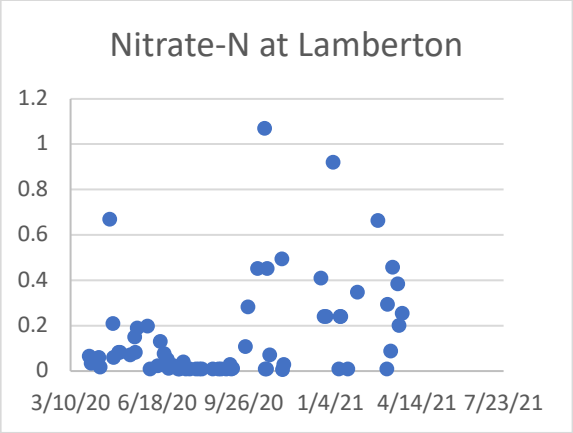


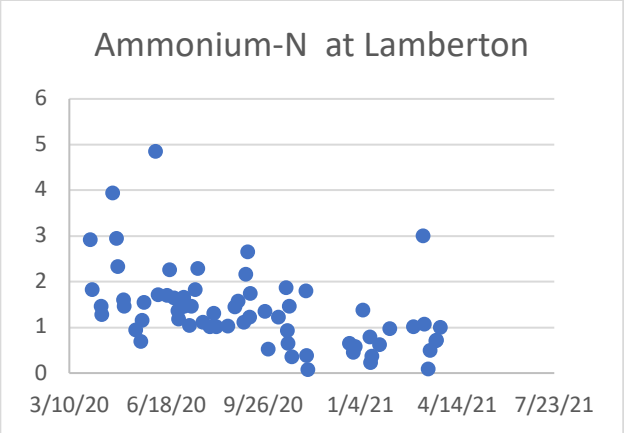
Lamberton

Rainfall total reported at Lamberton was 28.6" from April 2020 to March 2021. Rainfall water pH was also highly variable. At Lamberton rainwater pH was never below 6.0 (ranging between 6.3 and 8.9) regardless of rainfall amount. The amount of rainfall in each event was evenly distributed throughout the year with very several events higher than 1", 2.5" being the highest. Nitrate-N concentration in the rainwater was very low and ranged between 0.01 ppm to 1.1 ppm. Ammonium-N had higher concentrations than nitrate-N and ranged between 0.03 and 4.9 ppm.



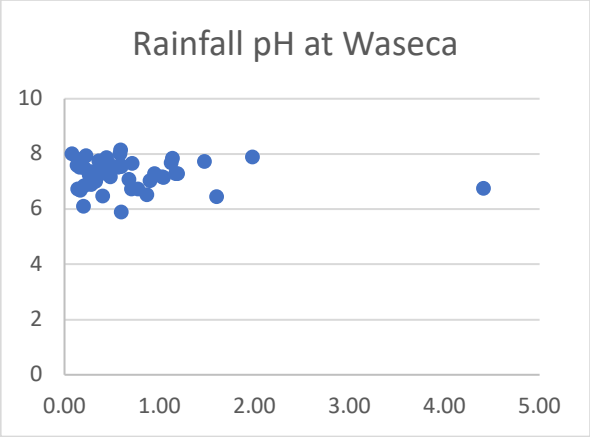


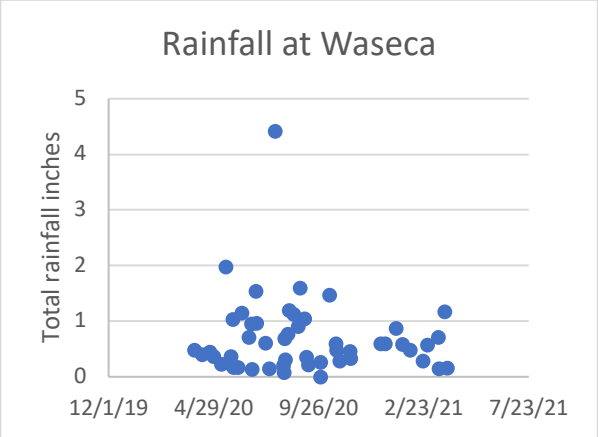


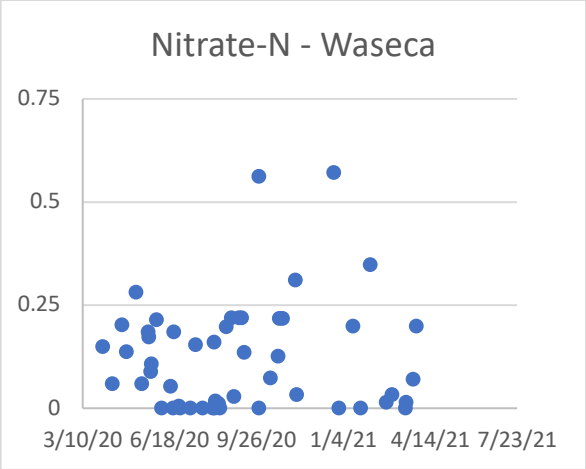


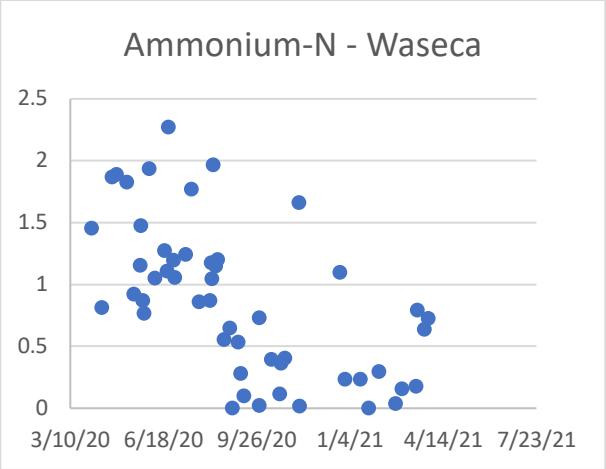
Waseca

Rainfall total reported at Waseca was 31.9" from April 2020 to March 2021. Rainfall water pH was also highly variable. At Waseca rainwater pH was mostly above 6.0 (ranging between 5.9 and 8.2). The amount of rainfall in each event was evenly distributed throughout the year with several events higher than 1", 4.4" being the highest. Nitrate-N concentration in the rainwater was very low and ranged between 0.01 ppm to 0.57 ppm. Ammonium-N had higher concentrations than nitrate-N and ranged between 0.05 and 2.27 ppm. Ammonium-N concentration tended to be higher in the summer and during rainfall events that were below 1.0".



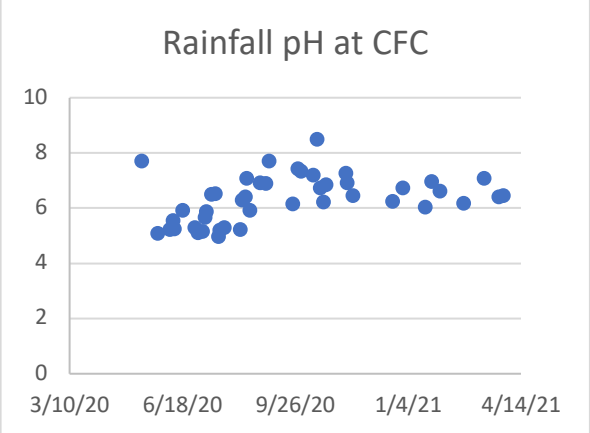


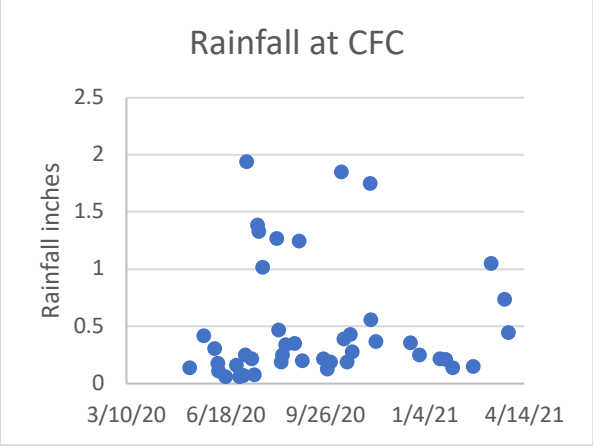


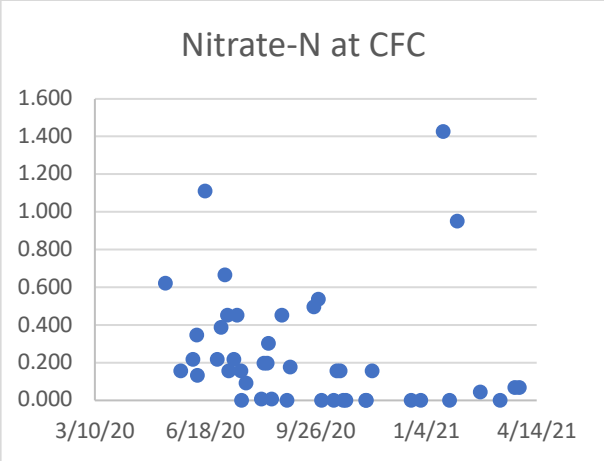


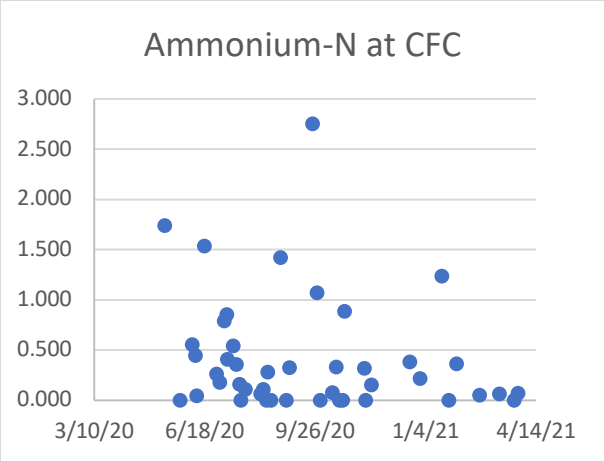
CFC

Total rainfall total reported at the CFC was 21.9" from April 2020 to March 2021. Rainfall water pH was as similar to the other locations and ranged between 5.0 and 8.5. The amount of rainfall in each event was evenly distributed throughout the year with several events higher than 1", 1.94" being the highest. Nitrate-N concentration in the rainwater was very low and ranged between 0.01 ppm to 1.43 ppm. Ammonium-N had higher concentrations than nitrate-N and ranged between 0.05 and 2.75 ppm.









Alkali and Alkali earth metals

In the samples collected from April 2020 and March 2021 were also used to measure the concentrations of Al, Ba, Ca, K, Mg, and Sr. Table 1 shows the total amount of those nutrients being deposited during the season. There were low amounts of Al, Ba and Sr being deposited, while there were slightly higher levels of Ca, K, and Mg compared with Al, Ba, and Sr. However, the amount of alkali and alkali earth metals being deposited was variable throughout the study as can be seen by the variation among the locations used in the study. The presence of these metals could help explain the high pH of rainfall water and melted snow. More data is needed to help link any potential relationship between pH and the present of these metals in the rain and snow samples.

Summary

The results of this research showed that the amount of nutrient in rainfall changes not only throughout the season but also by the amount of water in each precipitation event. Although the total amount of N we observed in the first year of the study were not as high as expected, they were still higher than what is reported by other national programs. Most interestingly was the water pH and how much it differs from what NOAA reports for the state. We were at least one unit higher than what is reported. The reason for this discrepancy is not known yet and warrant further investigations. The presence of high levels of Ca and K could be the reason for the high pH observed in the study. This is the first year that alkali and alkali earth metals have been measured in the study. It will be important to continue monitoring the concentration of those elements in rainfall and snow samples in the future years the study is conducted.

The PI and Co-Pis would like to thank the MDA-AFREC for providing the funding used to generate the data for this research.

Table 1. Summary of nutrient load in rainfall and snow during the 2020/2021 season.

Location	TP	NO^{3-}	NH_4^+	TN	Al	Ba	Ca	K	Mg	Sr	Rain total 2020	Snow total
						lbs ac^{-1}					inches	
CFC	---	0.7	1.4	---	0.7	0.01	3.39	18	0.7	0.01	22	52
SROC	0.27	0.8	7.1	8.5	1.2	0.10	11.9	19	2.9	0.04	32	49
SWROC	0.31	0.8	9	22.1	0.8	0.06	19.2	4	3.4	0.03	29	40
NWROC	0.08	0.2	10	25.4	0.5	0.03	6.8	4	4.8	0.03	18	18
Becker	0.05	0.4	5	8.2	---	---	---	---	---	---	17	15

--- These samples were not analyzed because there was not enough sample collected for the additional tests needed to determine the missing nutrient loads.