Effects of Deicing Agents on Stream Water Chemistry

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GEOL 394

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April 25th, 2017

1 Abstract

Deicing agents, which are used to improve driving conditions during winter storms, can have significant effects on the environment. The use of deicers has increased over time, which has led to increased changes in soil and freshwater chemistry. Rock salt and other deicers have been found to cause chemical changes in freshwater systems, including increased chloride concentrations and potential mobilization of carbon, nutrients, and base cations. Most research on deicers has centered on rock salt, and alternative deicers such as other salts and organic deicers have been studied to a lesser degree. The goal of this study is to investigate how different deicing agents interact with stream water and sediment, and how these deicers impact water chemistry. Three deicers were tested; two lab grade salts and one commercially used organic deicer. The two salts that were tested were sodium chloride and calcium chloride dihydrate, which differ in their potential for attraction to negatively charged soil particles. The organic deicer being used is a beet juice deicer, which is created from the brine of de-sugared sugar beets. In order to evaluate the effects of salinization on water quality, carbon, nutrients, and base cations were measured in laboratory experiments involving 24-hour incubations of sediment, stream water, and a deicer. Ash free dry mass was also be measured to obtain the organic content of the sediment after the incubations because the organic content may influence the potential release of carbon, nutrients, and base cations from sediments to stream water. The incubations were performed on sediment and stream water collected from two sites near Baltimore, MD. Each deicer was tested on samples from both sites, and the deicers were tested at six different concentration levels to study the effects that may be caused at different concentrations. Concentrations of H^+, total nitrogen, and dissolved organic carbon all increased as the concentration of deicer increased, while dissolved inorganic carbon concentrations decreased. Despite a significant potential for error in the base cation data, the data shows sharp peaks as deicer concentration increases, which may indicate precipitation at these levels.

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2 Introduction

During winter months, deicing agents are often applied to roadways around the world to melt snow and ice to improve driving conditions. Rock salt, or sodium chloride, is the primary deicing agent that is used on roads. The rock salt used on roads is often not pure NaCl though, and contains other substances like anti-caking agents. Alternative deicing substances are used because of their ability to melt ice at lower temperatures (Fay and Shi, 2012), but come at higher costs (Adirondack Watershed Institute, 2010). Common deicing alternatives include calcium chloride, magnesium chloride, calcium magnesium acetate, and organic deicers such as beet juice and corn molasses (MNDOT, 2012).

Salt was first used to deice roadways in the 1940's (Howard, 2014) and quantity of salt used as a deicing agent has been increasing since salt was first used (Findlay and Kelly, 2011; Kim and Koretsky, 2012). In a report from the U.S. Geological Survey, Kelly and Matos (2016) found that salt used for deicing more than doubled in a period of 27 years, from 8 million tons of salt used in 1975, to 18.5 million tons used in 2003. During and after application, the road salt can enter the nearby soil and waterways. Up to 90% of the road salt that is applied to the roadway can be carried into the roadside environment though runoff and splash or aerosol deposition (Green *et. al.*, 2008). Road salt dissolves in soils and water, which leads to increases in salinity. The salinity, or chloride concentration, of freshwater systems has been increasing over time in both the United States and worldwide (Corsi, 2010; Kaushal *et. al.*, 2005; Kaushal, 2016). Figure 1, taken from Kaushal (2016) shows worldwide increases in salinity in freshwater systems. Chloride concentrations also increase seasonally, with increased salinity levels seen in the winter and spring due to salt usage to clear snow and ice from roadways.

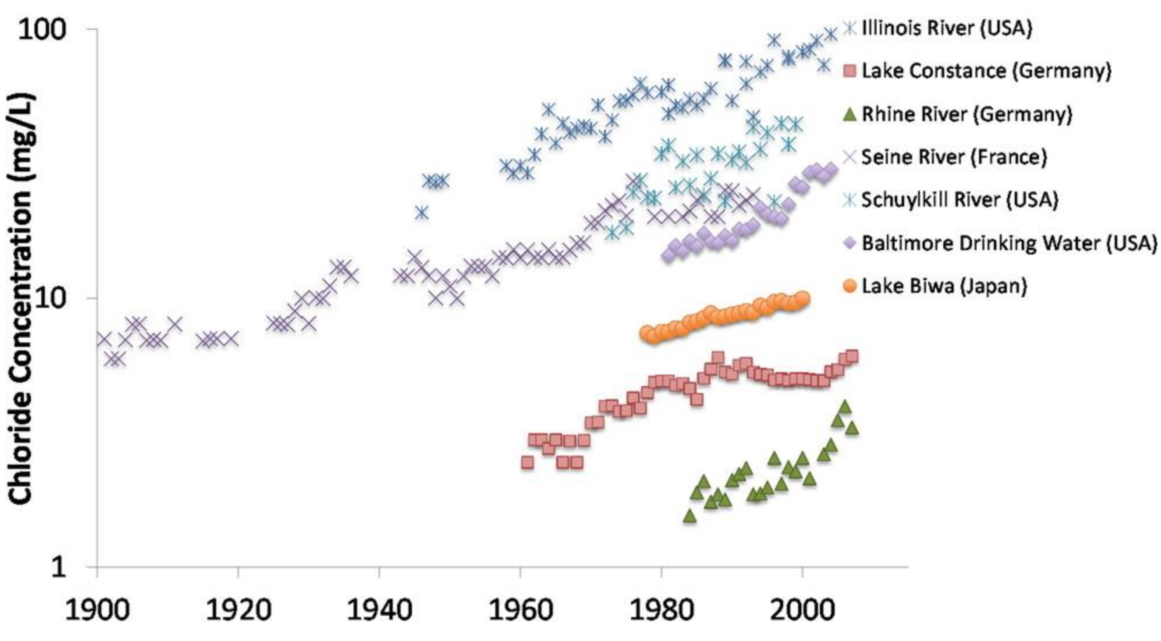


Figure 1. Chloride concentrations in freshwater systems worldwide have been increasing over time (Kaushal, 2016).

Increases in salinity induced by road salt can lead to changes in water and soil chemistry and changes in local ecology.

Deicing agents can impact freshwater systems when the deicers are transported into the environment. Increases in salinization, changes in carbon, nitrogen, and phosphorus cycles and mobility, and the mobilization of trace metals have been reported due to addition of deicers. Salinization increases due to the introduction of deicers have been found in many types of freshwater systems. Increasing salinization trends over time have been found in streams and rivers (Corsi *et. al.*, 2010; Corsi *et. al.*, 2015; Duan and Kaushal, 2015; Kaushal *et. al.*, 2005) and shallow aquifers and groundwater (Kelley, 2008; Williams *et. al.*, 1999). Deicers have been found to change concentrations and mobilization of bioreactive elements (such as carbon, nitrogen, and phosphorus) fresh water due to ion exchange and microbial activity in (Duan and Kaushal, 2015; Green and Cresser, 2008; Green *et. al.*, 2008; Green *et. al.*, 2009). Trace metal concentrations, including Mn(II) and Fe(II), and mobilization increased due to application of deicers (Kim and Koretsky, 2013). Concentrations of exchangeable ions (Ca, Mg, K, Na) also increase due to the introduction of deicers (Kim and Koretsky, 2013).

Wintertime deicers for roadways are known to cause changes in both water and soil chemistry. There is research on beet juice deicing agents, and there is very little on other organically based deicers. Road salt, not pure sodium chloride, has also not been studied extensively on the impacts it may cause to water chemistry. Introduction of deicers into water leads to ions release and mobilization due to ion exchange with water and sediment and due to microbial activity. There is also a general lack of knowledge about rock salt and beet juice deicer will impact water chemistry and phosphorus exchange and mobilization.

The objective of this study was to investigate how different deicing agents impact steam water and sediment chemistry. Specifically, I was looking at changes in the concentrations dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), total nitrogen, and base cations, as well as changes in pH and organic content. To study these changes, incubations sediment and stream water was incubated with different concentrations of deicing agents. The deicing agents included lab grade salts and commercially available deicers to help understand the relationship between real world examples and "ideal" models. The hypotheses that were tested were: (1) sodium chloride will mobilize higher concentrations of carbon, nitrogen, and base cations from sediments to stream water relative to calcium chloride dihydrate; (2) Inorganic salts (NaCl and $CaCl_2 + 2H_2O$) will mobilize higher concentrations of carbon, nitrogen, and base cations from sediments to stream water than beet juice deicer; and (3) Beet juice deicer will increase the organic content of the sediment compared to the inorganic salts.

3 Methods

Water and sediment samples were collected at two sites along Scotts Level Branch near Baltimore, MD. One site is in a restored section of the stream; the second site has not been altered. To measure chemical changes, the samples were incubated for 24 hours. The methods used are heavily based on and adapted from Duan and Kaushal (2013, 2015).

3.1 Site Selection and Description

The sites at Scotts Level Branch were chosen due to their proximity to a Baltimore Ecosystem Study gauging station (www.beslter.org) and because previous research has been conducted at these locations.

The two sites are approximately 125 meters apart from each other, with Allenswood Rd. in Randallstown, MD cutting between the sites and serving as the point at which the stream changes from unrestored to restored. The unrestored section is upstream of the restored section, and the two sites are visibly different. The unrestored section is predominantly comprised of fine-grained sediment and had steep banks 1-1.5 meters tall lined with vegetation. The restored section of the stream, has a wide range of sediment sizes, from fine-grained silt to clasts in excess of 10 cm in diameter. The unrestored section is lined with boulders and has significantly shallower banks, which were put in place during the restoration process. The unrestored section is straight and has a generally equal width of 2-3 meters, compared to the restored section which meanders more and the width varies from less than half a meter to more than 3 meters wide in some sections. Both streams had comparable discharge during sampling, and both contained litter, which likely originated from upstream or had been washed off the road.

3.2 Sample Collection

Three liters of stream water and roughly two liters of sediment were collected at both sites during sampling. In order to account for inconsistencies in sediment composition over the area of the streambed, three sediment samples were collected in the vicinity of water sampling location and the sediment samples were mixed to create a homogenous mixture.

Stream water for the unrestored site was collected at approximately 39.373819°N, 76.795183°W and the stream water for the restored site was collected at approximately 39.373748°N, 76.793157°W. The stream water was collected in three one-liter bottles, which were rinsed five times with stream water before being capped underwater to minimize the amount of air in the bottles. The sediment samples were collected using a shovel along a cross section a few meters upstream from where the water was sampled. Sediment was collected at the right bank, center, and left bank at the cross sections. Sediment were run though a 2 mm sieve at the sampling locations, and the fraction of the sediment that was 2 mm and smaller was collected in a single gallon-sized resealable plastic bag. Stream water was added to the sediment to prevent drying and the bag was sealed for transportation. After collection, both the sediment and water samples were immediately placed on ice in a cooler and were brought back to the lab. The stream water and sediment samples were refrigerated in the dark, and the sediment samples were left open to allow exchange of air.

Beet juice, the inorganic deicer used, was Beet 55™ Salt, which is produced and was provided by Smith Fertilizer & Grain. The lab grade sodium chloride and calcium chloride dihydrate were both ACS certified ≥ 99% pure. The beet juice deicer had large grains (up to 1 cm large) and the grains appeared to be non-uniform in their composition, both of which made working with the deicer difficult. To create a homogenous mix of the beet juice deicer, the deicer was crushed using a hammer. 100 grams of the crushed beet juice deicer was then weighed out and added to one liter of MilliQ water to create a 100 g/L solution. This solution would be later used for all incubations and the analysis of the beet juice deicer. The beet juice solution was refrigerated when not in use, and was shaken before each use since there appeared to be some settling over time. The beet juice solution also appeared to have some insoluble material that would always settle to the bottom of the container, regardless of how long the solution was mixed for.

The beet juice was also analyzed for chemical composition using inductively coupled plasma optical emission spectrometry (ICP-OS). To analyze the deicer, the 100 g/L solution of beet juice was diluted to a 1 g/L solution and filtered. The filtered solution was then diluted again to two concentrations, 0.5 g/L and 0.1 g/L. The 0.5 g/L and 0.1 g/L solutions were then prepared for ICP-OS analysis. Base cation composition of the beet juice deicer is shown in Table 1. (The filtering and sample preparation methods are explained in section 4.3, and the ICP-OS analysis is explained in section 4.4)

3.3 Incubations

Samples from both sites were incubated with six different concentrations of each deicer and one blank. Triplicates were run for each concentration, for a total of 21 incubations for each of the six site and deicer combinations (NaCl Restored, NaCl Unrestored, Beet Juice Restored, etc.). The blanks contained only stream water, which served as a control to see how the stream water behaved during the incubation. The remaining sets of incubations contained sediment and stream water, and were tested at six different concentrations of deicer, from 0 g/L, an initial concentration, and 2, 5, 10, and 20 times the initial concentration (Table 1).

All of the incubations were performed in 125 mL glass flasks. The flasks were weighed with and without their labels. 60 g of sediment was then added to each flask and the flasks were weighed for a third time.

The deicers were measured and added to 400 mL of stream water and mixed using a stirring bar. The two lab grade salts were weighed and directly added, but the beet juice had to be added as the concentrated brine to the stream water because of the difficulty of working with the deicer.

100 mL of the stream water or deicer brine was added to the samples. In samples that contained sediment, the water was carefully added using a pipette in order to not disturb the sediment.

To allow airflow but prevent external contamination, the flasks were loosely capped immediately after being prepared. Once capped, the flasks were put on a shaker table for 24 hours in the dark. The shaker table was set to a speed in which the water was gently stirred, but the sediment was not disturbed. For each of the six site and deicer combinations, the incubation flasks were prepared together and the incubations were run simultaneously.

	NaCl (g)	$CaCl_2 + H_2O$ (g)	Beet Juice Brine (mL)
Blank	0	0	0
0	0	0	0
1	3.28	4.14	4
2	6.56	8.28	8
3	16.4	20.7	20
4	32.8	41.4	40
5	65.6	82.8	80

Table 1. Amount of deicer added to 400 mL of stream water for incubations. NaCl and $CaCl_2$ + H_2O were added in crystalline form, while the beet juice was added as a brine.

After incubations were completed, the water was immediately removed from the flasks, filtered, and refrigerated to prevent further chemical changes. For the flasks containing sediment, the water was carefully removed using a pipette to prevent removal of sediment, which would affect later measurements of ash free dry. The water was filtered using through pre-combusted GF/F Whatman filters (Duan and Kaushal, 2015).

3.4 Chemical and Data Analyses

To study changes in pH due to the addition of deicer, pH measurements were taken immediately after the incubations had been completed. pH data was collected only for calcium chloride dihydrate and beet juice deicer additions. There is no pH data for the sodium chloride additions due to instrument error. This instrument error was not a problem during the calcium chloride dihydrate and beet juice deicer incubations. pH values were converted into hydrogen ion concentration using equation (1).

$$[\mathbf{H}^{+}] = \mathbf{10}^{-x} \tag{1}$$

Where x is equal to the pH measured after the incubation. The average of the three triplicate samples for each deicer concentration was then calculated.

pH measurements were recorded using a SI Analytics Lab 850 pH meter, which uses a 3-point calibration (pH of 4.01, 7.02, and 10.00) and automatically resets the electrode drift during calibration. To make the hydrogen ion concentrations comprehend graphically, the values for the H^+ concentrations were converted from mol/L to µmol/L by multiplying each value by 10^6.

Ash free dry mass was also measured to determine the amount of organic matter in the samples. Ash free dry mass was calculated only for the samples that contained sediment because the small amount of organic matter in the samples with only stream water would play a negligible role in the change in water chemistry. To determine the ash free dry mass, the sediment samples were dried and burned and weight measurements were made at each step of the process. Flasks were weighed before and after the addition of sediment. After incubations were completed the water was removed, the flasks were again weighed. The flasks were then placed in an oven and dried at 95° C for 24 hours in order to remove all of the water from the sediment. Labels were removed before the flasks were put into the oven so that the labels were not damaged in any way during the process, which would affect the weight measurements. After drying, the stickers were reapplied and the flasks were weighed again. The samples were then burned in a furnace at 450° C for four hours in order to remove any organic matter. Labels again were removed for this step to prevent incorrect measurements of weight. The labels were reapplied and weight was measured of the burned samples. To calculate ash free dry weight, the weight of the flask was subtracted from all other samples and the weight of dried samples was subtracted from the samples from before and after incubation. To calculate organic content, the mass of the sample after burning was subtracted from the mass of the sample after drying. The organic weight percent was then calculated by dividing the mass of the organic matter by the mass of the sediment. All ash free dry mass measurements were made on an Ohaus Scout Pro PS402 400g balance.

Dissolved organic carbon, dissolved inorganic carbon, and total nitrogen were measured on a Shimadzu TOC-L (Total Organic Carbon Analyzer) with a TNM-L (Total Nitrogen Measuring Unit) attachment. To measure total carbon concentrations, the TOC-L combusts the samples by heating them to 680°C then uses an infrared gas analyzer (NDIR) to detect the carbon dioxide that is produced during oxidation when the sample is combusted. Total nitrogen is studied in a similar way, but the sample is heated up to 720°C for analysis. Dissolved inorganic carbon is measured separately and uses a 20 mgC/L standard. Total nitrogen and dissolved organic carbon, which is measured as non-purgable organic carbon (NPOC) are measured simultaneously using a 20mgC/L and 20mgN/L standard.

Base cations were measured using inductively coupled plasma optical emission spectrometry (ICP-OES) on a Shimadzu ICPE-9820.

4 Results and Discussion

4.1 Calculation of Uncertainty

Since triplicates were run for all deicer concentrations, the mean was calculated for each concentration. Standard error was used to calculate the uncertainty of the means using equation (2).

$$\textbf{Standard Error} = \frac{\boldsymbol{\sigma}}{\sqrt{\boldsymbol{n}}} \tag{2}$$

Where σ is equal to the standard deviation of the mean and n is equal to the size of the sample. Standard error was used because of the small number of samples for each site and deicer combination.

4.2 H^+ Concentration

Hydrogen ion concentration was seen to increase in all samples as the deicer concentration in the water increased (Figure 2). In the beet juice deicer additions, the H^+ concentration was nearly identical for both the restored and unrestored sites. Compared to the unrestored site, the restored site that received calcium chloride dihydrate showed higher levels of H^+ at all but the highest concentration level.

The difference between the restored and unrestored site for the calcium chloride dihydrate incubations is likely because of different initial H^+ concentrations. The restored site had an average H^+ concentration of 0.01377 ± 4.659E-04, while the unrestored site had an average H^+ concentration of 0.008712 ± 3.775E-04. The trend for the overall increase in H^+ concentration as the deicer concentration increases may be due to ion exchange with the sediment. When the deicers dissolve in the stream water, ions from the deicer and stream water can replace H^+ ions into the water, increasing the overall H^+ concentration.

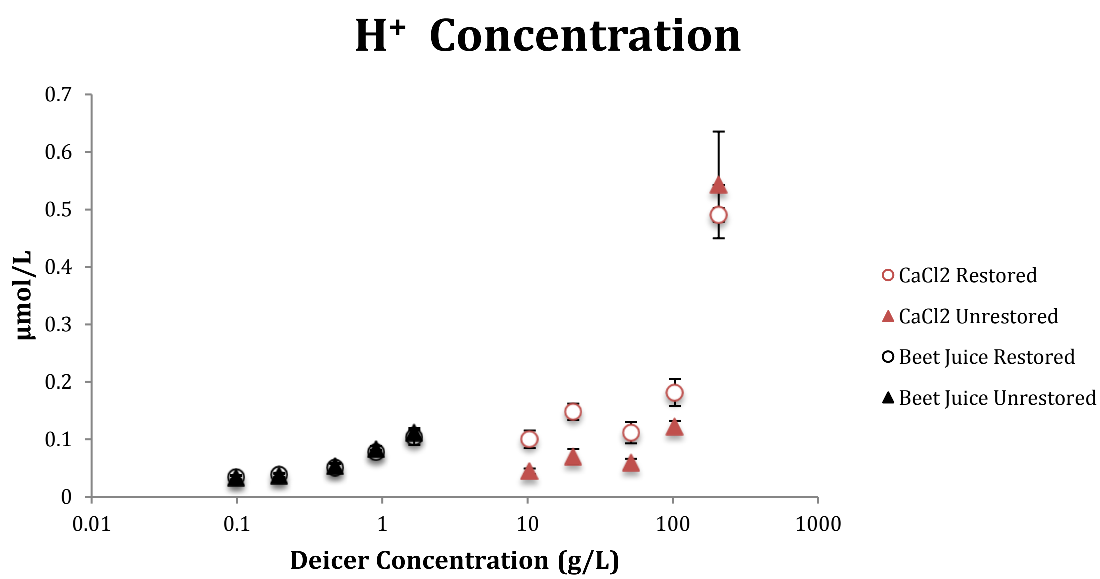


Figure 2. H^+ concentration vs. deicer concentration for calcium chloride dihydrate and beet juice deicer incubations.

4.3 DIC, DOC, and Total Nitrogen Concentrations

The general concentrations of both total nitrogen (Figure 3) and dissolved organic carbon (DOC) (Figure 4) increase as deicer concentration increases. Excluding the beet juice addition in the restored site sample, the total nitrogen concentrations for all incubation sets increase as more deicer is added, then the total nitrogen concentration tapers off (and decreases in some cases). For both the sodium chloride and calcium chloride dihydrate additions, the restored sites had steeper slopes as the total nitrogen concentration increased. This is likely due to differences in the soil chemistry between the restored and unrestored site.

Similarly to the total nitrogen concentration, the DOC concentration increases then tapers off for the beet juice unrestored, sodium chloride restored, and calcium chloride dihydrate restored sets. The other three sets only show increasing DOC concentrations, with the beet juice restored set having the most dramatic and exponential increase. All of the restored sites also showed greater increases in DOC concentrations than the unrestored sites. The DOC concentrations for the blank and 0 mg/L incubations for the sodium chloride and calcium chloride dihydrate incubations were fairly similar, which points to differences between the two sites. The DOC concentrations for the beet juice deicer at both sites contradict this though, since the DOC concentrations between the two sites are significantly different from one another.

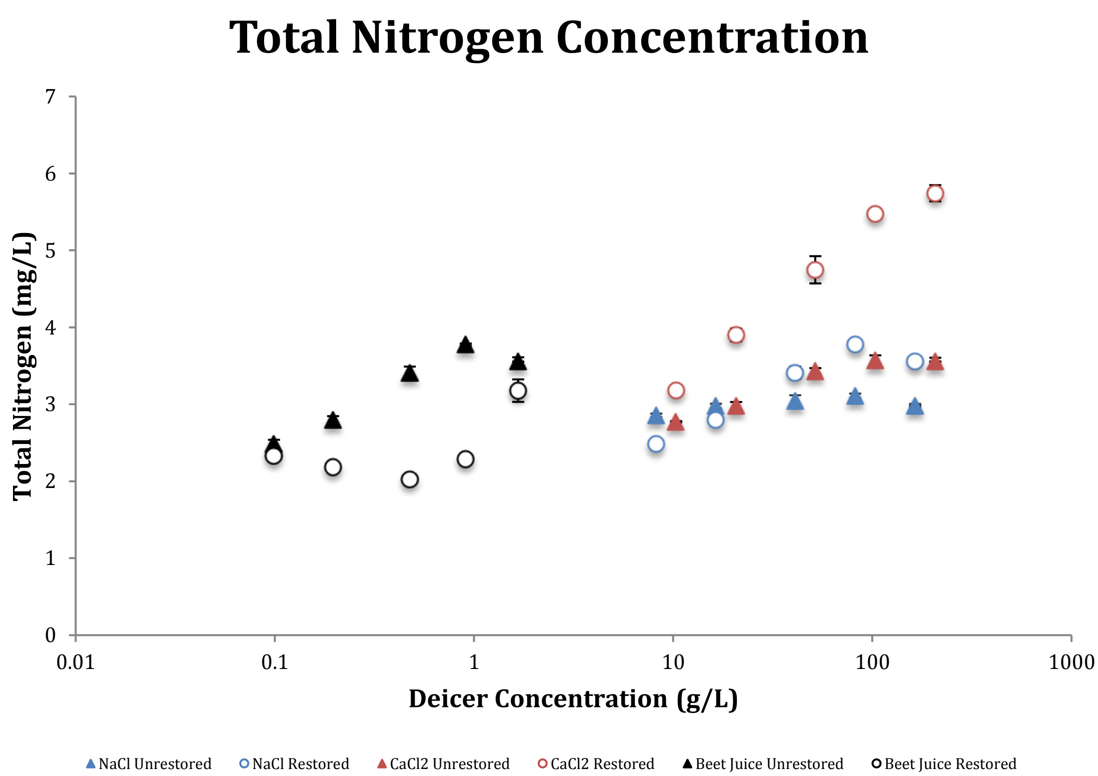
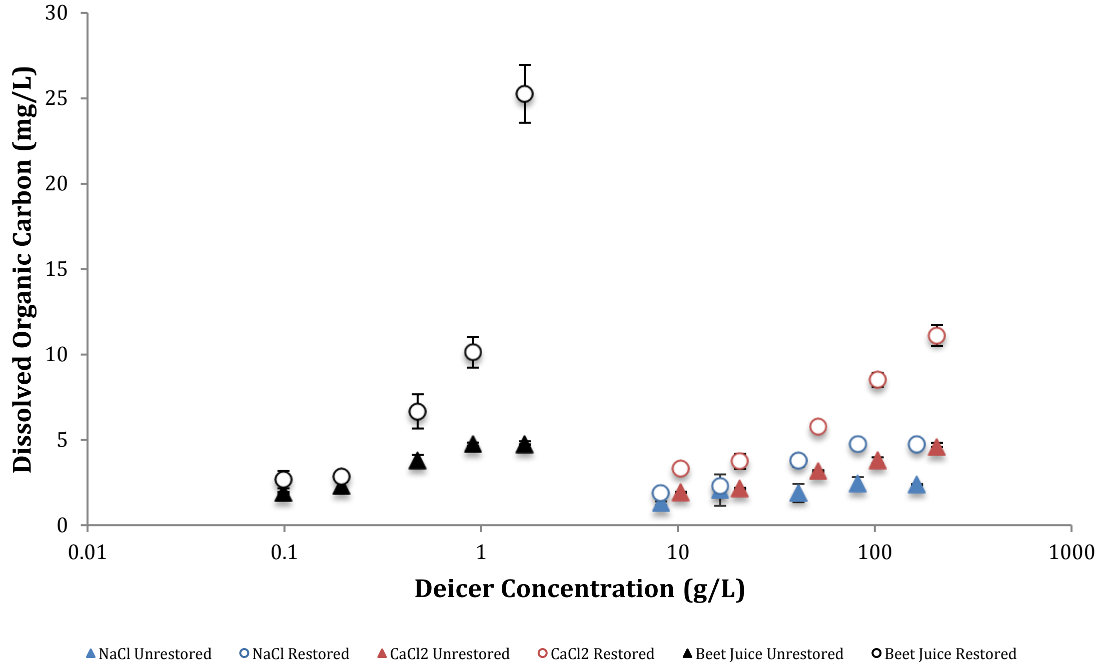


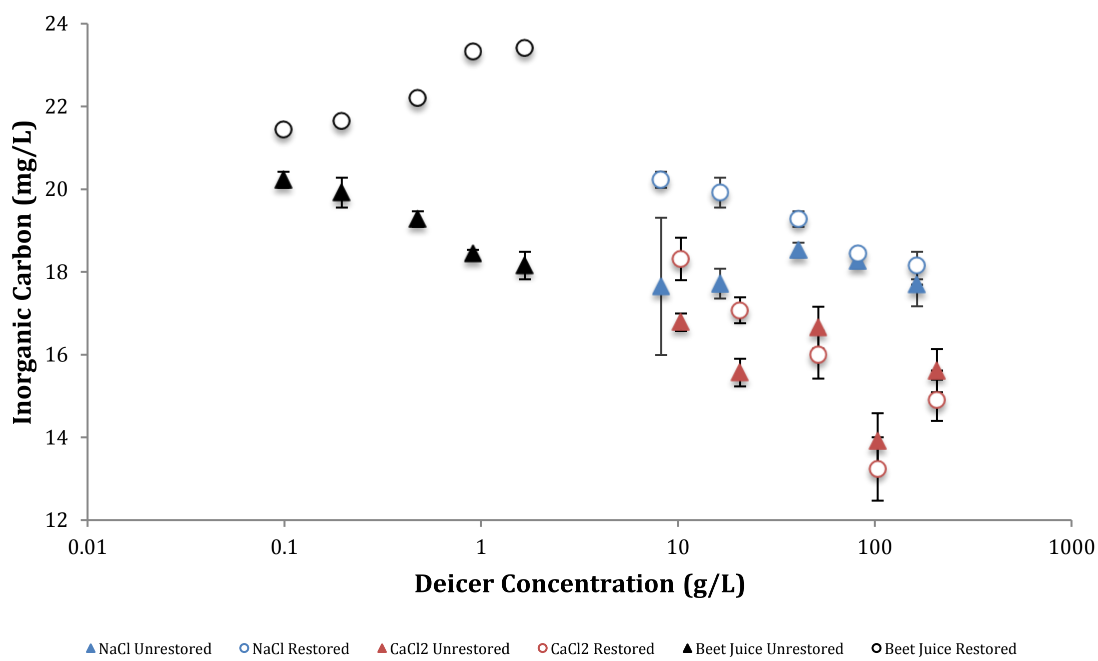
Figure 2. The total nitrogen concentration as a function of the concentration of deicer added.

The dissolved inorganic carbon (DIC) concentrations, excluding two sets, tend to decrease as the concentration of deicer added increases (Figure 5). The two sets that do not decrease are beet juice restored and sodium chloride unrestored. The sodium chloride unrestored set's DIC concentration slightly increases, then slightly decreases. The first deicer concentration (8.225 g/L NaCl) has a large uncertainty due to an outlying point. The three DIC concentration values for the 8.225 g/L NaCl are 12.28 mg/L, 17.28 mg/L, and 17.23 mg/L. The outlier may be due to some error, because if the outlier was eliminated the slope of the sodium chloride restored incubation set would fit better with the rest of the data.

Dissolved Organic Carbon Concentration



Dissolved Inorganic Carbon Concentration



4.4 Base Cations

Base cation concentrations were measured in mg/L for all of the samples. After processing the data, it appears there are two major sources of error that occurred during the analysis of the cation concentrations. The first source of error found was that the salts were bleeding through when being analyzed, especially at higher concentrations. What this means is that salt was causing background noise to occur at all measured wavelengths. This may have happened because the salt concentrations were too high for the ICP-OES and potentially the system was not completely flushed and cleaned before the next sample was run. The other source of error found was peaks in the blank. The blank run should have contained 0 mg/L of all the measured elements, but in the post measurement analysis the blank was found to have small peaks at the measured wavelength. This may have been caused by the same reasons for the previous problem, too high of salt concentrations being measured and the system not being fully cleaned before the next analysis.

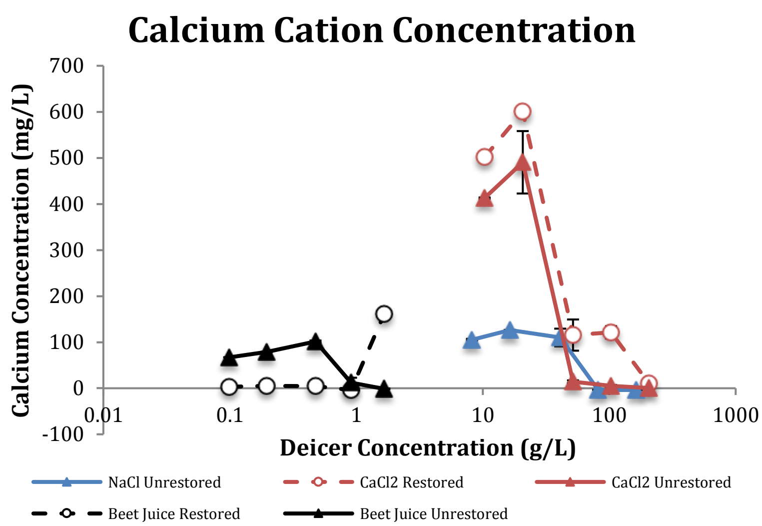


Figure 6. Ca^{2+} concentrations versus deicer concentration. Note that the sodium chloride restored set has been removed due to errors in the data.

These problems caused noticeable errors in the data, including negative cation concentrations and cation concentrations that were measured as below detection limit when the concentration is known to be high enough to measure (this would be due to a concentration being measured at a value lower than what was measured for the blank). Given the time frame when these sources of error were found, there was not sufficient time to try to correct for these issues. Thus, data that was clearly skewed due to incorrect measurement and error in the ICP-OES was removed from analysis in this paper, but all of the raw data was still included in the appendix.

Calcium concentrations in the samples are shown in Figure 6. The sodium chloride restored incubation set was removed because it contained negative Ca^{2+} concentration values and indicated that it was below detection level. The calcium chloride dihydrate incubations show a spike in Ca^{2+} concentration, then a sharp decrease. This is potentially due to the Ca^{2+} reaching the precipitation point, then precipitation starts to occur and the Ca^{2+} concentration decreases. The beet juice unrestored incubation set may also be experiencing a similar precipitation point, though the spike is significantly lower. The beet juice restored incubations are again not following the similar trends.

The potassium concentrations tended to increase as deicer concentrations also increased (Figure 7). The exception to this is the sodium chloride restored set, which increased, then decreased fairly evenly. The calcium chloride dihydrate sets were removed from due to negative K^+ values.

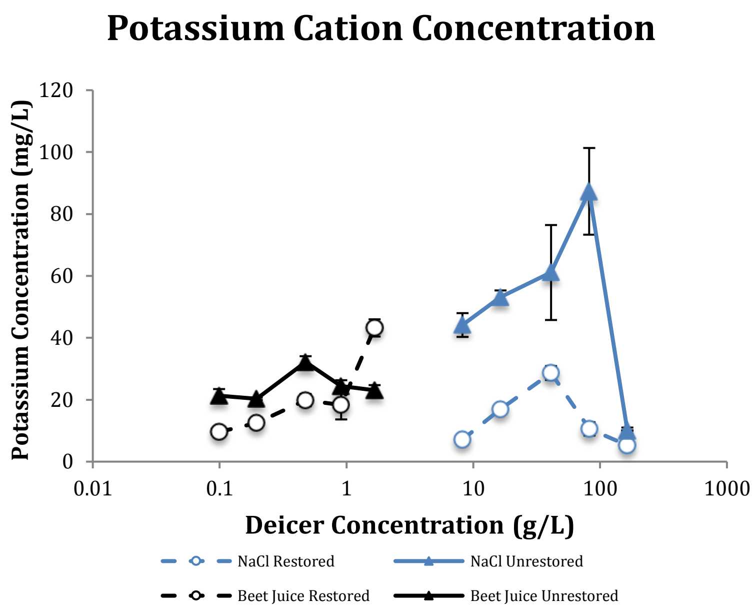


Figure 7. K^+ concentrations versus deicer concentration. Note that both calcium chloride dihydrate sets has been removed due to errors in the

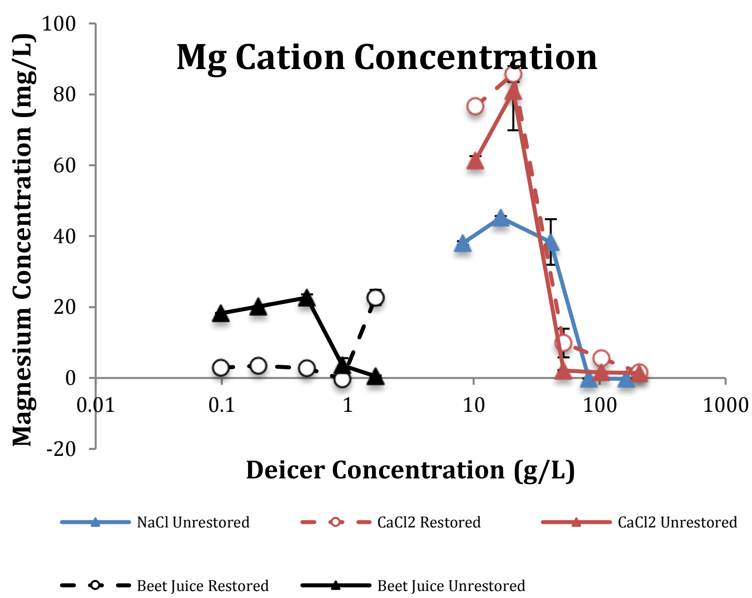


Figure 8. Ca^{2+} concentrations versus deicer concentration. Note that the sodium chloride restored set has been removed due to errors in the data.

The magnesium cation concentrations show peaks, then have a sharp drop in concentration for all sets excluding the beet juice restored incubations (Figure 8). These peaks are similar to those seen in the Ca^{2+} cation concentrations. These peaks also may be evidence of precipitation. The sodium chloride restored incubations were removed due to negative Mg^{2+} concentrations. The beet juice restored set again does not follow the peak, then sharp decrease trend like the rest of the data, and rather increases at the highest concentration of beet juice deicer.

Sodium cation concentrations are shown in Figure 9. The calcium chloride dihydrate sets were removed due to negative Na^{+} concentration values. The sodium chloride unrestored set shows a large peak then sharp decrease, which was seen in other cation concentrations. This also indicates there may be precipitation of Na^{+} in the sodium chloride unrestored set samples The sodium chloride unrestored does not show this peak though. Both the unrestored site sets have peaks, and both restored site sets decrease at lower deicer concentrations, then increase at the higher deicer concentrations. The lack of a peak in the sodium chloride restored set may be able to be explained by a later (higher deicer concentration) point at which the Na^{+} peaks. The lack of peak could also be due to interactions between Na^{+} and the sediment, causing the Na^{+} to bind to the sediment and not remain in solution.

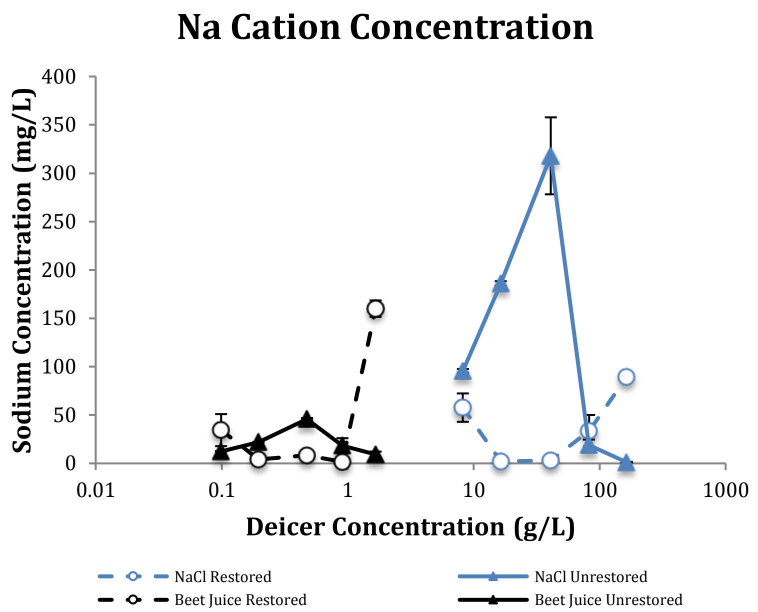


Figure 9. Na^{+} concentrations versus deicer concentration. Note that both calcium chloride dihydrate sets has been removed due to errors in the data.

Cation data for aluminum, chromium, nickel, and zinc was also collected, but the concentrations were contained too much uncertainty from negative concentration values to do any analysis with confidence. The raw data for these cations is still included in the appendix.

4.5 Organic Content

The organic content of the samples was collected and the weight percent organic content was calculated for all of the samples. For all of the incubation sets, most of the organic weight percent was less than 2%. The total weight of the organic content was measured to be less than 1 g for all of the samples in all of the incubations, and the percentage of organic content to the overall flask weight was significantly less than 2%. This change in mass is too small to be able to confidently say that the change in mass is due to changes in organic content and not due to the inherent uncertainty in the scale that was used or eternal factors such as contamination.

5 Summary

5.1 Future Work

Fixing the error and uncertainty in the base cation data is important and would help shed light on how these different deicers are impacting water chemistry. Continuing the research and testing more sites and with more repetitions could also help strengthen the data. Further study of additional deicers, both commercially available and lab grade salts, would help further our understanding of how the use of deicing agents impact stream water chemistry.

5.2 Conclusions and Broader Implications

Concentrations of H^+, total nitrogen, and dissolved organic carbon all increased as the concentration of deicer increased, while dissolved inorganic carbon concentrations decreased. Changes seen in DOC and total nitrogen may suggest that the increase of the DOC and total nitrogen slow down at a point. Base cation data indicated that there might be precipitation of the cations occurring at a certain concentration of deicer. This data could contain significant amounts of error though, because of instrument error. The ash free dry mass data showed no concrete changes that could be attributed to changes in organic content.

These findings disprove my third hypothesis, that beet juice deicer will cause greater changes in organic content of the soil, and disprove the dissolved organic carbon and total nitrogen components of my first hypothesis. Uncertainty in the base cation data is not able to support or disprove the base cation portions of my first and second hypothesis. Supporting or disproving my second hypothesis is not possible due to large differences between my beet juice restored and unrestored incubation sets.

This study can shed light on how different deicers compare and contrast in their effects on water chemistry through interactions with sediment and fresh water. Results from this study will help expand our knowledge on deicing agents and their impact on the environment. This research can help us understand the differences between different deicers have on water quality and may lead to further investigation of different deicing agents. This knowledge of how different deicers impact the environment and water quality could lead to changes in legislation to improve and preserve our environment and impact individual, community, and corporate decisions on how to remove snow and ice.

5.3 Acknowledgements

I want to thank Dr. Sujay Kaushal for all of his guidance and support though out the entirely of the project. I would also like to thank Tom Doody, Dr. Shiuwang Duan and especially Shahan Haq for help in the lab, in the field, and with my project.
Thank you also to Kelsey Wood for her assistance with running machines and teaching me how to use the ICP-OES, and to Emily Lathrop for her assistance with my data processing and analysis.

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8 Appendix

NaCl Restored

	Mass						
Flask	Initial	w/ label	w/ sed	Salt	Post Inc.	Post Bake	Post Burn
A1	80.19	80.26		0			
A2	82.13	82.22		0			
A3	79.67	79.73		0			
B1	78.85	78.91	138.86	0	141.1	124.15	123.37
B2	74.42	74.48	124.93	0	125.93	112.59	111.93
B3	79.03	79.1	138.7	0	139.19	123.9	123.17
C1	76.81	76.86	136.52	3.2818	136.65	121.28	120.71
C2	81.7	81.78	141.8	3.2818	142.76	126.98	126.33
C3	80.07	80.14	139.75	3.2818	142.45	125.9	125.21
D1	77.6	77.66	137.46	6.5573	139.48	123.58	122.94
D2	78.31	78.38	138.14	6.5573	139.19	123.7	123.03
D3	77.42	77.49	137.29	6.5573	137.62	122.41	121.7
E1	81.94	82.01	141.9	16.3996	141.67	125.73	125
E2	77.71	77.76	137.93	16.3996	138.98	123.45	122.69
E3	82.82	82.88	143.4	16.3996	144.34	128.93	128.16
F1	63.36	63.43	124.03	32.9786	124.2	109.52	108.77
F2	54.82	54.87	114.73	32.9786	114.58	100.04	99.29
F3	77.6	77.66	137.4	32.9786	136.61	122.35	121.61
G1	75.94	76.01	136.5	65.6001	134.3	121.65	121.01
G2	79.99	80.04	139.54	65.6001	140.47	126.27	125.6
G3	75.72	75.8	135.65	65.6001	133.94	121.05	120.41

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)W**
A1	0				16.66	1.22	2.852
A2	0				16.29	1.018	2.845
A3	0				15.32	1.105	2.874
B1	0	45.24	0.78	1.724	21.14	1.347	2.022
B2	0	38.11	0.66	1.732	20.47	1.399	2.281
B3	0	44.8	0.73	1.629	20.77	1.415	2.199
C1	8.2045	44.42	0.57	1.283	20.8	1.953	2.386
C2	8.2045	45.2	0.65	1.438	20.32	1.922	2.468
C3	8.2045	45.76	0.69	1.508	19.56	1.797	2.588
D1	16.39325	45.92	0.64	1.394	20.09	2.069	2.889

D2	16.39325	45.32	0.67	1.478	19.54	2.051	2.78
D3	16.39325	44.92	0.71	1.581	20.12	2.771	2.728
E1	40.999	43.72	0.73	1.670	19.32	3.978	3.26
E2	40.999	45.69	0.76	1.663	19.4	4.245	3.531
E3	40.999	46.05	0.77	1.672	19.11	3.101	3.44
F1	82.4465	46.09	0.75	1.627	18.57	4.579	3.8
F2	82.4465	45.17	0.75	1.660	17.82	4.777	3.777
F3	82.4465	44.69	0.74	1.656	18.95	4.892	3.75
G1	164.00025	45.64	0.64	1.402	17.88	4.981	3.535
G2	164.00025	46.23	0.67	1.449	18.15	4.84	3.662
G3	164.00025	45.25	0.64	1.414	18.43	4.36	3.461

NaCl Unrestored

	Mass						
Flask	Initial	w/ label	w/ sed	Salt	Post Inc.	Post Bake	Post Burn
A1	78.39	78.45					
A2	81.63	81.7					
A3	78.17	78.26					
B1	78.15	78.24	138.16	0	138.88	123.85	123.49
B2	77.84	77.9	137.74	0	138.47	123.3	122.92
B3	79.52	79.61	140.49	0	139.98	125.23	124.85
C1	78.88	78.96	138.74	3.29	138.81	123.94	123.52
C2	81.6	81.66	135	3.29	136.61	122.23	121.75
C3	80.99	81.07	141.21	3.29	141.53	126.07	125.55
D1	76.77	76.83	136.53	6.5606	137.65	121.74	121.24
D2	82.56	82.62	142.37	6.5606	142.32	128.09	127.56
D3	74.32	74.39	134.44	6.5606	134.55	119.91	119.39
E1	77.15	77.21	136.95	16.403	136.58	122.29	121.77
E2	73.89	73.96	134.59	16.403	134.88	119.97	119.4
E3	74.42	74.5	134.92	16.403	133.93	119.49	119.39
F1	80.46	80.51	141.2	32.8033	139.85	126.18	125.65
F2	79.18	79.23	139.5	32.8033	140.4	125.3	124.69
F3	79.33	79.4	139.44	32.8033	140.63	125.85	125.18
G1	74.94	75.01	135.21	65.6031	136.45	122.1	121.55
G2	75.28	75.37	135.26	65.6031	136.44	123.41	122.86
G3	78.36	78.48	128.95	65.6031	140.45	127.59	127.02

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)**
A1					12.69	0.9583	3.296

A2					12.87	0.9713	3.263
A3					12.68	0.914	3.248
B1	0	45.61	0.36	0.7893	12.28	0.8954	2.896
B2	0	45.4	0.38	0.837	17.28	0.8689	2.882
B3	0	45.62	0.38	0.833	17.23	0.8957	2.824
C1	8.225	44.98	0.42	0.9337	17.07	1.488	2.809
C2	8.225	40.57	0.48	1.183	17.57	1.091	2.877
C3	8.225	45	0.52	1.156	18.31	1.261	2.882
D1	16.4015	44.91	0.5	1.113	17.37	3.896	2.926
D2	16.4015	45.47	0.53	1.166	17.84	1.134	3.031
D3	16.4015	45.52	0.52	1.142	17.94	1.14	2.974
E1	41.0075	45.08	0.52	1.154	18.2	2.942	2.903
E2	41.0075	46.01	0.57	1.239	18.59	1.375	3.163
E3	41.0075	44.99	0.1	0.2223	18.8	1.318	3.061
F1	82.00825	45.67	0.53	1.160	19.24	1.923	3.063
F2	82.00825	46.07	0.61	1.324	18.1	3.169	3.103
F3	82.00825	46.45	0.67	1.442	17.46	2.221	3.164
G1	164.00775	47.09	0.55	1.168	17.42	2.399	2.993
G2	164.00775	48.04	0.55	1.145	18.17	2.29	2.936
G3	164.00775	49.11	0.57	1.161	17.48	2.43	3.017

$CaCl_2$ Restored

	Mass (g)						
Flask	Initial	w/ label	w/ sed	Salt	Post Inc.	Post Bake	Post Burn
A1	75.01	75.04					
A2	79.75	79.78					
A3	80.8	80.83					
B1	79.15	79.18	138.87	0	138.18	122.1	122.76
B2	78.61	78.65	138.67	0	138.96	121.49	122.45
B3	81.87	81.91	142.27	0	143.65	125.99	126.96
C1	78.14	78.18	138.12	4.1401	140.16	121.96	122.91
C2	81.78	81.82	141.83	4.1401	143.38	125.48	126.33
C3	78.18	78.22	138.43	4.1401	138.82	121.12	121.97
D1	75.03	75.06	135.05	8.2757	136.68	117.95	118.88
D2	77.85	77.88	137.76	8.2757	139.06	121.41	122.22
D3	78.66	78.7	138.84	8.2757	140.48	122.65	123.51
E1	79.65	79.68	139.56	20.7015	141.87	123.95	124.76
E2	79.16	79.2	139.36	20.7015	140.5	123.05	123.94

E3	80.76	80.8	140.65	20.7015	143.33	125.16	125.94
F1	78.7	78.73	138.81	41.4068	141.72	121.41	122.29
F2	75.96	76	135.92	41.4068	140.17	123.75	123.2
F3	75.5	75.53	135.31	41.4068	139.9	125.38	124.68
G1	74.95	74.97	134.96	82.7986	137.17	121.52	120.96
G2	78.19	78.22	138.25	82.7986	139.57	124.88	122.96
G3	81.71	81.78	141.67	82.7986	144.61	129.23	128.46

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)**
A1					17.05	2.771	2.135
A2					17	2.661	2.114
A3					17.01	2.796	2.134
B1	0	42.92	-0.66	-1.538	23.99	2.77	2.098
B2	0	42.84	-0.96	-2.241	24.27	3.12	2.055
B3	0	44.08	-0.97	-2.201	22.61	3.03	2.064
C1	10.35025	43.78	-0.95	-2.17	17.83	3.847	3.178
C2	10.35025	43.66	-0.85	-1.947	18.21	3.112	3.254
C3	10.35025	42.9	-0.85	-1.981	18.9	2.997	3.105
D1	20.68925	42.89	-0.93	-2.168	17.93	3.335	3.745
D2	20.68925	43.53	-0.81	-1.861	17.32	3.274	3.922
D3	20.68925	43.95	-0.86	-1.957	15.97	4.617	4.036
E1	51.75375	44.27	-0.81	-1.830	14.47	5.856	5.101
E2	51.75375	43.85	-0.89	-2.030	16.84	6.025	4.549
E3	51.75375	44.36	-0.78	-1.758	16.69	5.405	4.594
F1	103.517	42.68	-0.88	-2.062	14.16	8.593	5.504
F2	103.517	47.75	0.55	1.152	13.1	9.194	5.351
F3	103.517	49.85	0.7	1.404	12.45	7.774	5.571
G1	206.9965	46.55	0.56	1.203	16.42	12.05	5.916
G2	206.9965	46.66	1.92	4.115	14.4	11.3	5.76
G3	206.9965	47.45	0.77	1.623	13.87	9.948	5.553

	pH		
	Avg	St. Dev	St. Err.
A	0.01377	0.000807	0.0004659
B	0.02543	0.0001354	0.00007819
C	0.09993	0.02676	0.01545
D	0.1479	0.02475	0.01429
E	0.1115	0.03207	0.01851

F	0.1813	0.04094	0.02364
G	0.4904	0.02034	0.01174

CaCl2 Unrestored

	Mass						
Flask	Initial	w/ label	w/ sed	Salt	Post Inc.	Post Bake	Post Burn
A1				0.00			
A2				0.00			
A3				0.00			
B1	78.39	78.43	138.37	0.00	139.59	124.37	123.69
B2	82.14	82.17	142.04	0.00	144.55	128.30	127.65
B3	79.68	79.72	139.91	0.00	140.78	125.13	124.46
C1	77.50	77.54	137.40	4.14	138.73	122.80	122.01
C2	78.40	78.44	138.77	4.14	139.64	122.95	122.08
C3	81.63	81.66	141.43	4.14	139.43	125.10	124.23
D1	81.98	82.01	141.90	8.28	142.20	128.06	127.22
D2	80.19	80.22	140.24	8.28	139.93	125.99	125.18
D3	78.18	78.21	138.21	8.28	137.30	123.49	122.70
E1	80.00	80.03	140.28	20.70	140.30	126.44	125.57
E2	75.73	75.76	135.85	20.70	134.86	121.30	120.96
E3	80.79	80.83	140.77	20.70	138.74	125.21	124.39
F1	78.88	78.91	138.87	41.40	141.04	126.24	125.45
F2	75.95	75.99	135.85	41.40	137.32	122.92	122.10
F3	79.51	79.55	139.44	41.40	142.52	127.35	126.52
G1	81.59	81.62	141.55	82.80	144.29	129.61	128.93
G2	77.61	77.64	138.00	82.80	138.93	125.05	124.32
G3	78.17	78.23	138.65	82.80	139.79	125.85	125.09

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)**
A1	0				15.42	1.727	2.918
A2	0				15.24	1.627	2.967
A3	0				14.97	1.606	2.984
B1	0	45.94	0.68	1.480	19.76	2.253	2.549
B2	0	46.13	0.65	1.409	19.77	1.914	2.605
B3	0	45.41	0.67	1.475	20.4	2.255	2.494
C1	10.3475	45.26	0.79	1.745	16.17	1.991	2.79
C2	10.3475	44.51	0.87	1.955	16.86	1.864	2.763

C3	10.3475	43.44	0.87	2.003	17.32	1.922	2.765
D1	20.702	46.05	0.84	1.824	14.75	2.167	3.078
D2	20.702	45.77	0.81	1.770	15.46	2.05	2.937
D3	20.702	45.28	0.79	1.745	16.49	2.217	2.931
E1	51.7525	46.41	0.87	1.875	15.36	3.124	3.509
E2	51.7525	45.54	0.34	0.7466	16.95	3.133	3.403
E3	51.7525	44.38	0.82	1.848	17.65	3.263	3.379
F1	103.4995	47.33	0.79	1.669	12.94	3.807	3.611
F2	103.4995	46.93	0.82	1.747	14.05	4.099	3.659
F3	103.4995	47.8	0.83	1.736	14.73	3.488	3.431
G1	207.004	47.99	0.68	1.417	14.26	5.057	3.629
G2	207.004	47.41	0.73	1.540	15.47	4.474	3.577
G3	207.004	47.62	0.76	1.596	17.11	4.189	3.457

	pH		
	Avg	St. Dev	St. Err.
A	0.008712	0.0006539	0.0003775
B	0.01106	0.002417	0.001396
C	0.0445	0.00824	0.004757
D	0.06985	0.02265	0.01308
E	0.0595	0.01185	0.006841
F	0.1223	0.01731	0.009996
G	0.5426	0.161	0.09293

BJ Restored

	Mass						
Flask	Initial	w/ label	w/ sed	Salt	Post Inc.	Post Bake	Post Burn
A1				0.00			
A2				0.00			
A3				0.00			
B1	74.96	74.99	134.90	0.00	133.23	119.72	119.15
B2	79.20	79.24	139.29	0.00	137.16	123.60	123.05
B3	73.91	73.94	134.03	0.00	132.30	118.85	118.30
C1	79.77	79.80	139.85	4.00	139.78	125.18	124.57
C2	81.70	81.73	141.94	4.00	145.11	127.68	127.06
C3	82.84	82.88	142.79	4.00	142.48	128.28	127.68
D1	74.32	74.36	134.42	8.00	135.92	121.28	120.63
D2	82.56	82.60	142.81	8.00	140.38	126.79	126.14
D3	74.42	74.46	134.32	8.00	133.20	119.38	118.78

E1	77.62	77.66	137.78	20.00	137.43	122.82	122.20
E2	81.95	81.98	141.95	20.00	141.25	126.81	126.22
E3	78.32	78.36	138.34	20.00	137.46	123.19	122.59
F1	74.42	74.45	134.36	40.00	134.32	119.47	118.88
F2	75.01	75.04	135.10	40.00	133.30	119.09	118.36
F3	77.72	77.77	137.77	40.00	136.09	122.16	121.50
G1	77.14	77.18	137.18	80.00	135.33	121.70	121.08
G2	78.85	78.90	138.83	80.00	137.36	123.61	123.05
G3	74.98	75.02	135.01	80.00	134.59	120.21	119.74

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)**
A1	0				19	1.307	2.899
A2	0				19.07	1.282	2.849
A3	0				18.79	1.313	2.864
B1	0.000	44.73	0.57	1.274	20.89	1.938	2.313
B2	0.000	44.36	0.55	1.240	21.62	1.708	2.306
B3	0.000	44.91	0.55	1.225	21.1	1.773	2.375
C1	0.099	45.38	0.61	1.344	21.2	2.189	2.244
C2	0.099	45.95	0.617	1.343	21.9	3.685	2.413
C3	0.099	45.4	0.6	1.322	21.24	2.131	2.331
D1	0.196	46.92	0.65	1.385	20.78	2.764	2.191
D2	0.196	44.19	0.65	1.471	22.2	2.877	2.26
D3	0.196	44.92	0.6	1.336	21.95	2.879	2.101
E1	0.476	45.16	0.62	1.373	22.08	6.439	1.998
E2	0.476	44.83	0.59	1.316	21.84	8.501	1.994
E3	0.476	44.83	0.6	1.338	22.69	5.057	2.087
F1	0.909	45.02	0.59	1.311	22.82	11.53	2.342
F2	0.909	44.05	0.73	1.657	23.44	10.37	2.348
F3	0.909	44.39	0.66	1.487	23.73	8.467	2.172
G1	1.667	44.52	0.62	1.393	23.21	26.75	3.356
G2	1.667	44.71	0.56	1.253	23.1	27.15	3.289
G3	1.667	45.19	0.47	1.040	23.93	21.88	2.888

	pH		
	Avg	St. Dev	St. Err
A	0.01456	0.001409	0.0008136
B	0.02518	0.0007287	0.0004207
C	0.03356	0.008295	0.004789
D	0.0381	0.006809	0.003931

E	0.05022	0.0118	0.006815
F	0.07705	0.007571	0.004371
G	0.1032	0.02261	0.01305

BJ Unrestored

	Mass						
Flask	Initial	w/ label	w/ sed	Salt (mL)	Post Inc.	Post Bake	Post Burn
A1				0.00			
A2				0.00			
A3				0.00			
B1	81.71	81.75	141.72	0.00	143.26	127.67	127.24
B2	78.68	78.72	138.64	0.00	138.00	123.46	123.10
B3	75.30	75.34	135.23	0.00	133.87	119.46	119.14
C1	78.38	78.42	138.47	4.00	136.90	122.63	122.16
C2	75.51	75.54	135.41	4.00	134.28	120.06	119.63
C3	78.19	78.23	138.34	4.00	137.78	124.02	123.63
D1	75.05	75.08	135.28	8.00	134.54	120.77	120.26
D2	79.16	79.20	139.37	8.00	138.73	124.61	124.15
D3	79.05	79.08	139.06	8.00	137.99	124.10	123.68
E1	78.18	78.23	138.14	20.00	139.15	124.74	124.26
E2	80.66	80.70	140.76	20.00	140.83	126.92	126.45
E3	78.70	78.75	138.86	20.00	137.99	124.15	123.70
F1	75.21	75.24	135.15	40.00	132.93	119.75	119.30
F2	81.78	81.82	141.75	40.00	140.88	126.79	126.33
F3	76.82	76.85	137.04	40.00	135.18	121.75	121.30
G1	81.87	81.91	141.83	80.00	139.59	126.54	126.10
G2	80.46	80.51	140.29	80.00	137.87	124.64	124.23
G3	78.62	78.66	138.49	80.00		124.94	124.50

Flask	**Salt Conc. (g/L)**	**Dry Sed Wt.**	**Org. Cont.**	**Perc. Org.**	**IC (mg/L)**	**NPOC (mg/L)**	**TN (mg/L)**
A1	0				17.27	1.221	3.143
A2	0				17.25	1.058	3.092
A3	0				17.06	1.038	3.13
B1	0.000	45.94	0.68	1.480	21.44	1.231	2.657
B2	0.000	46.13	0.65	1.409	21.58	1.248	2.677
B3	0.000	45.41	0.67	1.475	21.51	1.265	2.653
C1	0.099	45.26	0.79	1.745	20.82	1.74	2.522

C2	0.099	44.51	0.87	1.955	21.27	1.764	2.576
C3	0.099	43.44	0.87	2.003	22.48	1.813	2.62
D1	0.196	46.05	0.84	1.824	21.44	2.346	2.529
D2	0.196	45.77	0.81	1.770	21.44	2.614	2.561
D3	0.196	45.28	0.79	1.745	22.08	2.307	2.486
E1	0.476	46.41	0.87	1.875	20.29	5.414	2.488
E2	0.476	45.54	0.34	0.7466	21.12	5.122	2.405
E3	0.476	44.38	0.82	1.848	20.94	4.187	2.542
F1	0.909	47.33	0.79	1.669	21.75	11.45	2.433
F2	0.909	46.93	0.82	1.747	21.67	10.72	2.399
F3	0.909	47.8	0.83	1.736	22.46	11.68	2.35
G1	1.667	47.99	0.68	1.417	21.36	28.52	3.24
G2	1.667	47.41	0.73	1.540	22.26	25.33	2.98
G3	1.667	47.62	0.76	1.596	22.46	22.63	2.889

	pH		
	Avg	St. Dev	St. Err.
A	0.01417	0.002018	0.001165
B	0.0348	0.001235	0.0007132
C	0.03301	0.004774	0.002756
D	0.0365	0.005934	0.003426
E	0.05332	0.009895	0.005713
F	0.08275	0.009801	0.005658
G	0.1117	0.01347	0.007778

ICP Results

Averages

Na Restored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.404	0.281	0.375	0.444	0.249	0.366	0.432
Ca	-3.76	-3.76	-3.75	-3.65	-3.51	-3.75	-3.76
Cr	-0.0362	-0.0358	-0.0361	-0.0355	-0.039	-0.0359	-0.0355
K	5.76	4.58	7.11	16.9	28.6	10.6	5.29
Mg	-0.224	-0.225	-0.222	-0.207	-0.204	-0.222	-0.225
Na	77.6	67.3	57.6	1.96	3.05	33.6	89.4
Ni	-0.119	-0.116	-0.117	-0.116	-0.118	-0.116	-0.117
Zn	-0.324	-0.327	-0.326	-0.32	-0.325	-0.324	-0.325

Na	**A**	**B**	**C**	**D**	**E**	**F**	**G**

Unrestored							
Al	0.230	0.277	0.244	0.213	0.0487	0.333	0.348
Ca	36.7	44.0	106	126	110	-3.56	-3.76
Cr	-0.0311	-0.034	-0.0243	-0.0245	-0.0283	-0.0355	-0.037
K	6.16	5.93	44.1	53.2	61.1	87.3	10.0
Mg	16.7	17.4	38.0	45.2	38.4	-0.176	-0.225
Na	36.0	34.0	95.6	186	318	18.9	1.13
Ni	-0.068	-0.0708	-0.0713	-0.0716	-0.0693	-0.116	-0.116
Zn	-0.314	-0.319	-0.320	-0.325	-0.238	-0.241	-0.307

Ca Restored	A	B	C	D	E	F	G
Al	0.745	2.74	-0.261	-0.685	0.0758	-0.103	0.347
Ca	35.9	12.2	502	601	115	121	10.0
Cr	0.589	2.59	0.596	0.592	0.586	0.583	0.582
K	8.50	71.4	23.9	27.0	7.61	4.43	-6.07
Mg	20.6	7.69	76.6	85.8	9.86	5.57	1.53
Na	5.63	8.91	19.8	2.24	18.1	2.1	0.630
Ni	0.924	0.371	0.944	0.707	0.676	0.67	0.665
Zn	0.292	0.260	0.418	0.638	0.302	0.307	0.295

Ca Unrestored	A	B	C	D	E	F	G
Al	0.666	0.715	-0.0353	-0.332	0.613	0.789	0.933
Ca	33.5	42.9	413	491	14.3	4.95	0.426
Cr	0.586	0.584	0.585	0.583	0.582	0.584	0.584
K	-8.05	-10.8	-5.84	-0.877	-8.95	-10.1	-9.19
Mg	10.9	15.6	61.3	80.9	2.13	1.55	1.42
Na	1.12	2.11	1.43	0.446	0.304	1.19	0.032
Ni	0.921	0.920	0.931	0.934	0.664	0.664	0.665
Zn	0.287	0.289	0.394	0.599	0.286	0.289	0.298

BJ Restored	A	B	C	D	E	F	G
Al	0.0479	-0.109	0.0343	0.01	0.0615	0.0000667	-0.00823
Ca	5.40	1.24	3.12	5.09	4.83	-3.83	162
Cr	0.251	0.247	0.242	0.248	0.248	0.245	0.378
K	10.2	6.61	9.57	12.50	19.9	18.3	43.2
Mg	6.96	2.43	2.94	3.47	2.75	-0.309	22.7
Na	76.0	49.7	34.4	4.14	8.37	1.52	160

Ni	0.191	0.175	0.172	0.175	0.173	0.159	0.217
Zn	-0.115	-0.119	-0.116	-0.113	-0.112	-0.117	0.100

BJ Unrestored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.244	0.335	0.156	0.260	0.162	0.143	0.0589
Ca	40.2	49.6	67.1	78.7	102	12.2	-1.40
Cr	0.275	0.261	0.288	0.262	0.258	0.248	0.246
K	8.02	6.95	21.3	20.3	32.2	24.4	23.1
Mg	15.0	14.8	18.3	20.1	22.7	3.55	0.481
Na	44.4	34.5	12.3	21.8	45.8	18.3	9.24
Ni	0.233	0.223	0.225	0.224	0.226	0.175	0.163
Zn	-0.115	-0.113	-0.0476	0.0257	0.0112	-0.0989	-0.119

Error

Na Restored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.0254	0.0487	0.0385	0.0473	0.0741	0.0373	0.0542
Ca	3.14E-16	3.14E-16	0.00242	0.0618	0.131	0.00778	3.14E-16
Cr	0.000722	0.000962	0.00085	0.00131	0.000779	0.000726	0.000619
K	0.255	0.292	1.05	0.668	2.24	2.15	0.468
Mg	0.000236	0.000176	0.00122	0.0107	0.0134	0.00243	9.81E-18
Na	2.18	1.90	14.7	0.268	0.837	16.4	3.26
Ni	0.000441	0.000799	0.00118	0.00139	0.000913	0.00107	0.00076
Zn	0.000261	0.000556	0.000512	0.00313	0.000726	0.000423	0.000601

Na Unrestored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.0543	0.0363	0.0452	0.054	0.0507	0.0769	0.0635
Ca	0.300	0.233	1.70	0.412	19.2	0.0764	3.14E-16
Cr	0.00225	0.00109	0.00137	0.000996	0.00142	0.00164	0.000558
K	0.300	0.139	3.85	2.14	15.3	14.0	0.959
Mg	0.0289	0.0527	0.554	0.477	6.43	0.0186	0.000147
Na	0.634	1.29	1.93	2.34	39.8	5.69	0.420
Ni	0.00129	0.000934	0.000787	0.000666	0.000479	0.00319	0.000973
Zn	0.0033	0.00296	0.00192	0.00224	0.0351	0.0363	0.0152

Ca Restored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.035	0.0513	0.0606	0.103	0.282	0.201	0.200

Ca	0.0833	0.103	0.444	1.94	33.9	13.4	7.40
Cr	0.00236	0.000512	0.00134	0.000872	0.00234	0.000925	0.00121
K	2.09	1.69	3.52	3.53	3.51	2.18	2.11
Mg	0.274	0.220	1.00	2.23	4.04	0.748	0.0991
Na	7.90	0.454	8.82	0.350	11.6	0.338	0.364
Ni	0.00145	0.00114	0.000707	0.00226	0.00679	0.00398	0.00213
Zn	0.00141	0.000988	0.0505	0.00485	0.00694	0.00716	0.00367

Ca Unrestored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.0501	0.0513	0.107	0.147	0.0649	0.0657	0.127
Ca	0.985	0.439	1.44	67.8	2.78	2.28	1.44
Cr	0.00246	0.000882	0.000556	0.000696	0.000784	0.000833	0.000898
K	0.653	0.0619	0.656	1.16	0.658	0.466	1.05
Mg	0.297	0.474	1.24	11.0	0.118	0.0513	0.0178
Na	0.236	0.207	0.265	0.501	0.357	0.319	0.289
Ni	0.00147	0.000707	0.0014	0.041	0.00113	0.00156	0.00139
Zn	0.000645	0.000741	0.0492	0.0504	0.000676	0.00131	0.00334

BJ Restored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.0616	0.0469	0.0889	0.0929	0.0529	0.0786	0.043
Ca	2.84	1.32	1.68	1.23	1.76	0.403	3.10
Cr	0.00242	0.00107	0.00186	0.0262	0.00117	0.00123	0.00146
K	1.61	1.19	0.728	1.39	2.00	4.63	2.78
Mg	2.18	0.654	0.747	0.595	0.635	0.120	2.14
Na	6.23	4.19	16.6	0.837	1.48	1.04	8.47
Ni	0.00944	0.00461	0.00513	0.0187	0.00474	0.00159	0.00445
Zn	0.00166	0.00123	0.0015	0.0121	0.00268	0.00247	0.00181

BJ Unrestored	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Al	0.0812	0.0519	0.0524	0.043	0.0421	0.0658	0.0475
Ca	13.4	0.176	0.192	0.542	2.10	10.7	0.774
Cr	0.0916	0.00176	0.00205	0.00316	0.00114	0.00215	0.00127
K	2.67	0.293	2.15	0.403	1.89	1.91	1.63
Mg	5.01	0.0278	0.0553	0.118	0.914	2.06	0.244
Na	14.8	0.708	0.435	0.356	1.14	7.74	2.99
Ni	0.0777	0.0015	0.0027	0.00141	0.00205	0.0065	0.00299

Zn	-0.0382	0.00085	0.033	0.0327	0.0257	0.0183	0.00109