Do the Waters of Sutton Lake Contain Metals That Indicate Coal Ash Contamination?

John T. Hoggard High School • Chem-Techathon Team

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Abstract:
Coal ash is a common by product near coal burning power plants. Due to recent environmental issues with coal ash in other parts of North Carolina, the team has decided to test the waters of Sutton Lake, which neighbors Sutton Plant, to determine if any metals are present which would indicate coal ash contamination.

Background:
Coal ash is the remnant of coal being burned. Most coal ash comes from coal burning power plants. Coal ash in waterways is a serious issue and an imminent threat to nature as well as the health of humans. Water resources are polluted by the toxic remnants of burnt coal from power plants. Coal has been at the center of our nation's energy supply and economy for over a century. "According to U.S. Energy Information Administration about 37% of all electricity in the U. S. comes from coal" (Coal Ash in NC). However, as coal ash is increasingly mixed into our water, wildlife is put in danger. Coal ash has been found in over 47 states. The ash contains over 15 toxic metals. Arsenic, cadmium, and nickel, for example, are serious carcinogens. Lead and mercury can severely damage the nervous system, especially in children. Lead and thallium may cause birth defects. Selenium has the ability to poison and deform fish. Eating the contaminated fish can cause health risks to the consumer such as bronchitis, numbness in limbs, and allergic reactions. Selenium pollution has been an issue in North Carolina particularly since the 1970's. "Coal ash is the second largest source of industrial waste in the United States" (Coal Ash).

"Sutton Lake is a 1,100-acre impoundment constructed by Progress Energy in 1972 to supply cooling water for an existing coal-fired power plant in Wilmington, N.C. It is near the intersection of I-40 and U.S.421. It is used for recreational fishing, boating, wildlife watchers, and canoeing. In 2013 Duke Power and the N.C. Wildlife Resources Commission renovated the pier and boat ramp for these recreational users" (McGrath).

The research team chose to test the waters of Sutton Lake to determine if the ash ponds at the Sutton Plant were running over into the lake and causing contamination of the lake water. This is of major importance to the local area due to the recreational fishing in the lake. If a person were to consume the fish of a contaminated lake, they would also be ingesting the poisons found in that water.

In February of 2014, a storm water pipe under an ash basin at the Dan River coal plant failed and released nearly 39,000 tons of coal ash into the Dan River (Duke Energy Progress). The Dan River is a 100 mile river on the North Carolina/Virginia border. It is located near Winston Salem, Greensboro, Raleigh, and Chapel Hill. This coal ash spill was "close to home".

This spill opened the team's eyes to the possibility of contamination in our own local river, the Cape Fear River. This research group wanted to determine the

true magnitude of pollution around our hometown. In order to shed light on this critical issue, it was decided that water along different spots of the Cape Fear River would be tested for the heavy metals found in coal ash. After more research, it was determined that Sutton Lake does not spill into the Cape Fear River. Water is pumped into the lake from the Cape Fear River, so our research plan was modified.

The new plan was to test the waters of Sutton Lake for several metals. The metals chosen were based on the available lamps for the Atomic Absorption/Emission Spectrometer at the Chemical Technology laboratory at Cape Fear Community College. It was not until after the team had determined their research topic that the local news broke a story about ground water contamination due to the Sutton Plant coal ash ponds leaking. In the beginning of March, it was announced that Duke Energy Progress had been fined $25.1 million dollars for groundwater contamination by the North Carolina Department of Environment and Natural Resources. This breaking news solidified the team's suspicions and inspired the team further to pursue their research. Team member Dominick Scialabba stated, "We set out with the goal to use chemistry to raise public awareness and determine for ourselves if the impact of coal ash was as extensive as presumed. With strong guidance from our AP chemistry teacher, Mrs. Siddons, and with the resources and technology of CFCC we combined hard work and hard science to discover what we would and leave nothing to chance."

Procedure/Observations:

Prior to going to the water collection site, team members organized the sample collection bottles into zipped bags for organizational purposes. In each bag three brown water collection bottles were used and two small clear vials. The brown collection bottles were used to collect the water to be tested, whereas the small glass vials were used to check for clarity. Members of the team used kayaks to reach different parts of the lake. At each collection point, three samples were collected. The samples were labeled with successive numbers and each set was labeled, a-b-c. The water samples were clear, but minor particulates could be found floating due to the organic material found normally in the lake. Wildlife in the area was abundant. While on the dock, a large bass could be seen at the base of the pylons. A snake was scared away, the birds were active, and the fire ants were in full force. It was a sunny, breezy afternoon. The temperature of the water at the dock at the time of water sample collection was 19^{o}C. The temperature outside was 61^{o}F (16^{o}C).

Seven water samples were collected from the surface of Sutton Lake. Three sample containers were filled at each collection site and labeled according to the location at which they were taken. The sample set spanned a wide variety of points on the lake. The containers were taken to the Cape Fear Community College and filtered manually, using syringes and .45 μm filters, in preparation for analysis on the Atomic Absorption / Emission Spectrometer (AAS).

A Varian 240FS Fast Sequential Atomic Absorption / Emission Spectrometer was used in conjunction with SpectrAA Software to analyze the samples after filtration. The instrument was equipped

with lamps to test for cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), silver (Ag), cadmium (Cd), lead (Pb), and zinc (Zn). This AA model is especially efficient because it measures all elements in each sample at once. A simple schematic of atomic absorption spectroscopy is shown below:

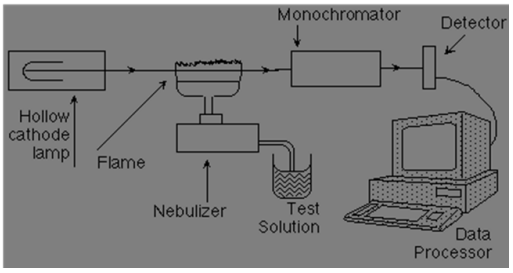


Image credit: New Mexico State University

AA Lamps

The following hollow cathode lamps were used to test for their respective metals in the samples:

Co/Cr/Cu/Fe/Mn/Ni (10 Voltage)		
Co	240.7 nm	0.2 slit
Cr	425.4 nm	0.5 slit
Cu	324.8 nm	0.2 slit
Fe	248.3 nm	0.2 slit
Mn	279.5 nm	0.2 slit
Ni	232.0 nm	0.2 slit

Ag/Cd/Pb/Zn (5 Voltage)		
Ag	328.1 nm	0.5 slit
Cd	228.8 nm	0.5 slit
Pb	217.0 nm	1.0 slit
Zn	213.9 nm	1.0 slit

These metals are all found in coal and many of them are released in the burning of coal (Heavy Metals and Coal).

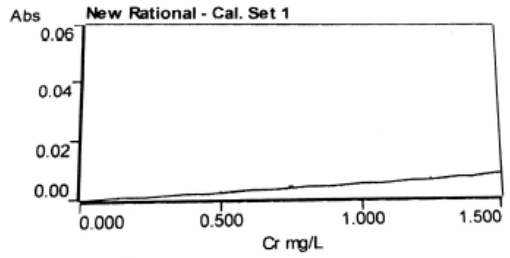
The filtered samples were analyzed using the AA machinery and software detailed above. The calibration curves used were provided by the CFCC lab as well as standards. Samples were run in the machine after an initial run of deionized water and a standard check run, in the order of 1a, 1b, 1c, etc. with deionized water run in between each new sample number. In total, seven separate samples were run; 1a through 8c, with the exception of 3a, 3b, and 3c due to the fact that these sample containers were not used. Three other samples labeled 31-33 were also completed. The team thought it would be interesting to see the data from the water fountain found near the Chem Tech Lab.

Data:

The metals Cr, Mn, Ni, Ag, Cu, Fe, Co, Cd, Sb, Zn, and Pb were tested in the samples from Sutton Lake. The following are the calibration curves for each of the metals that were tested:

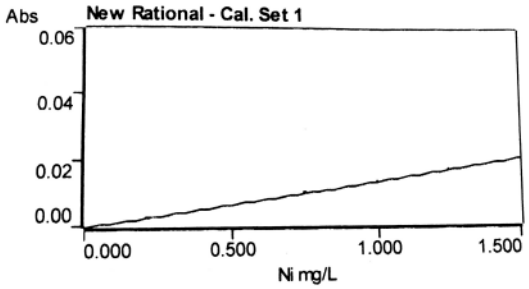
Analyst	
Date Started	10:00 AM 3/12/2015
Worksheet	2015 Hoggard Sutton Lake
Comment	
Methods	Cr,Mn,Ni
Computer name	N305-09
Serial Number:	AA0910M072

Method: Cr (Flame)



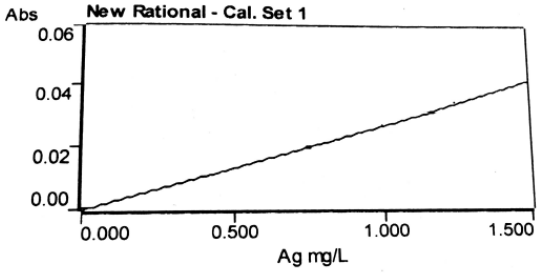
Curve Fit = New Rational
Characteristic Conc = 0.929 mg/L
r = 0.9994

Method: Ni (Flame)



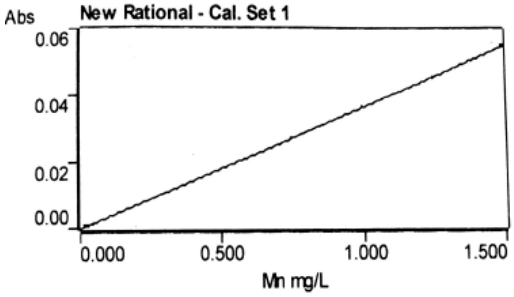
Curve Fit = New Rational
Characteristic Conc = 0.359 mg/L
r = 0.9984

Method: Ag (Flame)



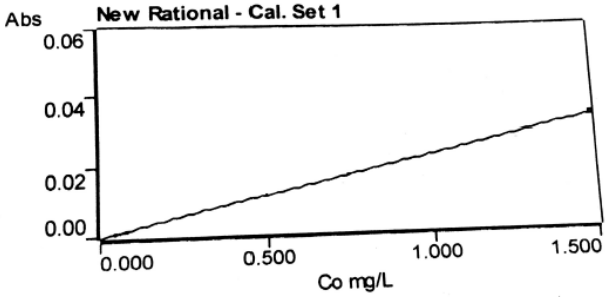
Curve Fit = New Rational
Characteristic Conc = 0.172 mg/L
r = 0.9999

Method: Mn (Flame)



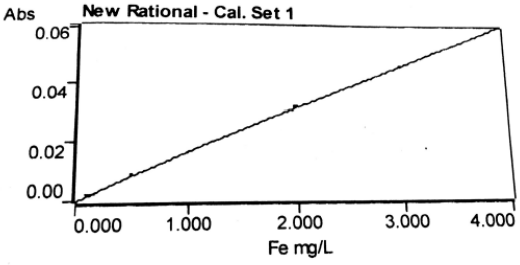
Curve Fit = New Rational
Characteristic Conc = 0.125 mg/L
r = 0.9999

Method: Co (Flame)

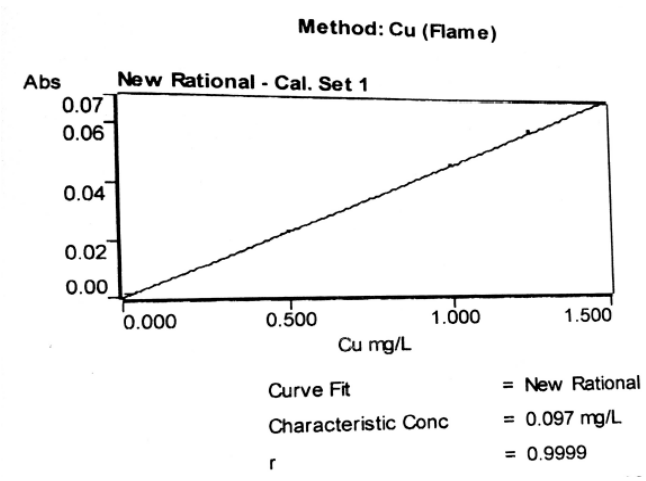


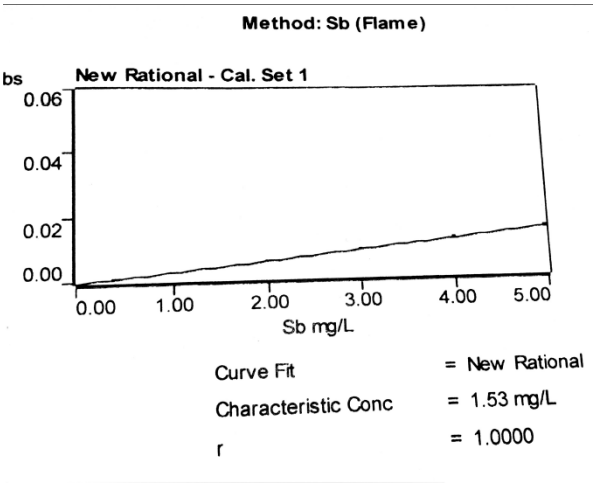
Curve Fit = New Rational
Characteristic Conc = 0.198 mg/L
r = 1.0000

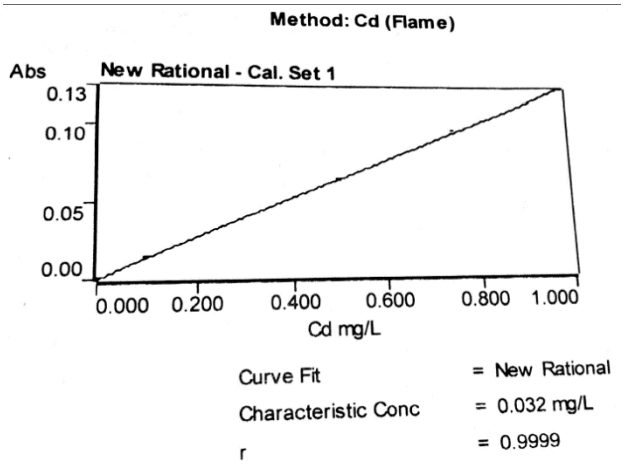
Method: Fe (Flame)

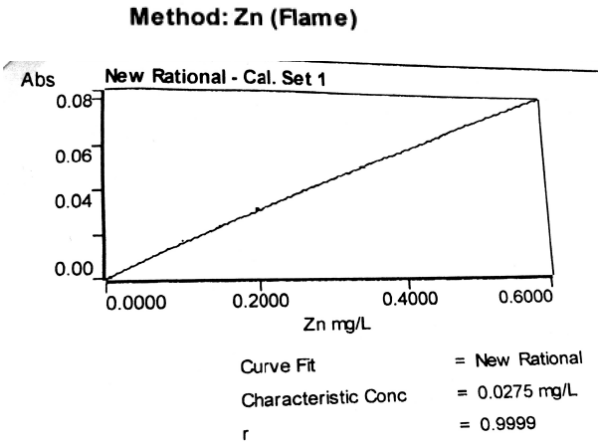


Curve Fit = New Rational
Characteristic Conc = 0.270 mg/L
r = 1.0000



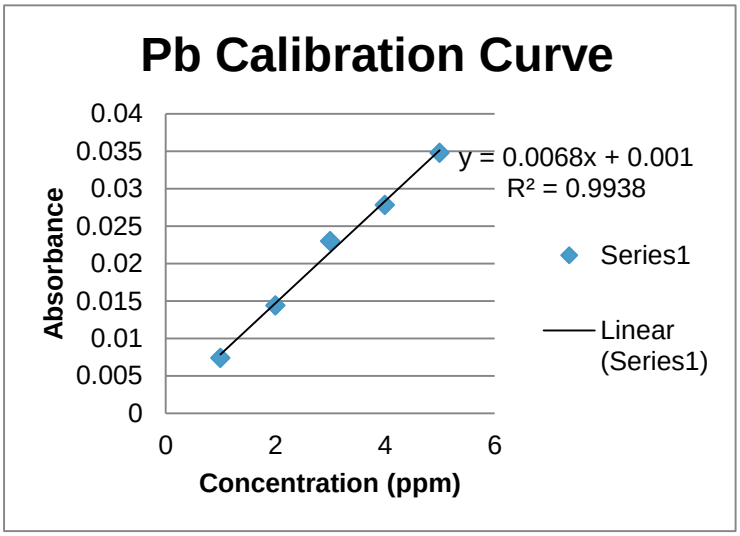






The calibration curves were completed prior to the samples being analyzed.

The curve for lead is also included. Pb was added on a later date as the group decided that the Pb concentrations were very important addition to our data. All of the data were entered into Excel so that averages could be determined. (The AAS does not export into Excel.) The following page is the data from the analysis of the samples.



	Cr	Mn	Ni	Ag	Cu	Fe	Co	Cd	Sb	Zn	Pb
	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	Conc mg/L	ppm
DI Water	0.000	0.030	0.217	0.017	0.023	0.122	0.060	0.005	0.42	0.0000	0.11
Check Standa	0.427	0.566	0.772	0.696	0.836	1.139	0.794	0.259	2.52	0.1527	
Sample 1a	0.000	0.069	0.271	0.011	0.037	0.150	0.030	0.000	0.00	0.0000	0.01
Sample 1b	0.000	0.070	0.257	0.010	0.044	0.176	0.007	0.000	0.00	0.0000	0.13
Sample 1c	0.000	0.065	0.292	0.009	0.041	0.159	0.000	0.000	0.00	0.0000	0.09
DI Water	0.000	0.050	0.163	0.014	0.028	0.105	0.000	0.000	0.00	0.0000	
Sample 2a	0.000	0.055	0.140	0.018	0.057	0.116	0.000	0.000	0.00	0.0000	0.16
Sample 2b	0.000	0.045	0.054	0.014	0.038	0.121	0.000	0.000	0.00	0.0000	0.14
Sample 2c	0.000	0.052	0.079	0.016	0.036	0.128	0.000	0.000	0.00	0.0000	0.14
DI Water	0.000	0.045	0.077	0.017	0.028	0.091	0.002	0.000	0.00	0.0000	
Sample 4a	0.000	0.050	0.064	0.015	0.043	0.115	0.000	0.000	0.00	0.0000	0.06
Sample 4b	0.000	0.051	0.071	0.020	0.052	0.124	0.000	0.000	0.00	0.0000	0.03
Sample 4c	0.000	0.051	0.052	0.013	0.028	0.114	0.000	0.000	0.00	0.0000	0.06
DI Water	0.000	0.037	0.065	0.016	0.031	0.108	0.000	0.000	0.00	0.0000	
Sample 5a	0.000	0.052	0.071	0.018	0.037	0.142	0.000	0.000	0.00	0.0000	0.11
Sample 5b	0.000	0.049	0.168	0.022	0.038	0.166	0.000	0.000	0.00	0.0000	0.15
Sample 5c	0.000	0.045	0.117	0.019	0.045	0.170	0.000	0.000	0.00	0.0000	0.26
DI Water	0.000	0.042	0.158	0.020	0.035	0.131	0.022	0.000	0.00	0.0000	
Sample 6a	0.000	0.042	0.165	0.023	0.039	0.145	0.000	0.000	0.00	0.0000	0.08
Sample 6b	0.000	0.049	0.185	0.023	0.038	0.136	0.000	0.000	0.00	0.0000	0.11
Sample 6c	0.000	0.045	0.168	0.021	0.037	0.152	0.000	0.000	0.00	0.0000	0.07
DI Water	0.000	0.039	0.201	0.018	0.026	0.129	0.000	0.000	0.00	0.0000	
Sample 7a	0.000	0.045	0.194	0.020	0.037	0.157	0.000	0.000	0.00	0.0000	0.17
Sample 7b	0.000	0.043	0.198	0.024	0.045	0.164	0.000	0.000	0.00	0.0000	0.11
Sample 7c	0.000	0.047	0.187	0.023	0.035	0.151	0.000	0.000	0.00	0.0000	0.07
DI Water	0.000	0.039	0.166	0.025	0.028	0.124	0.000	0.000	0.00	0.0000	
Sample 8a	0.000	0.039	0.207	0.023	0.041	0.153	0.000	0.000	0.00	0.0000	0.2
Sample 8b	0.000	0.039	0.120	0.019	0.035	0.163	0.000	0.000	0.00	0.0000	0.17
Sample 8c	0.000	0.041	0.197	0.022	0.042	0.188	0.000	0.000	0.00	0.0000	0.17
DI Water	0.000	0.039	0.192	0.645	0.795	1.081	0.724	0.250	1.34	0.1289	
Standard 1	0.572	0.566	0.725	0.028	0.03	0.123	0.021	0.000	0.00	0.0000	
Sample 032	0.000	0.032	0.182	0.031	0.206	0.134	0.008	0.000	0.00	0.0000	
Sample 033	0.000	0.027	0.167	0.027	0.211	0.113	0.000	0.000	0.00	0.0000	
Sample 034	0.000	0.036	0.218	0.039	0.218	0.120	0.005	0.000	0.00	0.0000	

The results for each letter of each sample were averaged to get the reported concentrations.

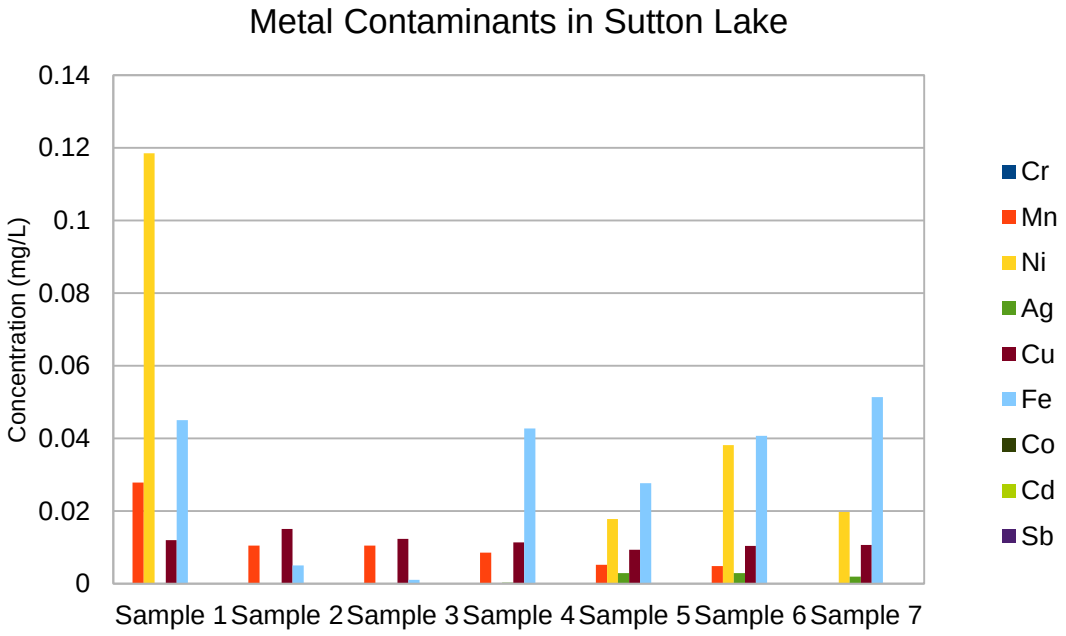
Conclusion

The results showed no significant contamination of the metals that were analyzed.

Metal	Average Concentration (mg/L)
Cr	0.000
Mn	0.010
Ni	0.000
Ag	0.000
Cu	0.012
Fe	0.031
Co	0.000
Cd	0.000
Sb	0.000
Zn	0.000
Pb	0.000

However, we are not at liberty to say that there is no metal contamination in Sutton Lake. For future research, it is recommended that the metals Selenium and Arsenic be tested and sediment from the lake needs to be also analyzed for these metals. These metals are a major indicator of coal ash contamination. The AAS lamp for Selenium was not available for use. The test for Arsenic is a long arduous process that requires much preparation and is beyond the scope of this research group. When one looks at the data, a person needs to be totally informed, looking at what these small numbers mean. One also need to consider that not all metals are bad. Selenium is an element that is considered an "essential" element for the human body (Cox).

The group was certain that contaminants would be found, given the recent news of groundwater contamination, and the proximity of Sutton Lake to the coal ash ponds. We were very surprised at the low concentration of metals, and lead in particular as it is another very common element found in coal ash. Samples that were labeled 32-34 were samples that contained the water from the water fountain to use as a comparison.



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