Hydrochemistry at the Durbin Agricultural Wetland in McLean County, Illinois

INTRODUCTION

Adopting water quality management for a wetland is important for proper removal of nutrients (mainly nitrate) from agriculture tile drains. In Illinois, 23 million acres, nearly 80%, land use is agriculture (Illinois Soy Association 2011) and tile drains, underneath subsurface, move excess nutrient waters from fields to open water sources. Illinois is considered a large nitrogen polluter from agriculture and the effects of excess nitrogen can be seen in the waters of Mississippi River and the Gulf of Mexico (David et. al. 2006). To remove nitrogen in the system, denitrification must take place where bacteria change the nitrate into nitrogen gas (Machefert and Dise, 2004), or nitrification if oxygen levels are high (Duran de Bazua et. al 2008), or plants uptake (Wadzuk et. al. 2010) which need to stay in contact with nutrients and the water for a long duration. Nitrate concentrations are removed through the use of wetlands.

A cost effective way to treat nutrient (nitrate) water is by building constructed wetlands, which mimic natural wetlands processes (Becerra-Jurado et. al. 2011; Tencer et.al. 2009). Wetlands were rebuilt because agricultural land in Midwest replaced natural wetlands to reduce nutrients (Rogers et. al. 2009). Wetlands are sinks to remediate nutrients before entering into water bodies (Bozic et al. 2013; Tencer et. al. 2009). Once the water flows into the wetland, the remediation of nitrate is based on the duration and contact with water.

The purpose of the project is to understand and use good groundwater and surface water field sampling practices to analysis the wetland’s overall water chemistry, specifically the comparison between the types of water (i.e. groundwater, surface water) to the wetland. Secondly, the project will look at the comparison between the upstream and downstream chemistry. Lastly, the project will look at the wetlands effectiveness to remove cations and anions by comparing the east; where water enters, and west; where water exits, of wetland.

METHODS

Field investigation focuses on the Durbin wetland located 56.3 km (35 miles) east of Normal/ Bloomington, Illinois in McLean County; $40^{o}30'22.61$ N and $88^{o}36'21.63$ W. The wetland (Figure 1) was built to treat the excess nutrients, nitrate, transported by tile drains from surrounding farm fields. Construction of the wetland includes an overflow wetland for additional water storage. Field collection was done on April 10, 2014 at the Durbin wetland. In the field, hydrologic field measurements using a water level meter and YSI-85 salinity- conductivity meter were used to collect; water to depth, temperature, dissolved oxygen, specific conductivity, and salinity. All the water samples were filtered in the field and put into sampling bottles; which were later refrigerated and analyzed within a four day period. Water samples were collected at 13 locations including wells, stream, and wetland (Figure 1). Water samples were taken at each location with one duplicate collected during each sampling site.

ANALYSIS

Analysis was done on cations and anions using the ion chromatograph (IC) in the Geology Department (anions: nitrate, sulfate, phosphate, and chloride) and Biology Department (cations: ammonium, magnesium, and sodium) at Illinois State University, Normal, Illinois. Also, nitrate and phosphate were tested on the flame injection analysis (FIA) in the Biology Department. Quality Assurance (QA) and quality control (QC) were used during analysis for water samples by running blank and duplicates; the analytical error was less than 3%. The analysis was done with a with a 99% confidence. Statistical analysis was done on mean/ANOVA to look for types of water significantly similar to the cations and anions. ANOVA results indicated significant difference ($p<0.05$) and were compiled in Excel 2010.

RESULTS & DISCUSSION

Thirteen samples were collected at the Durbin wetland. There are nine groundwater samples from wells, a sample each of the east and west bank of the wetland, and a sample of upstream and downstream from wetland (Figure 1). The samples were analyzed for ammonium, sodium, magnesium, nitrate, chloride, sulfate, and phosphate (Table 1). All the cations analyzed are above the standard calibration and future samples will need to be diluted. When comparing the water types, the significant difference was with chloride and sodium ($p<0.001$ and $p<0.0164$ respectively). Figure 2, sodium only shows difference between surface water and wetland. However, in Figure 3 chloride differences between groundwater and wetland to surface water. This suggests water chemistry for wetland is over all similar to both surface water and groundwater except for sodium and chloride concentrations. On the other hand, the wetland is overall chemically similar to groundwater. The high concentrations were found in the surface water (streams).The sodium and chloride difference could be the deicing salts of the roads and explains the high concentrations of sodium and chloride in stream compared to the low concentrations in the wetland.

Another comparison was made on the effectiveness of the wetland to sink or lower concentrations. Analysis was done on the east bank and west bank (Figure 1) to capture the overall change (Table 1). Figure 4, clearly shows the east where water comes into, has higher concentrations and concentrations decrease as a result of west analysis. Except for sodium, chloride, and sulfate. Chloride and sodium increase is based on salting of winter roads and sulfate could be agricultural runoff or surrounding rock bodies. Even though there is not a huge decrease in nitrate the wetland does lower the concentration by 0.88 mg/L. The wetland is limiting nitrate but not greatly. More analysis would need to be done in more locations than one for better representation on how effective the wetland is in limiting concentrations.

The last analysis done was the comparison between upstream and downstream. This will show if the wetland increases concentrations or help limit overall concentrations. Samples were collected up stream of wetland and downstream of wetland (Figure 1). The analysis was done with cations and anions for comparison (Table 1). Upstream started with higher concentrations and decreased downstream (Figure 5). Again the levels of chloride, and sulfate increased instead of decreasing. This results show the wetland does not increase concentrations to the stream. Since wetlands are meant to reduce nutrient loading in water bodies, the wetland lowered concentrations. The analysis does not show how much and further analysis from the stream could be done to justify effectiveness of the wetland.

In conclusion, the wetland is hydro chemically similar to groundwater. The streams had higher concentrations of sodium and chloride; which could be the deicing of roads during winter. Also the stream's overall concentrations decrease downstream; which suggest the wetland is not loading the stream. The wetland was built to reduce the nutrients in open water sources and the effectiveness is important for water quality management of a wetland. The wetland was decreasing concentrations but effectiveness is not understood. Further analysis of the wetland would be needed in multiple locations around wetland, up and down stream, and dilution of water samples for proper analysis.

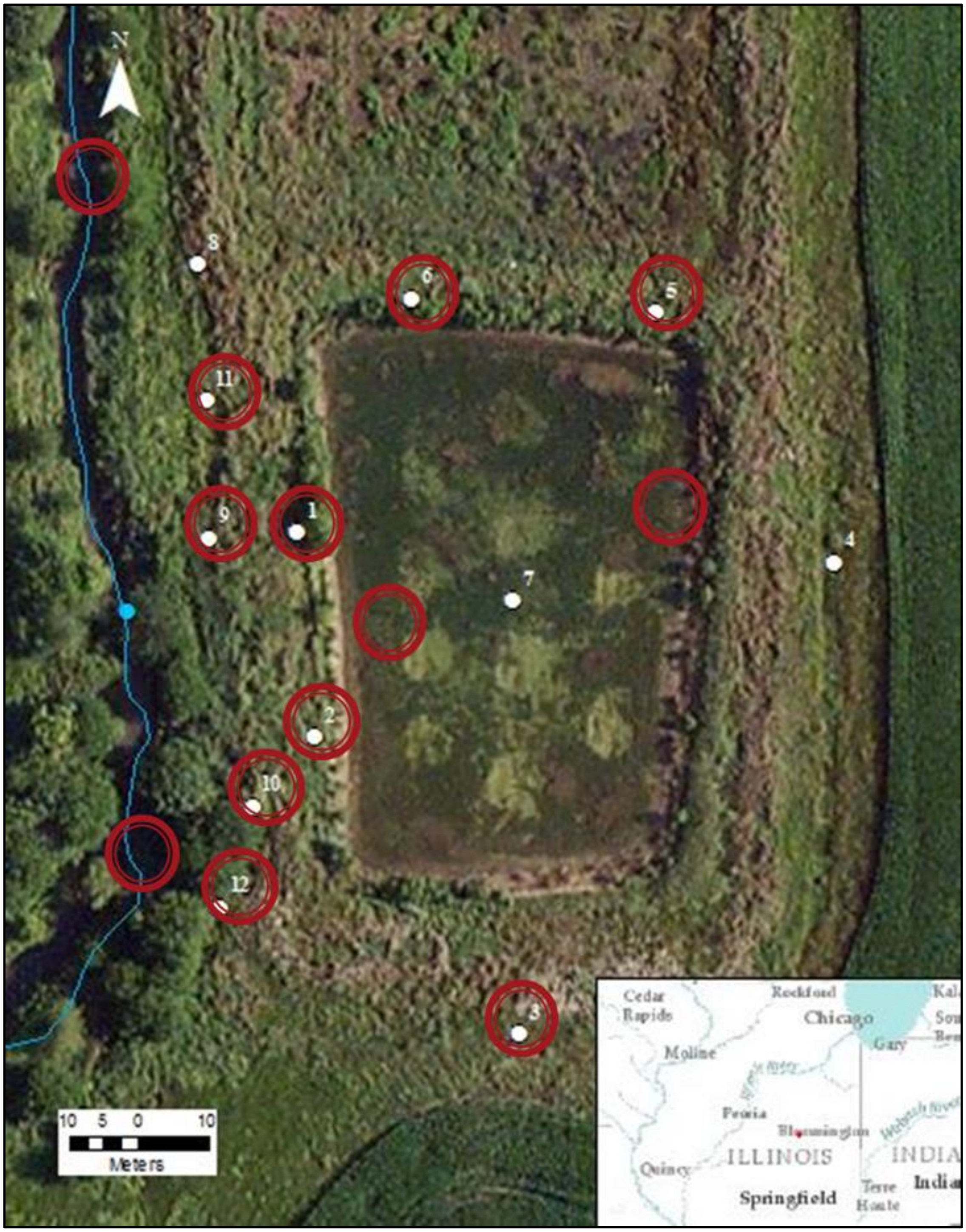

Figure 1: Areal view of Durbin wetland. The blues line is the stream located west of wetland. The white solid circles are the observation wells and the red hollow circles are the water sampling sites taken for analysis.

Table 1: Cations and anions concentrations analyzed for wells, stream, and wetland for the comparison between water types.

TYPE	**LOCATION**	**Na^+**	**Mg^{2+}**	**NO_3^-**	**Cl^-**	**SO_4^{2-}**	**PO_4^{3-}**
		mg/L	mg/L	mg/L	mg/L	mg/L	µg/L
Groundwater	Well 1	331	122	53.04	13.74	11.82	4.88
Groundwater	Well 2	219	187	61.83	15.03	11.56	8.15
Groundwater	Well 3	165	181	68.86	15.31	12.23	18
Groundwater	Well 5	176	190	52.16	15.49	12.39	10.6
Groundwater	Well 6	181	123	58.6	15.05	12.12	4.84
Groundwater	Well 9	428	146	41.9	14.61	17.81	21.9
Groundwater	Well 10	174	181	17.84	22.55	18.25	21.3
Groundwater	Well 11	337	217	3.9	21.24	49.79	20.7
Groundwater	Well 12	249	286	10.49	18.94	15.80	7.61
Wetland	West	131	135	71.79	16.99	73.91	-0.74
Wetland	East	104	149	72.67	15.74	12.29	6.76
Surface Water	Down Stream	383	142	36.63	38.34	27.97	7.54
Surface Water	Up Stream	461	209	36.92	37.91	27.54	5.76

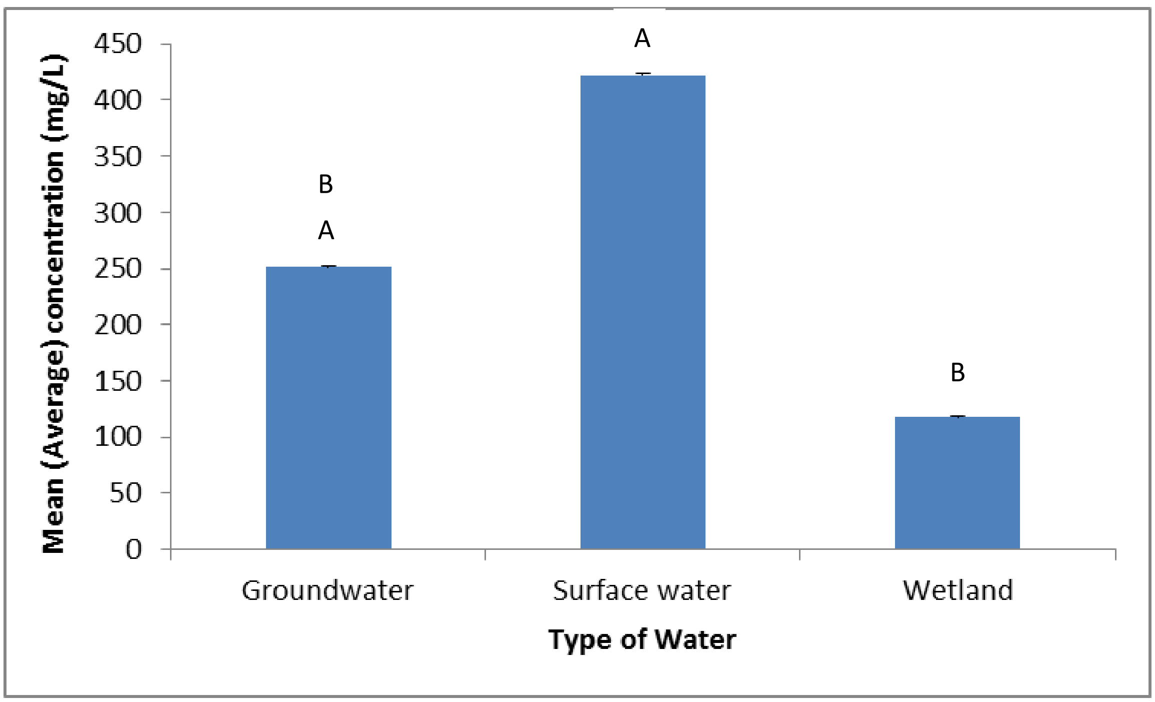

Figure 2: Mean average sodium concentration compared to water types. Significant difference analysis; where A is similar to A and B similar to B. Therefore A≠B.

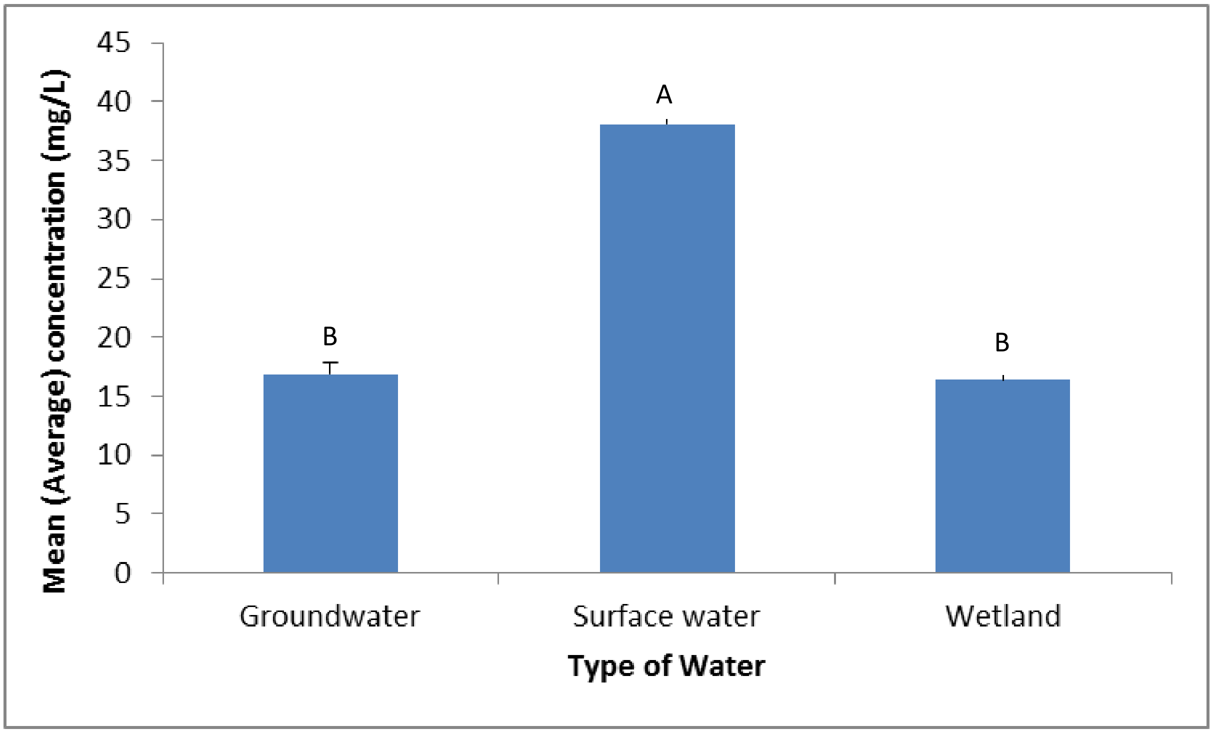

Figure 3: Mean average chloride concentration compared to water types. Significant difference analysis was used; where A is similar to A and B similar to B. Therefore A≠B.

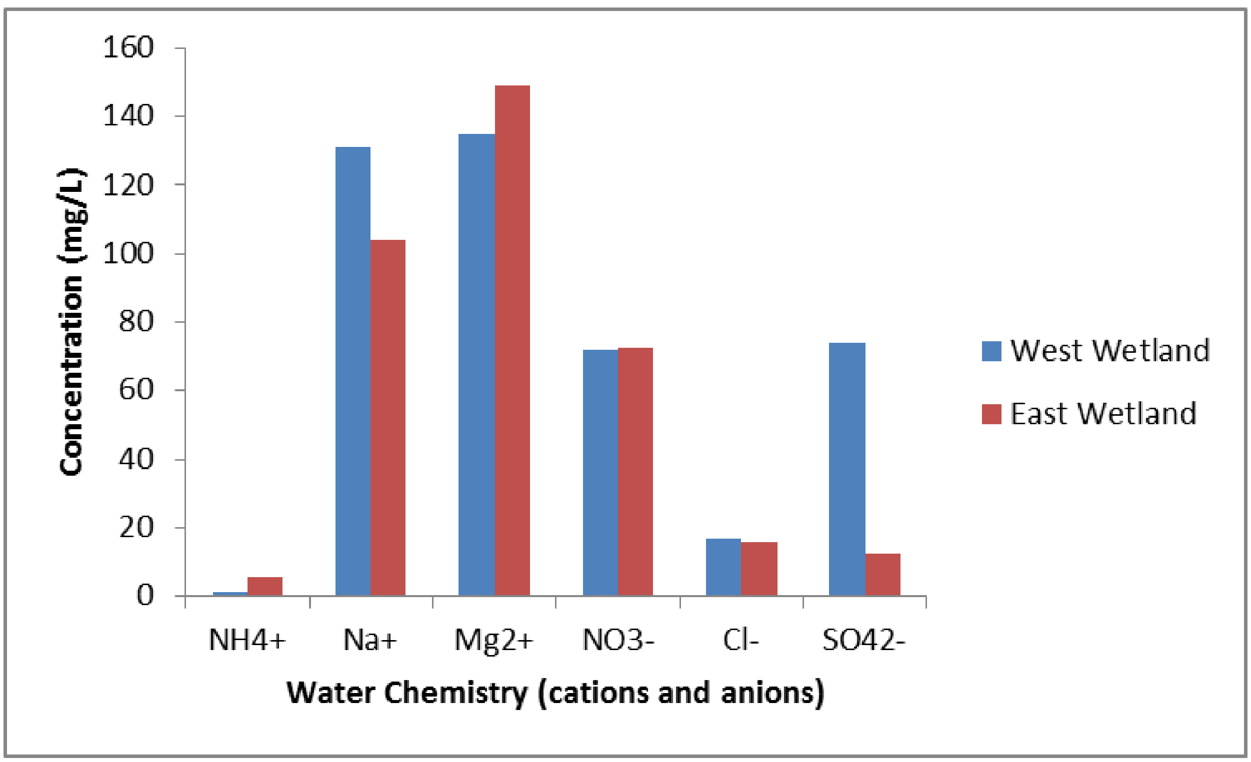

Figure 4: Comparative of the east bank sample and west bank concentrations for the cations and anions.

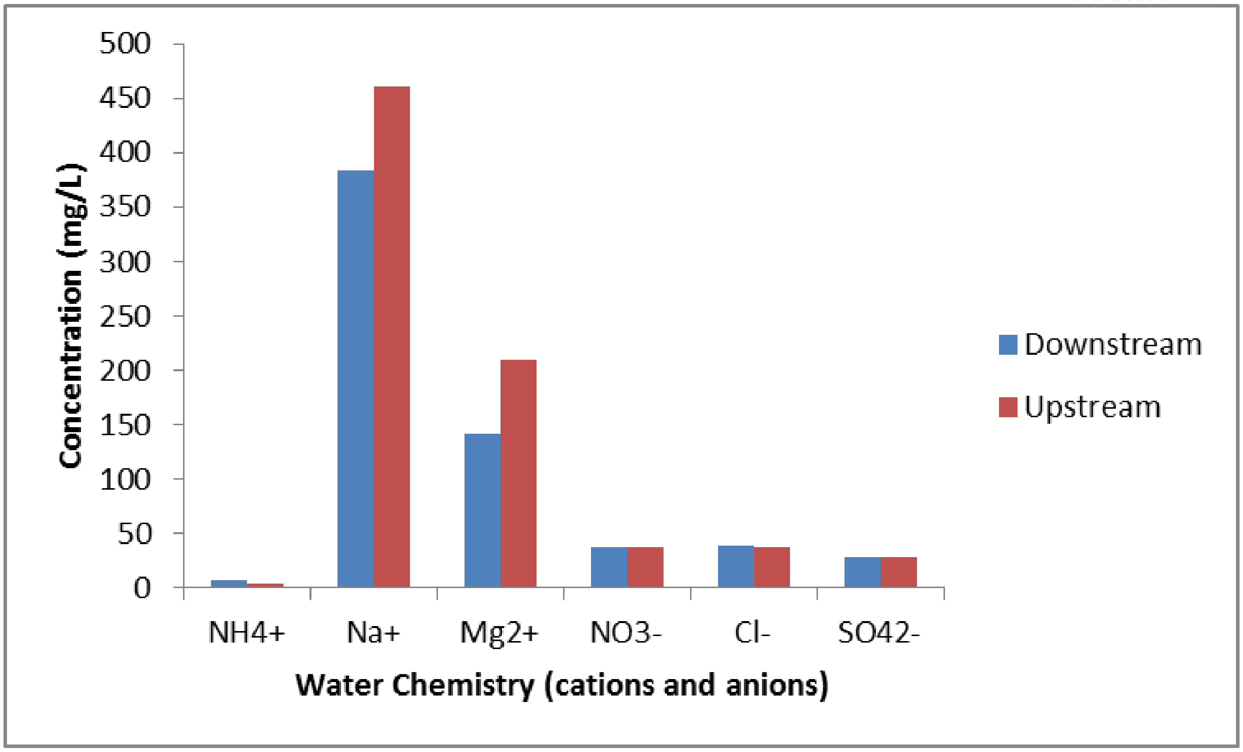

Figure 5: Comparative of the upstream and downstream concentrations of cations and anions.

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