

# Unusual Alkalinity in Lake Carl Blackwell, Oklahoma.

Dale Toetz

Zoology Department, Oklahoma State University, Stillwater, Oklahoma 74078

During a study of stable isotopes in Lake Carl Blackwell, Oklahoma, total alkalinity (TA) was measured at four stations over its thalweg during 2007. Based upon historical lake data, mean TA was four-five times higher than expected in February. Between then and September mean TA declined linearly from 10.8 to 2.29 meq/l. Baseline alkalinity in 1980-1981 was 2.40 to 2.96 meq/l. It is suggested that the decline in TA was caused mainly by evasion of CO<sub>2</sub> to the atmosphere. High TA may have been caused by mobilization of sedimentary carbonates by CO<sub>2</sub> at low water levels. Alternative sources of carbonates may have been anthropogenic. © 2012 Oklahoma Academy of Science.

## INTRODUCTION AND METHODS

Recently, it has been proposed that impoundments are far more important in global carbon cycling than initially believed because of their unappreciated large aerial extent and their capacity to trap carbon in their sediments (Tranvik, et al. 2009, Downing, et al. 2006 and others). Both large and small reservoirs are ubiquitous in Oklahoma, but their carbon cycles have not been well described. To close this gap the temporal and spatial distribution of the stable isotope,  $\delta^{13}\text{C}$ , was described for Lake Carl Blackwell (LCB) (Toetz, et al. 2009). However, detailed analysis of total alkalinity (TA) concentrations, which were collected to support the interpretation of the stable isotope data, were not done. Usually, seasonal changes in TA in lakes are modest and often predictable. However, in the research above a much higher TA was observed when samples were first collected and thereafter a much more rapid change in TA was observed than was expected based upon historical lake data. The purpose of this paper is to describe this phenomenon and suggest its cause.

Lake Carl Blackwell is located in Payne County, Oklahoma. There is no major groundwater input. Its area is 1250 ha and

has a maximum depth of 15.0 m and a mean depth 4.9 m. High turbidity is maintained by resuspension of sediments augmented by strong winds and shallow depth.

## MATERIALS AND METHODS

Sampling of the lake and laboratory methods have been previously described (Toetz, et al. 2009). Only those aspects that pertain to this paper are given. LCB was sampled at four stations over the thalweg approximately monthly between February and September, 2007.

Samples were taken at 0.5 and 3 m with a Kemmerer bottle and pooled to obtain a composite water sample at all stations, except for the most upstream one where samples were taken at one meter. Filtered water (0.5  $\mu\text{m}$  pore size) was used the same day or the next to determine total alkalinity (TA) which was measured by titration with 0.02 N H<sub>2</sub>SO<sub>4</sub> to an endpoint of pH 4.8. Linear regression was performed with an Excel 2003 spreadsheet.

## RESULTS AND DISCUSSION

Mean TA decreased from 10.80 to 2.29 meq/l between February and September (Table 1). The relationship of TA with time (days) was negative and significant (slope = - 0.04,  $P < 0.00$ ,  $n = 24$ ,  $R^2 = 0.96$ ). Between February

**Table 1. Mean total alkalinity at four stations during 2007 in Lake Carl Blackwell, Oklahoma. Standard errors are in parentheses.**

Date	Mean Total Alkalinity meq/l
February 25	10.80 (0.27)
May 16	8.27 (0.18)
June 20	6.47 (0.65)
July 20	3.39 (0.10)
August 24	3.77 (0.16)
September 24	2.29 (0.03)

and September, 1981, there was a slight increase in TA from 2.42 to 2.96 meq /l (Howick, et al. 1984). Surface waters of hard-water lakes often exhibit a small reduction in TA caused by photosynthetic withdrawal of CO<sub>2</sub>, but the magnitude of the decline is only a few meq/l (Otsuki and Wetzel, 1974 and others).

TA in lake water is affected by exchange of carbon dioxide (CO<sub>2</sub>) with the atmosphere, inputs from weathering in soils in the watershed, by stream flow or groundwater, photosynthetic withdrawals of CO<sub>2</sub>, additions from respiration, and losses in effluents or sediments (Bade et al. 2004, Quay et al. 1986 and others). A carbon budget would be desirable to explain the decline in TA we observed. Nevertheless, the linear decline in TA during 2007 suggests that the major factor responsible for it operated at a constant rate for seven months and might be due to some physical factor such as evasion of CO<sub>2</sub> from the surface of the lake and precipitation of calcite to the sediments. In many lakes CO<sub>2</sub> is supersaturated with respect to the atmosphere and some lakes experience seasonal evasions of CO<sub>2</sub> (Wetzel, 2001, Quay, et al. 1986, Finlay, et al. 2009 and others). However, some loss of TA could also have been due to loss in effluents and dilution by influents. It is possible that

in February the CO<sub>2</sub>-bicarbonate-carbonate system was not in equilibrium with the atmosphere and that there was a return to equilibrium conditions by September.

The high concentrations of TA observed in February may be due to by high concentrations of CO<sub>2</sub> and some source of carbonates in lake water that occurred at low water levels before 2007. At low water levels, LCB can be heterotrophic (Carroll 1975). This could lead to an ample supply of "aggressive" CO<sub>2</sub>, which would cause solid carbonates in the lake to dissolve. But, what would be a source of carbonates that "aggressive" CO<sub>2</sub> might attack?

Prior to 2007 sources of carbonate could have been natural (calcite in sediments) or anthropogenic. There was addition of rocks and broken concrete to the rip-rap of the dam and the construction of new breakwaters. There were also a large pile of broken concrete and dry-wall from building demolition that was deposited near the shore. Another source might have been deposition of aeolian dust from roads and/or concrete-mixing plants near the lake. Aeolian dust can be a source of calcite and as a result increase the alkalinity of acidic soils (Litaor 1986). Although the reason(s) for high TA in February will never be known, the abrupt decline in TA can be best explained by an equally abrupt cessation of input(s) of carbonate from anthropogenic sources.

#### ACKNOWLEDGEMENTS

This research was supported by the Ecotoxicology and Water Quality Research Laboratory and the Department of Zoology, Oklahoma State University. I thank Naomi Cooper (Zoology Department) for water chemistry analyses and Emily Oehlert (Oklahoma City, OK) for technology assistance.

#### REFERENCES

- Bade DL, Carpenter SR, Cole JJ, Hanson PC, Hesslein RH. 2004. Controls of δ<sup>13</sup>C -DIC in lakes: Geochemistry, lake metabolism and morphometry. *Limnol Oceanogr* 49:1160-1172.

- Carroll, JH. 1975. A comparison of two *in situ* methods for determining community metabolism of lakes and horizontal variation of primary production in Lake Carl Blackwell, Oklahoma. [MSc] Thesis: Stillwater (OK): Oklahoma State University. 72 p. Available from OSU library.
- Downing JA, and others. 2006. The global abundance and size distribution of lakes, ponds, and impoundments. *Limnol Oceanogr* 51:2388-2397.
- Finlay K, Leavitt PR, Wissel B, Prairie YT. 2009. Regulation of spatial and temporal variability of carbon flux in six hard-water lakes of the northern Great Plains. *Limnol Oceanogr* 54:2553-2564.
- Howick G, Wilhm J, Burks S, Toetz, DW. 1983. Feasibility study for the restoration of Lake Carl Blackwell. Report to the Oklahoma Water Resources Board, Oklahoma City, OK. 320 p.
- Litaor MI. 1986. The influence of eolian dust on the genesis of alpine soils in the Front Range, Colorado. *J. Soil Sci Soc Am* 51: 142-147.
- Otsuki A, Wetzel RG. 1974. Calcium and total alkalinity budgets and calcium carbonate precipitation of a small hard-water lake. *Archiv Hydrobiol* 73:14-30.
- Quay PD, Emerson SE, Quay BM, Devol AA. 1986. The carbon cycle for Lake Washington, a stable isotope study. *Limnol Oceanogr* 31:596-611.
- Toetz DW, Bidwell JR, Payton ME. 2009. Temporal and spatial variation in stable isotopes of carbon and nitrogen in Lake Carl Blackwell, Oklahoma. *J Freshwater Ecol* 24: 461-467.
- Tranvik LJ, and others. 2009. Lakes and reservoirs as regulators of carbon cycling and climate. *Limnol Oceanogr* 54:2298-2314.
- Wetzel RG. 2001. *Limnology: lake and river ecosystems*. 3<sup>rd</sup> Ed., San Diego, CA: Academic Press. 1006 p.

Received: July 16, 2012; Accepted September 27, 2012.

