File summary of Cayuga lake and its watersheds (Was sumtran) (draft 3/5/12)

Summary of Cayuga Lake and its watersheds 1927 to 2008

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Abstract

The data base consisted of Cayuga Lake data from 1927, 1968-1974 and 2000 to 2008 and water shed data from 1972 through 2008 – overall on the order of more than 2000 samples. An excel spreadsheet was developed to analyze this data as a calcium-carbonate-phosphate system and interactions with biomass and chemical precipitation.

First, as is well known, the Lake is a huge reservoir containing an amount of water equal to 10 years of runoff. This means consequences of changes in watersheds occur gradually but once changed are difficult to reverse.

Second, calcium carbonate chemistry of the lake has not changed 1927 to 2008. ALL (1927 to 2008) of the calcium carbonate parameters fit nicely on one cluster of points around one line. The stream water deviates slightly from the lake data but clearly belongs to the same "family".

Third, for the stream data, concentrations of phosphate, nitrate and sediment increases as flow increases and the relation between flow and concentrations has not changed 1972-2008.

Fourth, the most reactive phosphate fraction in lake samples (1968-1974 plus 1999-2008) fits within a framework defined by slightly soluble calcium phosphates. As pH increases, the solubility decreases. This provides a feed back mechanism which reduces the impact of inputs of phosphate; photosynthesis reduces the total inorganic carbon in solution and increases pH which in turn decreases solubility and slows photosynthesis. Stream samples do not conform to this framework.

Fifth, the concentration of most soluble phosphate fractions of stream water, mixed with inputs from waste water treatment and lake source cooling, decreased by a factor of more than 2 as measured by sampling within 100 m from stream input and to about the concentration of bulk lake in samples at 1000 m from inlet. This is hypothesized due to some unknown combination of dispersion, biological immobilization and precipitation. Clearly, the changes within 1000 m from the inputs transformed the water into something very nearly like bulk lake water. Don't mess with the inlet until we understand these transformations.

Sixth, for future monitoring of streams, the Impact of flow and seasonal effects **must include samples from all flow regimes and seasons** or else misleading / useless data will be collected.

Seventh, there are many discrepancies between observations and expectations based on solubility of mineral forms of calcium carbonates and calcium phosphates. But these relationships are not happenstance – so what is the basic chemistry?

Background

In 1972 a project was initiated to study the impact of human activity on water quality in NY with partial funding from the Rockefeller Foundation. Over the next 5 years a multidisciplinary group studied social, economic, and environmental aspects of human activities in central NY and summarized their findings in a book which influenced and influences applied research and extension. I was very fortunate to be part of that work and subsequently I have continued to study water quality in central NY periodically to 2008. During the initial work, Dr R.T. Oglesby introduced us to the limnology of lakes (Cayuga Lake in particular) and I have continued to work on understanding interactions between Cayuga Lake and its watersheds.

The several parts of this summary of Cayuga Lake and its watersheds follows:

First,"Fall Creek, stream and watersheds". Power point slides of Fall Creek and landscapes. This is an orientation to the physical aspects of one of the most important of the many watersheds which flow into Cayuga Lake.

Second, ”Nitrogen flows in Fall Creek Watershed” which is a summary of the nitrogen in the stream and sub-watersheds. 1972-2008. This watershed and some of the sub-watersheds are typical of those in other parts of NY.
Third, “Description of calculations of chemistry of stream and lake samples”. This is simply an application of basic chemistry to calcium carbonates and calcium phosphates and electroneutrality of solutions.
Fourth, poster “Cayuga lake and its watersheds, 1927-2008” Summary of data from several hundred samples from Cayuga Lake and Fall Creek from 1927 to 2008.
Fifth, “Transition from stream water to lake water. Phosphate in the south shelf of Cayuga Lake”. Transformation (Integration) of inputs from streams into the southern end of Cayuga Lake with lake water to a depth of 6m.
Sixth, “Lakes and Phosphorus Inputs” Copy of Information Bulletin 127, published in 1977, which is a summary of the multidisciplinary project referred to above. My name as first in the list of authors is an accident of alphabetical listing: everyone listed there worked very hard on this summary. In my opinion this is very relevant today and I urge you to read it.

Sources of data

Gene E. Likens in 1971-72 monitored stream inputs and input- output balances for Cayuga Lake. Data is published in NTIS, PB231477 and PB231478, copies are in CU Carpenter library.

The best , most complete and monumental data on Cayuga Lake was collected 1968-73. The results are in a report “Ecology of Cayuga Lake and proposed Bell Station” by R.T Oglesby and D. J. Allee, (a copy in CU Mann Library), a thesis by B.J. Peterson and a thesis by Paul J.Godfrey. In all three of the latter publications the raw data is listed including several hundred pages of chemical data and algal data. Chemical data included winter, summer, depths, locations etc.

Several thousand water samples were collected from wells and streams in central NY, 1972-2008, by David Bouldin and colleagues. The raw data, published manuscripts and unpublished manuscripts are available on ecommons: http://hdl.handle.net/1813/2547, ……./1813/8146, …../1813/8148, …../1813/8351, …./1813/9336, …../1813/8380.

The somewhat incomplete but voluminous data collected relative to the Lake Source cooling is available from Cornell University. It is mostly data during the summer months primarily centered on phosphorus in the southern shelf area, 1999-2008.

Most of the data for the calculations of the solution equilibrium were taken from Norstrum et al, Revised chemical equilibrium data for major water – mineral reactions and their limitations., Chapter 31, in ed D.C Melchoir Chemical modeling of aqueous systems II. American Chemical Society. 1990. This includes temperature effects for the carbonate solid phases and equilibrium among the inorganic carbon species.

The publication by Ito etal (J.biomed mater res 36:522-528.1997) furnished guidance on solubility of apatite-like calcium phosphate mineral and influence of solution composition on solubility.