BORON IN FLORIDA WATERS

HOWARD T. ODUM and BRUCE PARRISH
Dept. of Biology, University of Florida

As part of a study of the factors controlling productivity of Florida's constant temperature springs, a few boron analyses were made of waters from springs, lakes and streams to determine if existing boron concentrations were limiting plant growth in Florida's aquatic communities.

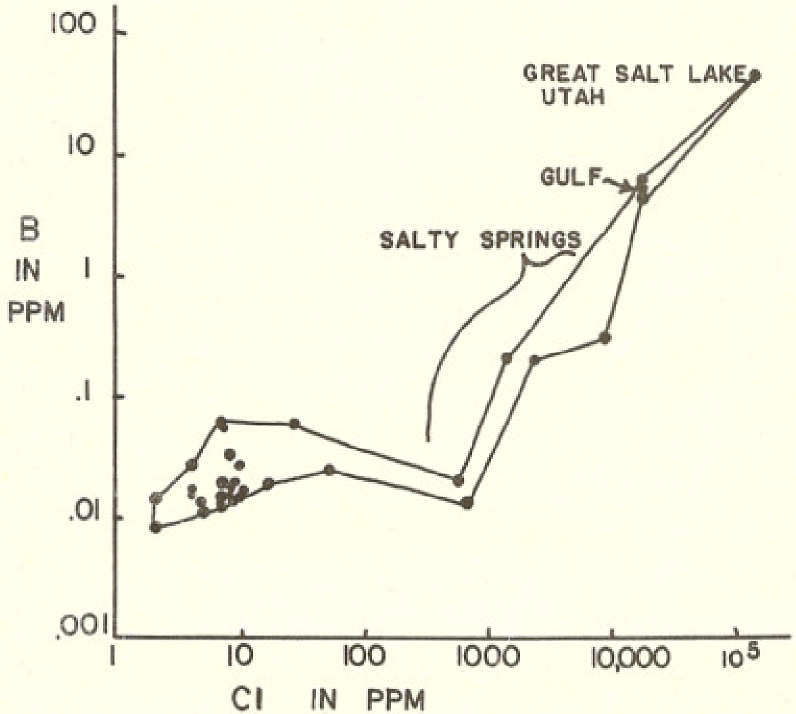
Boron is one of the biologically active minor elements. Boron is present in plant tissues in high concentration relative to the plants substrate (Hutchinson 1943). Like many biologically active elements it is necessary in small concentrations and becomes toxic in larger concentration. (Zittle, 1951.)

Water samples collected in plastic vessels were analyzed for boron with a tumeric colorimetric method modified from Naftel (1939) and Winsor (1948). We are especially grateful to Mr. H. W. Winsor of the Florida Agricultural Experiment Station for showing us his analytical methods and criticizing our results. This method which had been used with heterogeneous soil extracts seemed suitable for natural waters. Repeated analyses of the same sample of water from Silver Springs showed a standard deviation of .00311. Thus the percent error expected in 95% of the analyses is less than 25%.

The data on boron in Florida waters are given in Table I. These data are arranged in order of the chlorinities of the waters. Similar concentrations were found for Hawaiian waters by Tanada and Dean (1942).

As shown in the graph in Figure 1 there is a correlation between the boron and chloride concentrations. This is not a chloride bias effect on the chemical analysis because the three analyses of sea water did not differ radically from the 4.7 ppm usually found by other methods in the open ocean water of chlorinity 19,000 (Sverdrup, Johnson, Fleming, 1946).

Boron can be expected to be associated with chlorides because of some similarities in the geochemical behavior of the two elements. Both tend to be washed out of rock strata rapidly and to become concentrated in the ocean or in the desert lakes of arid regions. Where residual salt water is trapped in pore spaces of sediments and is entering springs and streams in the ground water, both boron and chloride may be expected to be added together. The observed correlation of boron and chloride in Florida waters is probably due to these geochemical similarities. As shown in Table I the ratio of boron to chloride in those waters which receive ground water salt is of the same order of magnitude as that in sea water. Data are given by Odum (1953) showing that the chloride content of fresh water in peripheral Florida below 25 ft. elevation can be accounted for by residual pore space salt from the ground water.



In several springs, especially two Sarasota County springs, Warm Salt Springs, Little Salt Springs, the B/Cl ratio is considerably lower than that in the sea. One possible explanation is that these drain evaporite deposits. Dr. A. P. Black, Dept. of Chemistry, Univ. of Florida, suggested that the high temperature of Warm

TABLE I

Boron in Florida Waters. Chlorinities Determined with the Mohr Method or from Ferguson, et. al., 1947 and B/Cl Ratios Are Given. Great Salt Lake, Utah, is Included for Comparison.

Locality and Date	Boron ppm	Chloride ppm	B/Cl x 10^{-4}
Great Salt Lake, Utah, 1950 (water furnished by Dr. W. Hartmann, Univ. of California)	43.5	149,224	2.9
Sea Water			
Mouth of Tampa Bay, May 30, 1953	4.4	18,700	2.3
Gulf, June, 1953	6.3	19,000	3.3
Gulf, June, 1953	5.4	19,000	2.8
Florida Springs, 1953			
Warm Salt Springs, Sarasota Co., June 17	.30	9,350	.3
Salt Springs, Marion Co., June 14	.20	2,439	.8
Little Salt Springs, Sarasota Co., June 17	.20	1,430	1.4
Blue Springs, Volusia Co., June 19	.125	775	1.6
Ponce DeLeon Springs, Volusia Co., June 19	.055	622	.9
Homosassa Springs, Citrus Co., June 6	.186	570	3.3
Chassahowitzka Springs, Citrus Co., June 20	.024	53	4.5
Silver Springs, Marion Co., May 28			
Boil, mean of 5 replications	.0154	8	19.
¾ mile downstream, mean of 5 replications	.0170	8	21.
¾ mile downstream, mean of 4 samples	.015	8	19.
Sanlando Springs, Seminole Co., June 19	.032	8	40.
Magnesia Springs, Alachua Co., June 10	.015	8	19.
Orange Springs, Marion Co., June 1	.019	7	27.
Weekiwachee Springs, Hernando Co., June 6	.013	5	26.
Ichtucknee Springs, June 9, at Rt. 27 bridge	.017	4	42.
Streams, 1953			
Orange Creek, Marion Co., June 1	.019	9	21.
Fenholloway River, Foley, June 9	.027	4	68.
Suwannee River, Branford, June 9	.012	7	17.
Santa Fe River, High Springs, June 9	.027	10	27.
Hogtown Creek, Gainesville, Rt. 26, May 31	.012	7	17.
Hatchet Creek, Gainesville, Rt. 24, May 31	.015	7	21.
Lakes, 1953			
Morris Lake, Putnam Co., June 1	.011	5	22.
North Twin Lake, Putnam Co., June 1	.013	7	53.
Lady Slipper Lake, Putnam Co., June 1	.016	4	41.
Lochloosa Lake, Alachua Co., June 3	.017	11	15.
Newnans Lake, Alachua Co., May 31	.012	7	17.
Rainwater, thunderstorm, Gainesville, June 14			
Sample No. 1	.009	2	43.
Sample No. 2	.015	----	----

Salt Springs in contrast to most of Florida's springs might be due to the heat of solution. Alternatively some boron in residual salt water may have been removed from the water by the sediments.

In the upland waters which do not receive so much salty ground water the boron content is low. However, the B/Cl ratio is 10 times or more larger than sea water and this raises a problem. Some of the boron like much of the chloride may come from cyclic salt. If representative, the two rainwater analyses suggest that the atmospheric derived boron might be adequate to account for the boron in upland lakes. However, this explanation of the boron content in lake waters requires a differential action in the cyclical salt transfer to account for the high B/Cl. Small amounts of the boron mineral tourmaline are found in some of Florida's sands so that the high B/Cl ratio may alternatively be accounted for by boron received from soils.

In many natural waters inorganic phosphorus is limiting to plant growth. A comparison of phosphorus with boron shows which is more likely to be used up first and thus limiting to growth. The B/P ratio in Silver Springs water is maintained at .35, but the B/P ratio in the aquatic plants (algae coated *Sagittaria*) is .0018. Thus if boron and phosphorus are removed from the water in the ratio found in the plants phosphorus will be used up long before boron.

A trace element may affect the growth rate even when its concentration is not so small as to be limiting. Baumeister (1943) found that .5—100 ppm B had a growth promoting effect on aquatic spermatophytes. Whether the higher boron concentrations in the more salty springs and streams contribute to fertility there is not known definitely.

Literature Cited

BAUMEISTER, W.
1943. Influence of Boron on Photosynthesis and Respiration of Submerged Plants. Jb. wiss. Bot., 91: 242-277. Only an abstract seen (C.A. 39, 1899).

FERGUSON, G. E., LINGHAM, C. W., LOVE, S. K., and VERNON, R. O.
1947. Springs of Florida. Fla. Geol. Surv. Bull. 31.

HUTCHINSON, G. E.
1944. The Biogeochemistry of Aluminum and of Certain Related Elements. Quart. Rev. Biol., 18: 1-29, 129-253, 331-363.

NAFTEL, J. A.
1939. Colorimetric Microdetermination of Boron. Indus. & Engin. Chem., Analyt., Ed., 11: 407-409.

ODUM, H. T.
1953. Factors Controlling Marine Invasion in Florida Waters. Bull. Mar. Sci. Gulf and Caribbean. In press.

SVERDRUP, H. U., JOHNSON, M. W., and FLEMING, R. H.
1946. The Oceans. Prentiss-Hall, N. Y.

TANADA, T., and DEAN, L. A.
1942. Boron in Some Hawaiian Soils and Crops. Hawaii Plant. Rec. 46: 65-74. Only an abstract seen.

WINSOR, H. W.
1948. Boron Microdetermination in Fresh Plant Tissue. Analyt. Chem., 20: 176-181.

ZITTLE, C. A.
1951. Reaction of Borate with Substances of Biological Interest. Advanc. Enzymol. 12: