

## AN EVALUATION OF GENERAL METHODS OF "DEOXYGENATION" OF WATER

RICHARD D. WOOD

*Northwestern University, Evanston, Illinois*

The recent interest in the physiology of aquatic plants and animals has stimulated the application of a technique employing "oxygen deficient" water (Kostychev and Soldatenkow, 1926; Gessner, 1938). One phase which has not received adequate attention is the methods of preparation of this medium.

Three mechanical methods for reduction of the gaseous content of water are in general use: (1) heating, (2) displacement by another gas, and (3) application of partial vacuum. Perhaps to date heating has been the most popular, but is found to disturb chemical and organic factors of natural water. Data are given which indicate the effectiveness of each method.

*Heating.*—One liter quantities of distilled water were heated in a 2 liter Erlenmeyer flask over a Fisher burner which increased the temperature of the water at the rate of about 7°C. per minute. Samples were siphoned off before and after treatment of each quantity into 200ml. flasks. Determinations of dissolved oxygen content were made by the Winkler method. Data are given in table I.

*Nitrogen Substitution.*—One liter quantities of distilled water were placed in a one liter Buchner flask, and nitrogen was bubbled through the water from the bottom. The rate of 0.1 cubic feet per minute was chosen, because preliminary tests indicated that at this rate nearly maximum deoxygenation seemed to be affected per unit time. Samples of water were drawn, and the dissolved oxygen concentration determined as outlined above.

*Partial Vacuum.*—One liter quantities of distilled water were added to a 1 liter Buchner filtering flask which was attached to a mercury manometer by one lateral tube and to an aspirator by a second. Maximum water flow through the pump was used in all experiments, and reduced the air pressure in the flask from 756.1 mm. Hg. to 16.1 mm. Hg. Samples of water were drawn and the dissolved oxygen concentration determined as outlined above.

TABLE I.—DEOXYGENATION OF WATER  
WITH HEAT

Length of treatment min.	Temperature °C.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0	29.0	6.8	100.0
2	38.5	6.8	100.0
4	55.0	6.0	88.2
6	75.0	5.4	79.4
8	91.0	3.8	55.8
10	100.0	0.8	11.8

TABLE II.—DEOXYGENATION OF WATER WITH  
NITROGEN GAS BUBBLED THROUGH AT  
THE RATE OF 0.1 CUBIC FEET  
PER MINUTE

Length of treatment min.	Total nitrogen bubbled through cu. ft.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0	0.0	9.2	100.0
1	0.1	7.4	80.5
2	0.2	5.0	54.5
4	0.4	2.8	30.5
6	0.6	1.7	18.6
8	0.8	1.2	13.1
10	1.0	0.9	9.3

TABLE III.—DEOXYGENATION OF WATER  
UNDER REDUCED PRESSURE  
(16.1 mm. Hg.)

Length of treatment min.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0.0	9.8	100.0
5.0	7.8	79.6
10.0	7.6	77.6

TABLE IV.—DEOXYGENATION OF WATER  
UNDER REDUCED PRESSURE (16.1 mm.  
Hg.) WITH VIGOROUS SHAKING BY  
HAND DURING TREATMENT

Length of treatment min.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0.00	9.8	100.0
0.75	1.8	23.7
1.00	1.2	12.2
2.00	0.6	7.9
2.50	0.4	4.1
5.00	0.4	4.1

To accelerate oxygen reduction, the preceding experiment was repeated with the one exception that the flask was shaken vigorously by hand in absence of an automatic oscillator.

The accompanying graph (Fig. 1) summarizes the data above in terms of relative rate of deoxygenation of water per unit time.

*Discussion.*—The aspiration technique for the deaeration of water has proved of such interest to men in the field of chemistry and zoology at Northwestern University that I have attempted to make these data of a general nature. The ap-

ures in general use, for the purpose was to evaluate the methods as actually employed. Each method, however, has peculiar advantages which should be recognized. By merely heating a given quantity of water to a particular temperature one can approximate a desired oxygen saturation, whereas without an automatic oscillator the aspiration method is difficult to standardize. The nitrogen method, by displacing the oxygen with nitrogen, has the advantage of more closely approximating true *oxygen deficient* rather than *deaerated water*. Aspiration has the advantage of rapidity of action and simplicity of method in accomplishing the same effect as boiling, but without disturbing the physio-chemical factors.

I am indebted to Dr. B. S. Meyer under whom this work was begun, to Dr. R. O. Freeland for many valuable suggestions, and to Dr. P. Haensel for the excellent facilities of the High Pressure and Catalytic Laboratories at Northwestern University.

#### REFERENCES

- Gessner, F. 1937. Untersuchungen über Assimilation und Atmung submerser Wasserpflanzen. *Jahrb. Wiss. Bot.* 85:267-328.  
 ..... 1938. Die Beziehung zwischen Lichtintensität und Assimilation bei submersen Wasserpflanzen. *Jahrb. Wiss. Bot.* 86:491-526.  
 Kostychev, S. und S. Soldatenkow. 1926. Der tägliche Verlauf und die Spezifische Intensität der Photosynthese bei Wasserpflanzen. *Planta.* 2:1-9.  
 Meyer, B. S. 1939. The daily cycle of apparent photosynthesis in a submerged aquatic. *Amer. Jour. Bot.* 26:755-760.  
 American Public Health Association. 1933. Standard methods of water analysis.

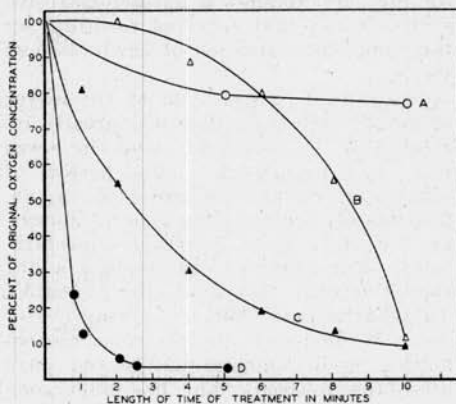


Fig. 1.—Graph of reduction in dissolved oxygen concentration of distilled water by (A) partial vacuum, (B) heating, (C) displacement by nitrogen, and (D) partial vacuum with oscillation.

paratus and techniques are not elaborated beyond mere duplication of the proced-