NITRIFICATION AND NITRATE DISSIMILATION IN SOIL

II. EFFECT OF OXYGEN CONCENTRATION

by D. J. GREENWOOD

National Vegetable Research Station, Wellesbourne, Warwick

INTRODUCTION

Although it is known that reducing the supply of oxygen to the soil micro-organisms inhibits nitrification and induces nitrate dissimilation, the precise way in which these processes are affected by the oxygen concentrations at the surfaces of the micro-organisms has not been fully established. Since the aerobic respiration rates of soil are unaffected by lowering of the oxygen concentrations until very low values are reached, it should be possible, by applying Fick's law of diffusion, to determine the distribution of oxygen in many soil systems. The object of the work, therefore, was to find the effect of oxygen concentration on nitrification and on nitrate dissimilation and to see if by applying Fick's law it is possible to predict the distribution of oxygen and thus the rates of nitrification and nitrate dissimilation in soil crumbs surrounded by different oxygen partial pressures.

THEORY

The formulation of the theory for the distribution of oxygen in soil crumbs, described in a previous paper has to be amended.

Consider a sphere of soil saturated with water and containing a uniform distribution of micro-organisms. Let M be the aerobic respiration rate. Then M can be taken as constant and independent of oxygen concentration for $C > C_0$ and zero for $C \leq C_0$. Suppose the oxygen concentration is $C$ at a distance $r$ from the centre of a
sphere of radius $R_1$ and $D$ is the diffusion constant of oxygen through the sphere. Then for the stationary state

$$\frac{D}{r} \frac{\delta^2(rC)}{\delta r^2} = M$$  \hspace{1cm} (1)

The boundary conditions are:

- $C = C_1$ for $r = R_1$ where the sphere is anaerobic
- $\frac{\partial C}{\partial r} = 0$ for $r = R_0$ for $r < R_0$ so that $C = C_0$
- $\frac{\partial C}{\partial r} = 0$ for $r = R_0$

On solving Eq. (1) and putting $r = R_1$ we have:

$$6D (C_1 - C_0) = M(R_1^2 + 2R_0^3/R_1 - 3R_0^3)$$  \hspace{1cm} (2)

Suppose the volume of the sphere having radius $R_0$ is $V_1$ and the volume of the sphere having radius $R_1$ is $V_2$. Then

$$6D (C_1 - C_0) = MR_1^2(1 + 2V_1/V_2 - 3(V_1/V_2)^4)$$  \hspace{1cm} (3)

Since it has been previously shown that $C_0$ is very small we have as a close approximation

$$6D C_1 = MR_1^2 (1 + 2V_1/V_2 - 3(V_1/V_2)^4)$$  \hspace{1cm} (4)

**EXPERIMENTAL**

**Soil**

Soil A described previously was used throughout. It was from a permanent pasture; clay loam; $C = 2.6\%$, $N = 0.36\%$ (by Kjeldahl) and pH = 7.8 at a soil; water ratio of 1:2 (w/v). Before use it was air dried and sieved between the limits of 2 and 4 mm.

**Preparation of stimulated soil**

Soil (10 g) was percolated at a temp. of 25°C either with a solution containing 70 mg of glucose, 11 mg of NH$_3$-N, and 28 mg of NO$_3$-N until the glucose had disappeared (about 2 days after the start of percolation), or repeatedly with 0.01 M (NH$_4$)$_2$SO$_4$ until the soil became enriched with nitrifying organisms (about 21 days). Percolation under air was carried out in forced-air percolators, and percolation under N$_2$ was carried out in electrolytic rocking percolators. In addition, control soils were prepared by percolation with water for similar periods.

**Gas mixtures**

These were prepared by the displacement procedure of Umbreit, Burris and Stauffer using air and oxygen-free nitrogen supplied by The British Oxygen Company Ltd., Birmingham, U. K.