COMMENT

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Use of chlorophyll-Secchi disk relationships

Several workers have proposed the use of empirical relationships between Secchi disk depth and chlorophyll a to predict changes in transparency to be expected from changed chlorophyll levels. Oglesby and Schaffner (1975) presented data as shown in Fig. 1 relating Secchi disk transparency to chlorophyll concentrations and correctly noted that at high concentrations of phytoplankton, reductions produce little change in transparency. However, the unstated implication that for low phytoplankton concentrations changes in concentration would produce large changes in transparency is not necessarily true.

Carlson (1977) presented similar data and developed the following regression equation:

$$\ln(\text{Secchi disk}) = 2.04 - 0.68 \ln(\text{Chl } a). \tag{1}$$

Carlson noted that the data did not fit an equation of the form

$$\frac{I_z}{I_0} = e^{-(\alpha+\beta C)z} \tag{2}$$

where I_0 = surface light, I_z = light at depth z, α = extinction coefficient from factors other an algae, β = incremental extinction coefficient from algae, and C = algal concentration. It was assumed that $I_z = 0.1 I_0$ when z = Secchi disk depth.

Carlson postulated that his inability to fit the data to this type of function may have resulted from changing chlorophyll content per cell as a result of different light conditions. However, it is possible that the value of α (nonchlorophyll light absorption) was simply quite different for the different lakes included.

The following theoretical analysis illustrates the importance of the extinction coefficient α and shows that the large variation in Secchi disk depth at low chlorophyll concentrations (such as those in Fig. 1) should only occur in lakes with small values of α.

If we assume that the Secchi disk depth can be approximated by the depth of 20% surface light (Lorenzen 1978), the Secchi disk depth (Z_{SD}) can be expressed as

$$Z_{SD} = \frac{-\ln(0.20)}{\alpha + \beta C}. \tag{3}$$

The Secchi disk depth is inversely proportional to the total extinction coefficient ($\alpha + \beta C$). When chlorophyll concentrations are high ($\beta C \gg \alpha$), the extinction coefficient, and thus the Secchi disk depth, are largely controlled by the chlorophyll concentration. However, when chlorophyll concentrations are low ($\beta C \ll \alpha$), the total extinction coefficient and Secchi disk depth are largely con-

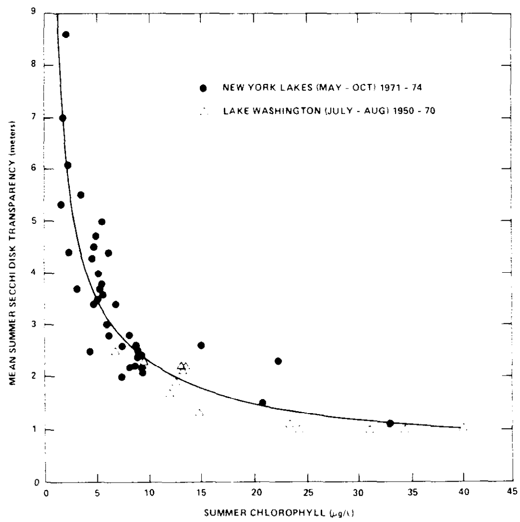

Fig. 1. Relationship between Secchi disk transparency and chlorophyll (redrawn after Oglesby and Schaffner 1975).

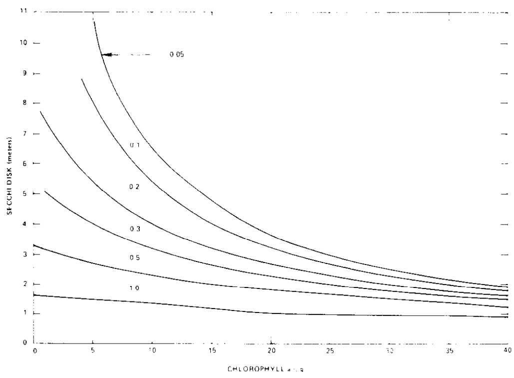

Fig. 2. Theoretical relationship between Secchi disk and chlorophyll.

trolled by light-absorbing properties other than chlorophyll (α). Although the Secchi disk depth is inversely proportional to the phytoplankton concentration, the constant of proportionality is very small; for example, at a chlorophyll *a* concentration of about 25 $\mu g \cdot$liter and very clear water ($\alpha = 0.1$) the change in Secchi disk depth resulting from a 10 $\mu g \cdot liter^{-1}$ increase in chlorophyll *a* is only 0.3 m (Eq. 3). For more turbid waters, the change would be even less.

Figure 2 illustrates the theoretical relationship between chlorophyll and Secchi disk depth for different values of α. Equation 3 was used to compute Secchi disk as a function of chlorophyll for values from 0 to 40 $\mu g \cdot liter^{-1}$ (larger chlorophyll values have a very small effect on Secchi disk depth). The value of α was allowed to range from 0.05 to $1.0 \cdot m^{-1}$. The value of $0.05 \cdot m^{-1}$ probably represents a limit for the clearest waters; for visible light, Clarke (1954) reported an extinction coefficient of $0.04 \cdot m^{-1}$. The incremental extinction coefficient, β, was held constant at $0.02 \cdot m^{-1} \cdot \mu g^{-1} \cdot$liter Chl a^{-1}. This value is in agreement with the $0.2 \cdot m^{-1} \cdot \mu g^{-1} \cdot$liter ash-free dry wt^{-1} reported by Lorenzen (1972) if chlorophyll *a* is assumed to be 1.0% of ash-free dry weight.

Examination of Fig. 2 shows that there should be large increases in Secchi disk depth at low chlorophyll concentrations only for lakes with very low color or turbidity. The spread of the lines illustrates that it is crucial to know the value of α before predicting the effect of changed chlorophyll concentrations on transparency.

The analysis presented illustrates that using data for chlorophyll *a* and Secchi disk from different lakes can result in very misleading projections. I suggest that the value of α should be obtained for any particular lake under study and the appropriate line in Fig. 2 then be used to estimate the effects of changed chlorophyll on transparency.

Marc W. Lorenzen

Tetra Tech, Inc.
1900–116th Ave. N.E.
Bellevue, Washington 98004

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