The constants K_R and K'_R are not the same, but they are related.[3]

$$K'_R = 2.3K_R \qquad 8.4$$

Table 8.12 lists representative values of K_R.

B. BIOCHEMICAL OXYGEN DEMAND

When oxidizing organic waste material in water, biological organisms remove oxygen from the water. Therefore, oxygen use is an indication of the organic waste content. The biochemical oxygen demand (BOD) of a biologically active sample is given by equation 8.5:

$$\text{BOD}_s = \frac{DO_i - DO_f}{\frac{V_{\text{sample}}}{V_{\text{sample}} + V_{\text{dilution}}}} \qquad 8.5$$

BOD is determined by adding a measured amount of wastewater (which supplies the organic material) to a measured amount of dilution water (which reduces toxicity and supplies dissolved oxygen). An oxygen use curve similar to that in figure 8.1 will result. (More than one identical sample must be prepared in order to determine initial and final concentrations of dissolved oxygen.)

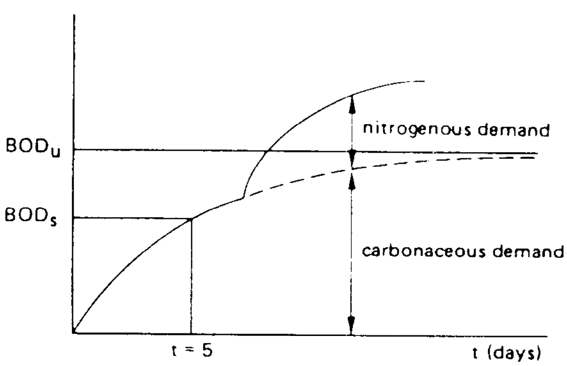

Figure 8.1 BOD Time Curve

The deviation from the expected exponential growth curve in figure 8.1 is due to *nitrification* or *nitrogenous demand*. Nitrification is the use of oxygen by *autotrophic bacteria*.[4] Such bacteria use fixed carbon as food. (For example, the carbon in carbon dioxide is used by autotrophic bacteria.) Autotrophic bacteria oxidize ammonia to nitrites and nitrates. However, the number of autotrophic bacteria is small. Generally, six to ten days are required for the autotrophic population to become sufficiently large enough to affect a BOD test. Therefore, the standard BOD test is terminated before the autotrophic contribution to BOD becomes significant.

The standard BOD test typically calls for a 5-day incubation period at 20°C. The BOD at any time can be found from equation 8.6.

$$\text{BOD}_t = \text{BOD}_u(1 - 10^{-K_D t}) \qquad 8.6$$

K_D is the ***deoxygenation rate constant***, typically taken as 0.1. The ultimate BOD cannot be found from long term studies due to the effect of nitrogen-consuming bacteria in the sample. However, if K_D is 0.1, the ultimate BOD can be found from equation 8.7.

$$\text{BOD}_u \approx 1.47\,\text{BOD}_s \qquad 8.7$$

K_D for other temperatures can be found from equation 8.8. (The 1.047 constant is often quoted in literature. Recent research suggests 1.135 for 4°C to 20°C, and 1.056 for 20°C to 30°C.)

$$K_{D,T} = (1.047)^{T-20} K_{D,20°C} \qquad 8.8$$

The variation in BOD with temperature is given by equation 8.9.

$$\text{BOD}_T = \text{BOD}_{20°C}(0.02T + 0.6) \qquad 8.9$$

Table 8.1
Typical Values of K_D

treatment plant effluents	0.05–0.10
highly polluted shallow streams	0.25

Example 8.1

Ten 5-ml samples of wastewater are placed in 300 ml BOD bottles. Half of the bottles are titrated immediately with an average initial concentration of dissolved oxygen of 7.9 mg/l. The remaining bottles are incubated for 5 days, after which the average dissolved oxygen is determined to be 4.5 mg/l. What is the standard BOD and ultimate carbonaceous BOD assuming $K_D = 0.13$?

From equation 8.5:

$$\text{BOD}_s = \frac{7.9 - 4.5}{\frac{5}{300}} = 204 \text{ mg/l}$$

[3] K'_R may be written as K_R (*base e*) in the literature.

[4] Most bacteria in wastewater are heterotrophic. *Heterotrophic bacteria* use organic carbon as food.