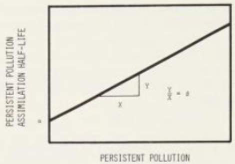

Figure 6-21 The theoretical linear relationship between the persistent pollution assimilation half-life and the level of pollution

indicating that pollution assimilation is proportional to the concentration of pollutants [P] and that the assimilation half-life AHL is constant (line A of Figure 6-20A). If, however, pollution is large relative to the number of degraders, so that $(k_1' + k_2) << k_1[P]$, then:

$$\text{PPASR} = \frac{k_1 k_2 [P][D^*]}{k_1 [P]} = k_2 [D^*]$$

and

$$\text{AHL} = \frac{[P]}{(1.4)\,(k_2)[D^*]},$$

which indicates that the degradation rate is no longer determined by the concentration of pollutants but only by the limited concentration of available degraders. In this case the assimilation half-life AHL is directly proportional to the pollutant level (line D of Figure 6-20A).

The foregoing arguments are based on the assumption of a constant total concentration of degraders [D*]. If this concentration changes, then the pollution assimilation rate will have a still more complex behavior. For example, biotic degraders, such as bacteria, may be poisoned by high levels of the pollutant. In this event, [D*] declines as [P] increases, and, from equation (6.9), the pollution assimilation half-life increases with increasing pollution [P] at a greater than linear rate (line C of Figure 6-20A).

An example of a case where the degrader concentration is apparently a function of pollutant levels is provided by the relation of mercury levels to the activity of methylating bacteria. Figure 6-22 presents empirical data suggesting that levels of mercury beyond a certain threshold actually decrease the activity of the bacteria that convert metallic mercury to its organic form. In this case the relationship between AHL and PPOL is indicated by line C of Figure 6-20A.

Even when the distribution and composition of pollution are assumed to be constant, the precise real-world relationship between the level of pollution and the assimilation half-life depends upon the relative importance of the three modes of assimilation—disintegration, deposition, and degradation—and on the magnitude of the half-lives of the individual persistent materials. There is little empirical basis for

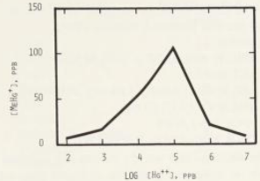

Figure 6-22 Maximum concentration of methylmercury [MeHG+] produced from a given concentration of mercuric ion [Hg++]
Source: Anderson et al. 1973.

projecting the future values of either factor over the next several decades. However, we could find no suggestion that persistent materials might be assimilated more quickly as their level in the global environment increases. Thus curve B of Figure 6-20A was not chosen to express the relation between AHL and PPOL. Instead we incorporated in World3 a linear relationship belonging to the same class as curve D of Figure 6-20A. However, because the relationship is highly uncertain, we made AHL a function of the pollution index PPOLX rather than of pollution PPOL itself.

While some set of precise equations must be developed to express the influence of the pollution level on AHL, it is important to develop the equations in a form suited to the low level of information actually available. To illustrate this important point we give two different statements expressing the same relationship between the level and the assimilation half-life of persistent pollution. The first suggests a rather comprehensive knowledge about the nature and the precise magnitude of all influences on the assimilation half-life. The second conveys a lower level of knowledge. We would say that the first statement implies a ratio scale for pollution and assimilation half-life. The second statement implies only an interval scale.* The DYNAMO equations appropriate for each scale are given below the corresponding statement.

1. Statement implying a ratio scale:

   The assimilative half-life of the biosphere is a linearly increasing function of the level of pollution present. When pollution is less than 10^8 units, the assimilation half-life will be 1.5 years. For each additional 25×10^8 units of persistent pollution beyond 10^8 units, assimilation half-life AHL will increase by 1.5 years.

   DYNAMO Equations:

   ```
   A AHL.K=TABHL (AHLT, PPOL.K,1E8,1001E8,250E8)
   T AHLT=1.5/16.5/31.5/46.5/61.5
   ```

2. Statement implying an interval scale for pollution and assimilation half-life:

   If persistent pollution rises to 1,000 times its level in 1970, the assimilation

*For a useful discussion of the difference between ratio and interval scales see Blalock 1960.