

1. Please explain the following terms and their related environmental implications. (15 points)
 - (a) Oxygen Sag Curve
 - (b) Median Lethal Dose
 - (c) Water-Energy-Food Nexus
2. Find the theoretical oxygen demand (mg/L O₂) for the solution of 100 mg/L of acetic acid, CH₃COOH. (5 points)
3. Explain the difference between Point Source and Nonpoint Source of water pollution. (5 points)
4. A small lake with a volume equal to 500,000 m³ is approximately completely mixed. A stream flows into and out of the lake with a flow rate of 1000 m³/d. The contents of a truck carrying a liquid chemical waste are spilled accidentally into this lake. The resulting initial concentration of the chemical waste in the lake is 200 mg/L. If the chemical waste undergoes first-order chemical decay with a reaction rate of 0.008 d⁻¹, determine the time required for the concentration of the chemical waste in the lake to be reduced to 10 percent of the initial value. Describe any assumption you use. (15 points)
5. 為達成河川水質改善及畜牧業循環經濟之目標，環保署積極推動畜牧糞尿沼液、沼渣之資源化再利用，請提出與說明畜牧糞尿的資源化方式 (10 points)。
6. 根據下圖，說明何謂(1) VOC-sensitive and NO_x-sensitive conditions; (2) titration effect; (3)請各提出一種常見的固定污染源與移動污染源，其產生之污染物可造成日間之 O₃ 濃度上升，並針對你所提出之污染源，提出至少兩種管制策略。(15 points)

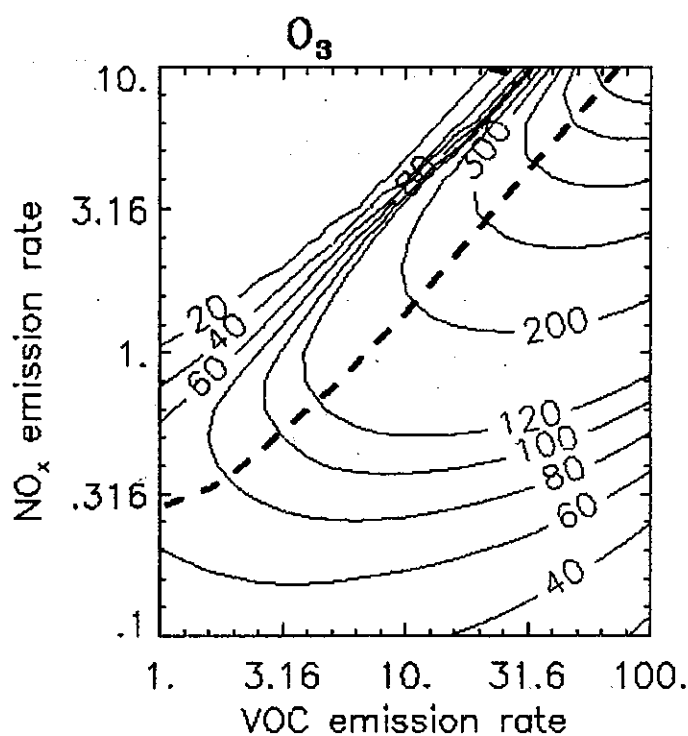


Figure 1. Ozone isopleths (ppb) as a function of the average emission rate for NO_x and VOC (10¹² molec. cm⁻²s⁻¹) in 0-d calculations. The isopleths (solid green lines) represent conditions during the afternoon following 3-day calculations with a constant emission rate, at the hour corresponding to maximum O₃. The short blue dashed line represents the transition from VOC-sensitive to NO_x-sensitive conditions. (資料來源: <http://www-personal.umich.edu/~sillman/ozone.htm>)

7. Given a sunny summer afternoon with an average wind speed of 5 m/s, an emission of SO₂ from a coal-fired power plant of 0.02 kg/s and the effective stack height = 50 m, please:
 - (1) explain what is effective stack height; (5 points)
 - (2) using the Gaussian plume dispersion equation (as follow) to calculate the maximum SO₂ concentration at 200 m from the stack and at (a) ground level and (b) a 10-m height building roof.
(本題不須計算出最後數值，僅需將合理數值帶入公式並簡化算式即可) (5 points)

見背面

(3) 本題所給定的 Gaussian plume dispersion equation 為考慮地面具有將煙流全反射之情境；如果假設地面不具煙流反射能力，請列出簡化後之方程式。(5 points)

Gaussian plume dispersion equation:

$$C = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{1}{2} \frac{y^2}{\sigma_y^2}\right) \left\{ \exp\left(-\frac{1}{2} \frac{(z-H)^2}{\sigma_z^2}\right) + \exp\left(-\frac{1}{2} \frac{(z+H)^2}{\sigma_z^2}\right) \right\}$$

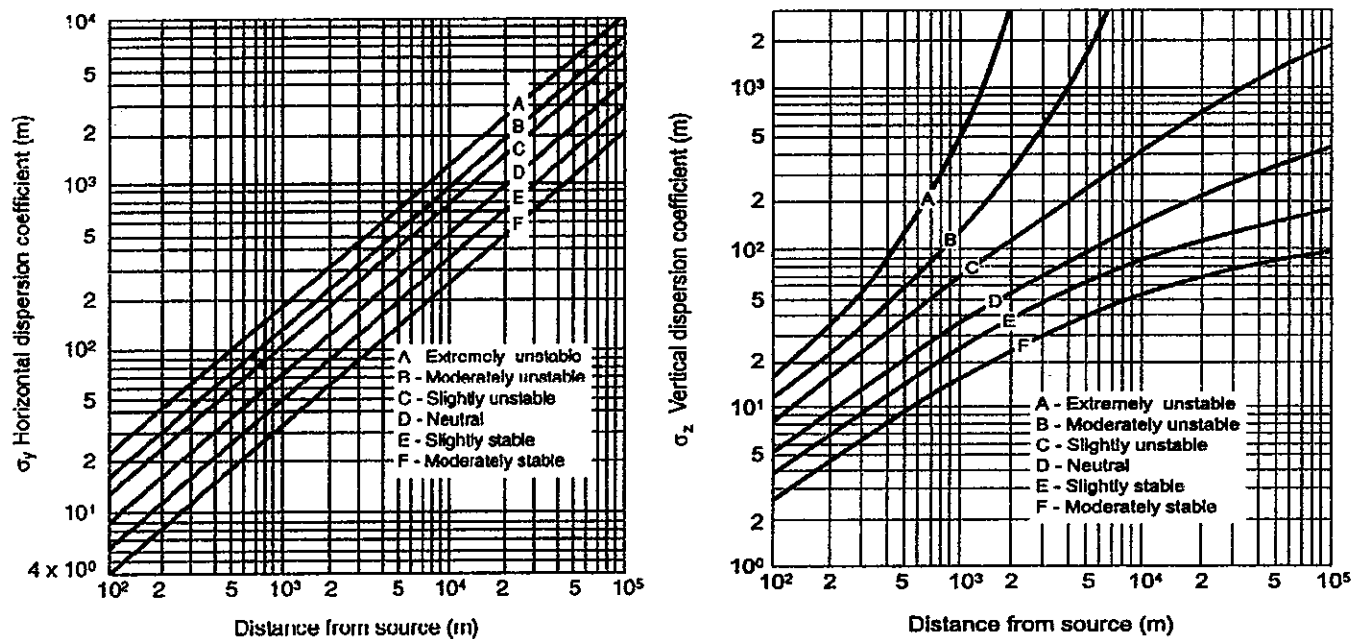


Figure 2. Dispersion coefficients

Table 19.1 Stability Classifications*

Surface Wind Speed ^d m/s	Day Incoming Solar Radiation			Night Cloudiness ^e	
	Strong ^b	Moderate ^c	Slight ^d	Cloudy (≥4/8)	Clear (≤3/8)
<2	A	A-B ^f	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

NOTES:

- a. Surface wind speed is measured at 10 m above the ground.
- b. Corresponds to clear summer day with sun higher than 60° above the horizon.
- c. Corresponds to a summer day with a few broken clouds, or a clear day with sun 35-60° above the horizon.
- d. Corresponds to a fall afternoon, or a cloudy summer day, or clear summer day with the sun 15-35°.
- e. Cloudiness is defined as the fraction of sky covered by clouds.
- f. For A-B, B-C, or C-D conditions, average the values obtained for each.

* A = Very unstable D = Neutral
 B = Moderately unstable E = Slightly stable
 C = Slightly unstable F = Stable
 Regardless of wind speed, Class D should be assumed for overcast conditions, day or night.

Adapted from Turner, 1970.

8. 請詳述濕式洗滌塔(wet scrubber)去除各類空氣污染物作用原理，以及使用濕式洗滌塔之優缺點。(10 points)

9. 請說明土壤與地下水汙染整治，(1)現地地下水抽除處理法(in-situ pump&treat)，以及(2)現地空氣注入法(in-situ air sparging)的原理，適用條件以及優缺點。(10 points)