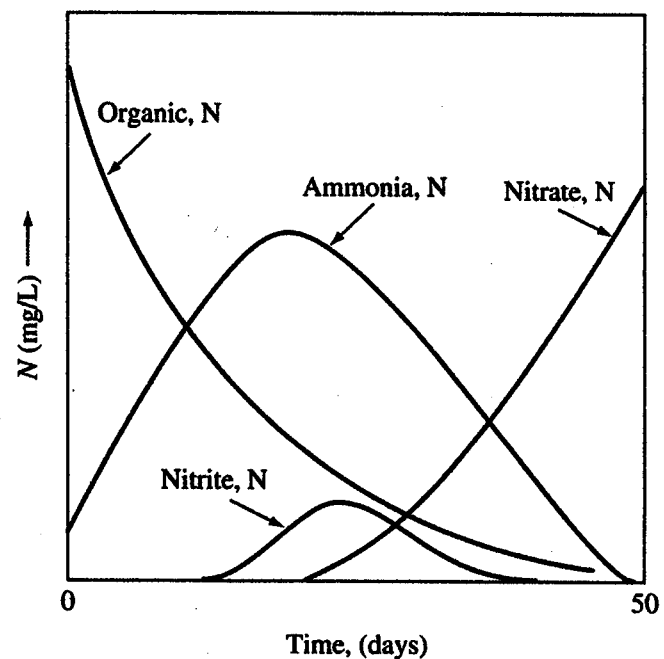


1. An industrial plant is located next to a river. Without wastewater treatment, the pollutant is discharged into the river. A lake, which initially was not polluted, receives this illegal discharge from upstream of  $20 \text{ m}^3/\text{day}$ , carrying  $100 \text{ mg/L}$  of the pollutant. The lake has a volume of  $2000 \text{ m}^3$ . The pollutant is nonconservative with a first-order decay rate ( $k = 0.05/\text{day}$ )
- Derive the mass balance equation of the continuously stirred tank reactor (CSTR) for the pollutant concentration in the downstream as a function of time. Describe any assumption you use. (8 points)
  - Determine the steady-state concentration of the pollutant in the effluent of the lake. (5 points)
  - What would the concentration in the effluent of the lake be 5 days later. (7 points)

2. Nitrogen is the critical element in aqueous environment. Please describe and explain the change in nitrogen forms in polluted water (10 points)



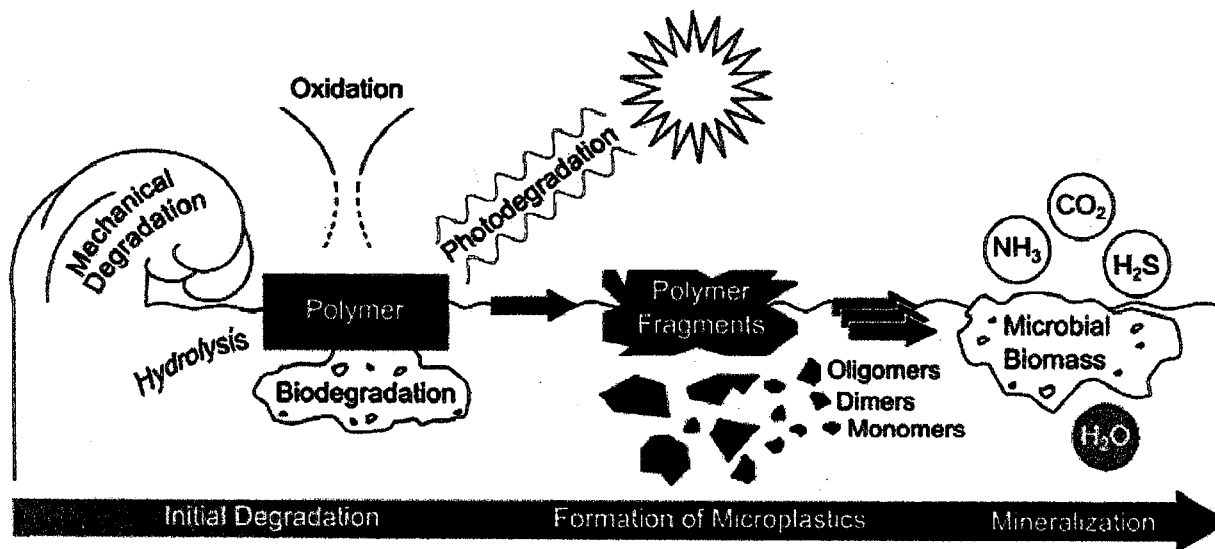
(G. M. Masters and W. Ela, Prentice-Hall, Inc. 2008)

3. For human-caused air pollution, what is a primary pollutant? what is a secondary pollutant? Also, explain the difference between primary pollutants and secondary pollutants. (10 points)
4. Please introduce a technology in the control of fine particle air emissions and its working mechanism. (10 points)
5. Which of the following statement about source water is NOT true? (10 points)
- The major issue about reclaim water is public acceptance
  - Surface water contains less humic substances compared to that of groundwater
  - Groundwater has less microbial contaminant compare to that of the surface water
  - All true
6. Which of the following wastewater treatment process requires external electron donor addition? (10 points)
- Nitrification
  - Denitrification
  - Sedimentation
  - Sludge digestion
  - Neither of above

見背面

**Problems 7-9**

Plastic debris (synthetic polymers) is one of the important pollutants in the marine environments. Scientists/researchers have focused on the analysis, occurrence and degradation of small plastic particles, so-called **microplastics** (with particle size < 5 mm). These synthetic polymers undergo very low degradation in the aquatic environments; slowly, they are aged and converted into smaller molecular units. The figure below shows the degradation pathways of synthetic polymers in aquatic systems.



Reference: Klein, S., Dimzon, I.K., Eubeler, J., Knepper, T.P., "Analysis, Occurrence, and Degradation of Microplastics in the Aqueous Environment." The Handbook of Environmental Chemistry, 2017, 58, 51 – 67.

7. Which type of pollutant do microplastics belong to? (10 points)

- a) Trace organic pollutants
- b) Inorganic pollutants
- c) Nutrients
- d) Pathogens
- e) Radioactive substances

8a. Which process in the drinking water treatment can remove microplastics? (5 points)

- a) Sedimentation
- b) Filtration
- c) Coagulation
- d) Chlorination
- e) Neither of above (cannot be completely removed)

8b. Please explain your choice. (5 points)

9. Despite slowly, the synthetics polymers still have chance of being mineralized with the help of microbes.

Please explain what 'mineralization' is. (10 points)

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