The Environment

Cost Effectiveness of Radiation Processing

Depends On

- Uniqueness of the desired change
- Efficiency (chain length) of the radical reactions
- Large volumes, use of high power electron accelerators
- Use of the lowest electrons appropriate for a process
- Combination treatment (synergistic effect)

Radiation Processing Technology for the Environment

- Areas of interest
  - Natural and polluted waters
  - Industrial chemical wastes
  - Sewage
  - Flue gases

Contaminated Natural Drinking Water

- Pathogenic microorganisms
- Colouration (humic acids)
- Fertilizers
- Pesticides
- Fungicides
- Chloro-organic compounds

Treatment of Contaminated Water

- Filtration - partially effective
- Chemical treatment - partially effective
- Chlorine treatment - fairly effective against microorganisms, chloro-organic compounds produced
- UV photolysis, ozone treatment - partly effective, expensive
- Irradiation - with or without ozone treatment, effective
  - Pilot plant in Austria, and now a commercial plant under construction
  - Extensive work in several countries

Irradiation of Contaminated Waters

- Quite effective in reducing microorganisms and chemical pollutants
- Synergistic effect with ozone treatment
- Drinking water, 0.5 to 1 kGy dose enough in most cases

Synergistic Effect with Ozone Treatment

- The presence of O_3 during irradiation
  - Increases the yield of ·OH, and thus of oxidative degradation
  - Oxidizes NO^-_2 to NO^-_3 (NO^-_2 is toxic)
- Key reactions are

$$H_2O, RH \xrightarrow{\sim\!\!\sim} {\cdot}H + {\cdot}OH + e^-_{aq} + R{\cdot} + RO_2^{\bullet} + HO_2^{\bullet} + O^{-\bullet}_2$$

$$HO_2^{\bullet} + O_3 \rightarrow {}^{\cdot}OH;\quad O^{-\bullet}_2 + O_3 \rightarrow {}^{\cdot}OH$$

$$RO_2^{\bullet} + O_3 \rightarrow RO{\cdot};\quad RO{\cdot} + RH \rightarrow ROH + R{\cdot}$$

$$R{\cdot} + O_2 \rightarrow RO_2^{\bullet}$$

Industrial Polluted Waters

- Irradiation (with ozone treatment) also applicable to treating municipal wastewater and waste waters from pulp and paper mills, textile industry
  - Pilot plants in USA, Germany and Russia
  - Purification of wastewater from a rubber plant in Russia

Woods and Pikaev (1994)