Eutrophication

**Eutrophication**: the process of becoming or being made eutrophic

**Eutrophic**: the state of being enriched in nutrients or food sources

In aquatic ecosystems, eutrophication is caused by excessive inputs of nutrients, both N & P. Generally, freshwaters are P-limited and coastal estuarine waters are N-limited. The nutrients **enhance algal growth**, and this, in turn, may have a cascade of effects on the ecosystem. These effects may include: **algal blooms**, growth of **undesirable algal species**, **oxygen depletion** or **anoxia** in bottom waters, loss of cold-water fish species, abundance of **“rough fish”**, **fish kills**, unpleasant **tastes and odors**.

Sources of nutrients

- **Point sources**
  - Sewage treatment plant discharges
  - Storm sewer discharges
  - Industrial discharges
- **Non-point sources**
  - Atmospheric deposition
  - Agricultural runoff (fertilizer, soil erosion)
  - Septic systems
### Solution: Reduce nutrient inputs

- **Agriculture**
  - Reduce animal density, restrict timing of manure spreading, buffer strips by streams, reduced tillage, underground fertilizer application, wetland preservation and construction
- **Watershed management**
  - Buffer zones, wetland filters
- **Storm runoff**
  - Eliminate combined sewer systems (CSO’s)
  - Stormwater treatment required (holding ponds, alum, etc.)
  - Education on yard fertilization
- **Erosion from construction, forestry**
  - Erosion barriers, soil cover, road and bridge stabilization
- **Septic systems**
  - Distance from lake, adequate drainfields

### Mitigation strategies

Often there is pressure for quick actions that will reduce the severity of the symptoms. Numerous options exist. To understand these options and choose among them, one should understand the nutrient cycle within the aquatic system (lake).
The P cycle may be manipulated in several ways to reduce the regeneration of inorganic P and its transport to the epilimnion or to reduce the algal uptake of P.

**Within-lake actions**

- **Reduce algal growth**
  - Apply algicide
  - Biomanipulation
- **Reduce mineralization**
  - Remove organic P before it is mineralized
    - Dredging
    - Macrophyte harvesting
- **Reduce transport of inorg. P to epilimnion**
  - Hypolimnetic water withdrawal
In-lake strategies cont.

- Reduce P release from sediments
  - Sediment amendments (NO$_3^-$, Fe oxides, alum)
  - Hypolimnetic aeration
  - Artificial circulation

P release from sediments is greatly enhanced by anoxic conditions under which iron oxides dissolve and release all P sorbed to their surfaces. Maintaining oxic bottom waters not only retards P release from sediments but also helps maintain benthic and fish species.

Useful references

- [http://www.aquatics.org/pubs/madsen2.htm](http://www.aquatics.org/pubs/madsen2.htm)
Macrophyte harvesting
Macrophyte harvesting
Lake aeration

Below: Bubbles rising to surface in winter when large-diameter air bubbles are released from diffusor. Lake Sempach, Switzerland.

Above: 10-m diameter diffusor being lowered to bottom (87 m) of L. Sempach, Switzerland.

Aeration continued


http://www.rittenhouse.ca/

http://www.windmillaeration.com/