"Natural treatment" - includes the use of controlled mass culture of higher plants, artificial and natural wetlands

Incorporates some fundamental functional characteristics of natural systems into the design and operation of waste-water treatment systems

History of using aquatic plants for wastewater treatment

**ecological x engineering approach**

Types of wastewater:
- municipal - biodegradable organic matter, suspended solids, pathogens
- industrial - toxic substances
- agricultural run-off - nutrients, SS, pesticides
- mining run-off - acidity, heavy metals
- urban run-off - heavy metals

Three stages: (1) **Primary** - removes suspended solids (50-75%)
(2) **Secondary** - removes dissolved biodegradable organic material (BOD)
(3) **Tertiary** - removes inorganic nutrients

Processes involved in wastewater treatment:
- physico-chemical processes including sedimentation, sorption and precipitation
- volatilization
- bacterial transformations (oxidation by OM; nitrification/denitrification)
- direct nutrient uptake by plants

Types of natural systems used in WW-treatment:
- infiltration and overland flow - used since middle ages
- surface irrigation, flood irrigation, ridge and furrow irrigation
- floating macrophyte system
- constructed wetlands with macrophyte vegetation
Combination of macrophyte-based treatment system with conventional technologies

**Constructed wetlands** - use (mostly rooted) aquatic macrophytes
- greater potential for wastewater treatment than natural systems
- more controlled environment
  1) Surface flow (SF)
  2) Subsurface flow (SSF)

**Criteria for plants used in wastewater treatment**
- high mineral absorption capability
- extended growing and harvesting periods
- few natural pests
- easy of harvesting
- low water content
- high protein content (IF USED AS ANIMAL FEED)
- low fibre and lignin content

**Types of plants used in wastewater treatment**
- algae: Scenedesmus, Chlorella **NO**: Microcystis, Aphanizomenon
- floating macrophytes: duckweeds, water hyacinth
- creeping macrophytes: pennywort (Hydrocotyle spp.), parrotfeather (Myriophyllum aquaticum)
- submersed macrophytes: Potamogeton, Ceratophyllum
- emergent macrophytes: **reed** (Phragmites australis), **bulrushes** (Scirpus spp.), **cattails** (Typha spp.), arrowhead (Sagittaria latifolia), canna lily

Combination of several different species, growth forms
Very few of large variety of aquatic plants have been tested for pollutant removal capabilities

**Advantages of using macrophyte-based wastewater treatment system as compared to conventional systems**
low operating costs:

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>CWWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction cost</td>
<td>$4,112,000</td>
<td>$3,664,000</td>
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</tbody>
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Maintenance costs | 156,000 | 45,000
---|---|---

- plant biomass can be recycled
- creation of wildlife habitat (ONLY IF THE SYSTEM DOES NOT USE ANY TOXIC SUBSTANCES !!)

**Health Consideration** - water born pathogens
- mosquitoes

**Regulations**
National Pollution Discharge Elimination System (NPDES) permit issued by EPA
(administered by state, EPA oversight) - regulates water disposal to natural wetlands
Clean Water Act

**Examples:**
- City of Davis - overland flow
- Elk Grove Sacramento County Regional WW Treatment plant
- Santee CA - Scirpus, Typha, Phragmites; primary WW municipal
- Arcata, Humboldt Bay - secondary effluent
- Chevron, Richmond
- DUST marsh, Fremont near Coyote Hills

**Reading:** M&G 3rd edition Chapter 20