Introduction

Micro organisms in aquatic systems feed on dissolved/suspended organic matter; their digestion processes decompose organic wastes. Oxygen is consumed during these decomposition processes thus decreasing the supply of dissolved oxygen in the water. If the rate of decomposition is excessive, the resultant oxygen depletion produces stresses on aquatic organisms. Biological (secondary) treatment systems address problems associated with biochemical oxygen demand. Break-down of wastes is transferred from natural waterways to lagoons and/or vessels where conditions can be controlled so that decomposition occurs efficiently. Biological treatment is simply a concentrated, controlled, application of a natural process. Wastewaters often require physical and/or chemical treatment as well; these processes are introduced in Monograph W3.

Facts

<table>
<thead>
<tr>
<th>An Activated Sludge System</th>
<th>Biological Treatment Is Effective For These Wastes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wastewater Sources and Examples</td>
</tr>
<tr>
<td></td>
<td>• Municipalities - domestic and storm* waters</td>
</tr>
<tr>
<td></td>
<td>* combined sanitary and storm sewers</td>
</tr>
<tr>
<td></td>
<td>• Food Processing - meat and vegetable trimmings;</td>
</tr>
<tr>
<td></td>
<td>caustic soda - used to peel vegetables</td>
</tr>
<tr>
<td></td>
<td>• Petroleum Refining - phenol, oil and grease</td>
</tr>
<tr>
<td></td>
<td>• Petrochemical Production - phenol, styrene, benzene</td>
</tr>
</tbody>
</table>

Key Words

- activated sludge - a semi-liquid mass that is highly populated by microorganisms; through controlled aeration, oxygen is maintained at a high level throughout the mixture
- acclimatization - adaptation to environmental change, the population of a specific strain of bacteria increases over successive generations in response to its environment; other bacteria for which the environment is not particularly suitable remain in the system but their numbers are small until possible changes favour their increase
- aerobic bacteria - require oxygen; anaerobic bacteria function in the absence of oxygen
- Biochemical Oxygen - the amount of oxygen utilized when the organic matter in a given volume of water breaks down biologically
- microorganisms - microscopic organisms (microbes); included are bacteria, protozoa, yeasts, viruses, algae

Monograph W4
Biological Oxidation (Biox) Treatments Break Down Wastes

Microorganisms (bacteria, fungi, algae) feed on wastes

**Treatment Systems - Some Examples**

**Lagoon**
- Shallow excavation (1.5 metres in depth) - designed to receive domestic sewage and/or some industrial wastes; purification is dependent upon the combined action of air, sunlight, sedimentation and microorganisms.

**Wetland**
- Natural treatment occurs as water contacts vegetation, air, plant litter and sediments.

**Trickling Filter**
- Wastewater is sprayed over rocks that are covered with microorganisms; spraying brings the wastewater into contact with air (oxygen) and also with the microorganisms.

**Rotating Biological**
- Large discs on a rotating shaft are mounted in tanks containing waste water; one-half of each disc is out of the water (exposed to air); microorganisms on the rotating discs repeatedly contact air and then the organic substances in the water.

**Activated Sludge**
- Microorganisms, nutrients and air are mixed with organic substances in a tank containing waste water. Over a period of time, several generations of microorganisms are produced. Species that can tolerate specific wastes within a system increase in numbers and consume those wastes.

---

**Activated Sludge System - The Cornerstone of Wastewater Treatment**

Eckenfelder, 1989, page 221
**Biological Oxidation (Biox) Treatments Break Down Wastes**

*Microorganisms (bacteria, fungi, algae) feed on wastes*

**Waste Decomposition - at the Cellular Level**

- **energy, carbon dioxide and water** \( \rightarrow \) products of respiration
- **bacterium cell**
- **food** in the water are food for bacteria
- **undissolved waste particle**
- **slime layer**
- **nucleus**

**cell membrane of a bacterium**

Substances that are dissolved in water enter the cells through their membranes; these substances include oxygen and compounds that contain carbon and nitrogen. Oxidation of carbon provides energy; nitrogen is essential for protein synthesis.

**binary fission**

A single bacterium cell splits to form two when conditions are favourable. This form of reproduction may be repeated at two hour intervals.

**Waste Decomposition - Some Chemistry**

**Organic matter is removed by two pathways**

**Oxidation and Synthesis**

**Organic Matter (Carbon)**

- is consumed by microorganisms eg. algae, bacteria, fungi, protozoa, viruses

**Oxidation:** wastes serve as sources of energy (food) to drive metabolic processes

\[ + \text{oxygen} \rightarrow + \text{carbon dioxide} + \text{water} + \text{energy} \]

**Synthesis:** products formed through decomposition are used to make proteins which are essential for building and maintaining cells

**Manahan, 1991, page 188**
Examples of Important Microorganisms Found in Activated Sludge

Paramecium
- short hair-like structures (cilia) wave in an undulating fashion, this allows the paramecium to move and also to direct food into a mouth-like opening.

Amoeba
- moves by means of streaming movements and temporary extensions of the cell called pseudopodia. Pseudopodia surround minute food particles.

Bacteria
- most obtain their energy from dead plants and animals and thus are the principal agents of decay.

Conclusion
If conditions are inadequate to maintain healthy populations of microorganisms, potentially harmful wastes may remain in partially treated wastewaters.

Bioaccumulation of harmful substances and their progression up through the food web can result in harmful concentrations in higher forms of life.

Resources
American Chemical Society, Environmental Science & Technology, Feb. 1993
Eckenfelder, W. Wesley 1989, Industrial Water Pollution Control
Manahan Stanley, 1991and 2000, Environmental Chemistry
ORTECH 1995 to present, Annual Report, Water Quality Assessment

Information Compiled by:
Tom Hamilton, teacher, retired
* materials from this monograph may be reprinted
* references available in our resource centre
* additional copies of this monograph are available from the Sarnia-Lambton Environmental Association or on-line at http:\www.sarniaenvironment.com

2005
Monograph W4
Sarnia-Lambton Environmental Association
Suite 111, 265 Front St. N
Sarnia ON N7T 7X1
519-332-2010
e-mail: admin@sarniaenvironment.com