The Prehistory of the Activated Sludge Process

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Outline

- Disease theories
- Early process development
- Land treatment
- The fight against “artificial” processes
Demonic theory of disease

- Punishment for sins
Humoral theory

- Yellow bile
- Black bile
- Phlegm
- Blood
Miasmas

- Odors or vapors from decomposition
- Malaria = Mala + Aria
- Claims of reduction in tuberculosis and pneumonia when sewers were installed:

  “The beneficial effects of sewerage are plainly seen in the statistics of towns where an efficient [sewerage] system has been carried out. By sewering certain towns in England, the death rate from pulmonary diseases alone was reduced 50 per cent.” (from McGuire)
Filth theory

- Bubonic plague
- Yellow fever
Development of plumbing and drainage systems led to water conveyance for human waste.

Invention of the toilet:
- John Harrington (1596)
- George Jennings (1852)
- Albert Giblin (1898)
- Popularized by Thomas Crapper (1880s)
John Snow and the Soho epidemic of 1854
Germ theory – Pasteur (1859) and Koch’s postulates (1884)

The bacteria must be present in every case of the disease.
The bacteria must be isolated from the host with the disease and grown in pure culture.
The specific disease must be reproduced when a pure culture of the bacteria is inoculated into a healthy susceptible host.
The bacteria must be recoverable from the experimentally infected host.
Development of Biological Treatment of Wastewater

- 1865 – Land application
- 1870s – Intermittent filtration
- 1896 – Cameron’s Septic Tank
- 1892 – Scott-Moncrieff – Cultivating Filter
- 1893 – J. Corbett – Trickling Filter
Cesspool

http://www.septicairaid.com/cesspoolproblems.html
Land application / sewage irrigation

- Plant growth not needed
  - Concluded to be a chemical process
- Abandoned when alternate sources of fertilizer became available

FIGURE 2. BASIC METHODS OF APPLICATION
Sand filters

Not successful
Intermittent Filtration

1884 – London’s municipal sewage authority demonstrated the biological nature of purification.

1890 – William Sedgwick (MIT) and Hiram Mills (Lawrence Experiment Station) showed sand filters also were biological, and required periods of rest for aeration.

Led to trickling filter.
The Trickling Filter

Sir Edward Franklin – Croydon, England sewage farm

Lawrence Experiment Station – 1890

First large plants:
  - Manchester, England – 1893
  - Madison, Wisconsin - 1901

Primary sedimentation

About 35% removal of BOD$_5$
The Imhoff Tank (1906)

Integrates sedimentation and anaerobic digestion
Land application - Biology

- Chloroform-sterilized soil does not nitrify
- Established microbial basis of treatment
- "Natural" process
- Darwinian metaphor – adaptation of microbial population to conditions is like natural selection
Land application - Loading

- 1 acre land per 500 to 1000 p.e.
- 1.5 to 3 gal/d/sf
  - Compare to slow sand filter: 72-168 gal/d/sf
- London requires 40,000 acres
- Berlin requires 23,000 acres – more than the area of the city
Land application – Nature’s Way

“The ‘law of nature’ has made no provision whatever for the disposal of the sewage, otherwise than that of restoring it to the soil… It is idle in the extreme to attempt otherwise to deal with this great question.”

Thus, all other technologies are “artificial”

Further, artificial = bad
The Activated Sludge Process

Gilbert Fowler (Univ. of Manchester) visited Lawrence Experiment Station 1912 and observed experiments with aeration of sewage in bottles.

Edward Ardern and William Lockett conducted fill-and-draw experiments and produced complete nitrification after one month.

Published results in seminal 1914 paper.

Per capita area requirements for wastewater treatment

<table>
<thead>
<tr>
<th>Method</th>
<th>500 acres/kpe</th>
<th>1,000 acres/kpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land application</td>
<td>500</td>
<td>1,000</td>
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<tr>
<td>Aerobic stabilization pond</td>
<td>0.26</td>
<td>0.78</td>
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<tr>
<td></td>
<td>11,351</td>
<td>34,054</td>
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<tr>
<td>Trickling filter</td>
<td>555</td>
<td>1,733</td>
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<tr>
<td>Conventional activated sludge</td>
<td>354</td>
<td>708</td>
</tr>
<tr>
<td>Pure oxygen activated sludge</td>
<td>142</td>
<td>177</td>
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</tbody>
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Pure oxygen takes 200,000 times less space than land application
Thanks!

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References


http://en.wikipedia.org/wiki/Sewage_treatment