Biotic and abiotic chemical transformations

Much of the previous information regarding contaminant fate assumes little or no degradation.

A) Biotic transformations

   Principle of infallibility

B) Types of microorganisms

   Bacteria
   
   Mineralization
   
   Detoxification
   
   Methylation

   Fungi
   
   Lignin peroxidase
   
   Methylation

   Algae
   
   Biosorption
   
   N-removal

   Other "large" eukaryotes also help to breakdown contaminants
C) Nutritional classification of microbes

<table>
<thead>
<tr>
<th>Group</th>
<th>Energy</th>
<th>C source</th>
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</thead>
<tbody>
<tr>
<td>Photoautotrophs</td>
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<tr>
<td>Photoheterotrophs</td>
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<tr>
<td>Chemoheterotrophs</td>
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<tr>
<td>Chemolithoautotrophs</td>
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D) Metabolism

<table>
<thead>
<tr>
<th>Type</th>
<th>e- donor</th>
<th>Terminal e- acceptor</th>
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<tbody>
<tr>
<td>Fermentation</td>
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<td>Respiration</td>
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<tr>
<td></td>
<td>aerobic</td>
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<tr>
<td></td>
<td>anaerobic</td>
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</tbody>
</table>

E) Energetics of chemical transformations

Typically, organic contaminants serve as an electron donor

\[ \text{CH}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}^+ + \text{e}^- \]
Electron acceptors listed in order of energy gain

\[ \text{O}_2 \rightarrow \text{H}_2\text{O} \]

\[ \text{NO}_3^- \rightarrow \text{N}_2 \]

\[ \text{NO}_3^- \rightarrow \text{NO}_2 \]

\[ \text{Fe}^{3+} \rightarrow \text{Fe}^{2+} \]

\[ \text{SO}_4^{2-} \rightarrow \text{H}_2\text{S} \]

\[ \text{CO}_2 \rightarrow \text{CH}_4 \]
F) Biochemistry of organic contaminant degradation

In order for an organic contaminant to be mineralized it must be converted into a compound involved in the central metabolic pathways.

1) Glycolysis
2) Krebs cycle
3) e- transport system
Example 1. Beta-cleavage of alkanes
Example 2. Degradation of aromatics
G) Recalcitrant compounds

1) Unsaturated and substituted alkanes

2) Increased number of rings

- Benzene
- Naphthalene
- Phenanthrene
- Chrysene
- Benzo[a]pyrene
3) Substituted halogens

   Aerobic respiration

   Reductive dechlorination

   Cometabolism

4) Substituted nitro groups