### Principal Groundwater Contaminants:
Their Sources, Environmental Fate, Health Effects and Treatment Options

<table>
<thead>
<tr>
<th>Contaminant (with examples)</th>
<th>Sources</th>
<th>Environmental Fate</th>
<th>Health Effects</th>
<th>Treatment Options</th>
</tr>
</thead>
</table>
| **Solvents** | • Industry  
• vehicle maintenance  
• metal parts cleaning, degreasing  
• dry cleaning  
• furniture finishing  
• printing  
• gasoline additives  
• cleaning products  
• improper disposal in septic systems  
• septic tank cleaners | **Surface**: volatilize readily  
**Soil**: resist biodegradation; breakdown products may be toxic  
**Groundwater**: very mobile and persistent; some are denser than water and move downward to bedrock | Vinyl chloride and benzene are known human carcinogens; some others, especially chlorinated solvents, are suspected carcinogens; can cause a range of other health effects, including central nervous system effects, irritation of respiratory and gastrointestinal systems. | Evaporation by aeration (public supplies); carbon filtration |
| **Petroleum Products** | • vehicle maintenance  
• automobile service stations  
• heating fuel tanks  
• industrial machinery | **Surface**: light oils, gasoline volatilize readily  
**Soil**: low solubility, may persist in pore spaces and be leached into groundwater by precipitation for long period  
**Groundwater**: gasoline and light oils float on water table; heavy oils less mobile; move down to bedrock | Petroleum products can produce a variety of toxic effects, including central nervous system damage, irritation of respiratory and gastrointestinal system; benzene, a gasoline additive, causes leukemia in humans. | Same as solvents |
| **Pesticides** | • agriculture  
• lawn applications  
• pesticide manufacture, storage | Highly variable: chlorinated hydrocarbons tend to be very persistent, highly susceptible to leaching, and produce toxic breakdown products; other pesticides may be degraded to inert forms or bound to soil particles | Wide range of toxicity to humans; many pesticides are highly toxic, cause central nervous system damage, or are suspected carcinogens. | Some can be removed by carbon filtration or aeration |
<table>
<thead>
<tr>
<th>Pollutant Type</th>
<th>Sources</th>
<th>Soil</th>
<th>Groundwater</th>
<th>Health Effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nitrates</strong></td>
<td>agriculture (fertilizers and manures) • lawn care • septic systems • sewage treatment and collection systems</td>
<td>highly soluble, very mobile; can be taken up by growing plants</td>
<td>very mobile and persistent</td>
<td>Nitrates react with blood hemoglobin, impairing ability to transport oxygen; infants can be fatally affected at relatively low concentrations.</td>
<td>Reverse osmosis (small quantities)</td>
</tr>
<tr>
<td><strong>Biological Pollutants</strong></td>
<td>septic and sewerage systems • agriculture (manures)</td>
<td>bacteria and parasites readily removed by soil filtration</td>
<td></td>
<td>Bacteria cause gastrointestinal diseases (cholera, typhoid, enteritis, hepatitis); viral disease from groundwater uncommon, but no good lab tests available</td>
<td>Disinfection by boiling, chlorination or other methods</td>
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<tr>
<td><strong>Salt (sodium chloride)</strong></td>
<td>road salt storage and application • home water-softener backwash • salt water intrusion (near coast)</td>
<td>very soluble, highly mobile</td>
<td>mobile and persistent</td>
<td>Excessive sodium intake has been linked with high blood pressure and hypertension.</td>
<td>Reverse osmosis (small quantities)</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td>metal finishing and metal working industries • photo and x-ray processing • printing painting • automobile radiator and body shops</td>
<td>metals readily removed by reactions with soil particles under neutral to basic conditions but soluble and mobile in acidic waters</td>
<td></td>
<td>Some heavy metals (e.g., lead, chromium) are highly toxic, cause developmental and nervous system effects; iron, manganese low in toxicity.</td>
<td>pH adjustment to neutralize water and filtration of precipitate</td>
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<tr>
<td><strong>Acids/Bases</strong></td>
<td>industry • photo processing • printing • painting • automobile radiator and body shops</td>
<td>mobile and persistent except in presence of natural pH buffers (e.g., limestone)</td>
<td></td>
<td>Acids and bases are rarely a significant health hazard in themselves, but they affect the solubility of toxic metals.</td>
<td>pH adjustment</td>
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</tbody>
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