

Unit	Human Impacts
Lesson	4.1 Addressing water pollution
Essential question	How can anthropogenic pollution affect stream habitats and how can it be mitigated?
Objective	Students will be able to identify the sources, effects and mitigation strategies of anthropogenic pollution
Key words	anthropogenic, point/nonpoint source pollution, eutrophication, acid rain, bioaccumulation, biomagnification, riparian buffer
Related Standards	
NGSS standard	HS-ESS3-4
AP Env Sci topic	8.1, 8.2, 8.5, 8.6, 8.7, 8.8
IB Biology topic	
IB ESS topic	4.4
Suggested sequence of learning activities	<ol style="list-style-type: none"> <li>1. Starter quiz/prior knowledge check</li> <li>2. Direct instruction (if traditional) or classroom discussion (if flipped). Slides <a href="#">here</a>.</li> <li>3. Students do analysis questions <a href="#">here</a>.</li> <li>4. Peer or teacher check. Answers <a href="#">by request</a>.</li> <li>5. Exit ticket/comprehension check</li> </ol>
Assessment	Exit ticket/comprehension check
Possible modifications	<ul style="list-style-type: none"> <li>• Give a keyword list (with or without definitions already included) to students before or during class</li> <li>• Be intentional about student pairings (eg. heterogeneous skill levels)</li> </ul>
Resources required	Hard copy or digital access to analysis questions <a href="#">here</a> .
Starter questions	<ol style="list-style-type: none"> <li>1. What are three potential sources of pollution in a stream?</li> <li>2. Choose one source of pollution and identify three ways you could reduce the amount of that pollution that ends up in the stream.</li> </ol>
Concepts covered in lesson	Pollution is the presence of chemicals or microbes that are harmful to an ecosystem or humans. Generally, pollution is <b>anthropogenic</b> which means it is caused by human activity. Sources of pollution can be

divided into two categories. **Point source** pollution comes from a single, identifiable source like a factory or chemical spill. **Nonpoint source** pollution comes from multiple, diffuse sources like car exhaust or fertilizers spread on lawns in a neighborhood.

One specific type of water pollution called **eutrophication** occurs when excess nutrients like nitrates and phosphates are added to an aquatic ecosystem. These nutrients can come from fertilizers added to farms or lawns that run off during rain events or can come from intensive livestock farming or sewage. When added to aquatic environments, excess nutrients cause algae to grow in excess (called an algae bloom) which can block sunlight, killing plants below. At this stage, the water has a very high biological oxygen demand (BOD). Then the algae bloom all dies at once which leads to massive decomposition, uses up all the dissolved oxygen causing an anoxic (low oxygen) zone where living things are stressed or die.

Another type of water pollution which can come from anthropogenic or natural sources is **sedimentation**. When runoff brings small soil particles like mud or clay into streams, this can disrupt insect and plant life and cover gravel beds that trout need to spawn.

Another type of water pollution can be caused by **acid rain**. Burning fossil fuels, particularly coal, releases sulfur dioxide and nitrogen oxides into the atmosphere. In clouds, these molecules dissolve into rain droplets, making the rain slightly acidic (lower pH). When this falls as precipitation into streams and lakes, it can lower the pH of the water which can stress or kill aquatic organisms.

Other water pollution can be the direct release of toxic chemicals or metals into the stream. Examples of this type of pollution include mercury (primarily from coal-burning power plants), arsenic (can come from mining activities) and PCBs (industrial chemicals). Depending on the type of toxin and the dose, these chemicals can be lethal to aquatic organisms. If they are not lethal, some chemicals can build up in the tissues of organisms, a process called **bioaccumulation**. If a toxin bioaccumulates in organisms lower on the trophic pyramid, then higher level consumers can have even greater levels of toxins in their tissues after they eat many prey organisms, a process called **biomagnification**.

Like all types of pollution, water pollution can be managed in three ways:

- I. altering human activity to reduce the amount of pollution produced

	<ol style="list-style-type: none"> <li>2. controlling the release of pollution so it does not enter the water after being produced.</li> <li>3. cleaning up or restoring water after the pollution has been introduced to the ecosystem</li> </ol> <p>One of the most common and effective ways to prevent pollutants from entering a waterway (strategy number 2) is to protect or replace a strip of vegetation along both sides of a stream, an area called a <b>riparian buffer</b>.</p> <p>After a rain event, runoff flows towards the stream, but plants in the riparian buffer slow down the flow and give the water a chance to infiltrate. Any pollutants in the water are trapped in the soil and have a chance to break down before they get into the water. This is particularly important on farms so fertilizer and pesticides do not enter waterways.</p>
Slide presentation	Link <a href="#">here</a>
Activity	Analysis questions <a href="#">here</a> . Answers <a href="#">by request</a> .
Exit ticket questions	<ol style="list-style-type: none"> <li>1. Is a leaking septic tank an example of point source or nonpoint source pollution?</li> <li>2. Explain how eutrophication can affect trout in a stream.</li> <li>3. What would be a way to prevent sedimentation from affecting a stream?</li> </ol> <p><u>Answers:</u></p> <ol style="list-style-type: none"> <li>1. Point source (single, identifiable source)</li> <li>2. Excess nutrients cause algae bloom which decomposes using up dissolved oxygen that trout need to survive</li> <li>3. Many answers, including: allow a wide buffer strip of plants to grow along the stream, slowing runoff</li> </ol>
Extension questions/activities/resources	<p>Good water pollution video <a href="#">here</a> (Bozeman Science, 8 minutes).</p> <p>Have students pick a type of pollution and come up with ways to mitigate according to the framework introduced in the lesson. Types of pollution could include:</p> <ul style="list-style-type: none"> <li>● Sewage-- Human waste</li> <li>● Nitrates and phosphates-- fertilizers produced in factories</li> <li>● Animal waste-- manure (fecal matter from, cows, pigs, etc.)</li> <li>● Solid waste (garbage)-- households, manufacturing</li> <li>● Phosphates-- washing detergents</li> <li>● Hot water (thermal pollution)-- power plants</li> </ul>

	<ul style="list-style-type: none"><li>● Biological detergents-- washing soap</li><li>● Food processing waste-- fats and grease down the drain</li><li>● Agricultural pesticides-- herbicides, insecticides</li><li>● Heavy toxic metals-- industry, vehicles</li><li>● Debris (trash)-- natural disasters, cities</li><li>● Noise-- industry, transportation</li><li>● Chemicals from industry-- PCB's, DDT</li><li>● Chemicals from industry-- drugs like endocrine disruptors</li><li>● Pathogens-- bacteria</li><li>● Invasive species-- didymo, other species of trout/fish</li><li>● Oil-- industry, transportation</li><li>● Radioactive materials-- nuclear power station</li><li>● Suspended solids (sediments)-- construction, mining</li></ul>
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