

Unit 8: Aquatic and Terrestrial Pollution

Unit 8 follows pollution into water and onto land, and traces what it does when it gets there. It covers where pollution comes from, how it damages ecosystems, how nutrients overload waterways, how persistent chemicals climb food webs, how we dispose of solid waste and treat sewage, and how pollution and pathogens affect human health.

AP Environmental Science

Aquatic and Terrestrial Pollution

About 15 minutes to read

How to use this guide

Read it in order the first time because the topics form a chain. Sources of pollution (8.1) produce the ecosystem impacts in 8.2 through 8.4. Nutrients drive eutrophication (8.5). Persistent chemicals bioaccumulate and biomagnify (8.7 and 8.8). Solid waste and sewage are the human outputs we manage (8.9 through 8.11). Toxicity and disease are the health consequences at the end (8.12 through 8.15).

Exam questions in this unit often ask you to trace a full cause-and-effect sequence, such as fertilizer runoff to a dead zone, or to compare two similar ideas, such as bioaccumulation and biomagnification. Practice explaining each sequence out loud in order rather than just naming the terms. Finish with the practice questions, then complete the recall check on the last page and note any items you cannot explain yet.

What this unit is worth. Aquatic and Terrestrial Pollution is about 7 to 10 percent of the AP Environmental Science exam. It also connects back to earlier units constantly: nutrients from Unit 4, food webs from Unit 1, and water resources from Unit 5. A sequence you can explain cold, like eutrophication or biomagnification, pays off in both the multiple-choice section and the free-response section.

8.1 Sources of Pollution

The first distinction in this unit is where pollution comes from. A **point source** is a single, identifiable source of a pollutant, such as a smokestack or a waste discharge pipe. Because you can find it, you can monitor it and regulate it. A factory outfall is the classic example.

Nonpoint source pollution is diffused, which makes it difficult to identify. Examples include pesticide spraying across fields and urban runoff washing oil and chemicals off streets into storm drains. The pollution comes from everywhere at once, so no single pipe or stack is responsible.

Trap. Nonpoint source pollution is harder to control than point source pollution, not easier. The Clean Water Act has been effective against point sources precisely because they are identifiable. When a question asks why a waterway stays polluted despite regulation, the answer is usually the nonpoint sources that no permit covers.

8.2 Human Impacts on Ecosystems

Pollutants affect organisms through their **range of tolerance**. For any pollutant, organisms have an optimum band where they maintain homeostasis. Outside that band they experience physiological stress, limited growth, and reduced reproduction. In extreme cases they die. Different species have different tolerance bands, which is why some organisms vanish from a polluted stream while others persist.

Coral reefs are suffering damage from several factors at once: increasing ocean temperature, sediment runoff, and destructive fishing practices. Reefs are a good example of how a stressor outside the range of tolerance, like warmer water, combines with physical damage to push an ecosystem past recovery.

Oil spills harm marine life in several ways. Organisms die from the hydrocarbons in oil. Oil floating on the surface coats the feathers of birds and the fur of marine mammals, destroying insulation. Some components of oil sink to the ocean floor and kill bottom-dwelling organisms. The damage is not only ecological. Oil that washes up on beaches hurts the fishing and tourism industries, which is the **economic consequence** the exam may ask about.

Trap. Oil spill questions test both the biological and the economic damage. If a question asks for an economic consequence, the answer is fishing and tourism losses, not dead seabirds. Read which kind of consequence is being asked for.

Oceanic dead zones are areas of low oxygen in the world's oceans caused by increased nutrient pollution. The nutrients fuel algal growth, and when the algae die, decomposition consumes the dissolved oxygen. Fish and mobile organisms flee; organisms that cannot move die.

The **oxygen sag curve** is a plot of dissolved oxygen levels versus distance from a pollution source, usually excess nutrients and biological refuse. Dissolved oxygen drops sharply just downstream of the source, then recovers farther away as decomposition finishes and reaeration catches up. The lowest point of the curve is where aquatic life is in the most danger.

Heavy metals used in industry, especially mining and the burning of fossil fuels, can reach groundwater and threaten the drinking water supply. **Litter** in aquatic ecosystems is more than unsightly: it creates intestinal blockage and choking hazards for wildlife and introduces toxic substances into the food chain. **Sediment** in waterways reduces light infiltration, which harms primary producers and visual predators, and when it settles it disrupts habitats.

Mercury becomes far more dangerous in water. When elemental mercury enters aquatic environments, bacteria convert it to highly toxic methylmercury. That conversion is the step that matters for the exam, because methylmercury is the form that bioaccumulates in fish.

Trap. Two laws get confused constantly. The **Clean Water Act** regulates pollutant discharges into the nation's rivers, lakes, and streams and sets surface-water quality standards. The **Safe Drinking Water Act (SDWA)** authorizes the EPA to set standards for drinking water quality and oversee public drinking water supplies. If the question is about a factory pipe, it is the Clean Water Act. If it is about tap water, it is the Safe Drinking Water Act.

8.3 Endocrine Disruptors

Endocrine disruptors are chemicals that interfere with hormones. They do it in three ways: mimicking hormones, blocking hormone receptors, or altering hormone production. The effects include birth defects, developmental disorders, and skewed sex ratios in wildlife, such as gender imbalances in fish and other species.

Trap. Endocrine disruptors act at very low doses because hormones themselves work at very low concentrations. A question may describe reproductive abnormalities in a fish population downstream of a wastewater plant and expect you to name endocrine disruption, not acute toxicity. Look for the hormonal signature: skewed sex ratios, developmental disorders, birth defects.

8.4 Human Impacts on Wetlands and Mangroves

Wetlands are areas where water covers the soil, either part or all of the time. Their **ecosystem services** include water purification, flood protection, water filtration, and habitat. A wetland acts like a sponge and a filter at once: it absorbs stormwater that would otherwise flood downstream areas and traps sediments and nutrients that would otherwise reach waterways.

These ecosystems are endangered by commercial development, dam construction, overfishing, and pollutants from agriculture and industrial waste. Draining a wetland for development removes both the flood protection and the filtration, which is why wetland loss tends to make flooding and water pollution worse at the same time.

8.5 Eutrophication

Eutrophication is the enrichment of a body of water with nutrients. The anthropogenic causes are agricultural runoff and wastewater release, both of which carry nitrogen and phosphorus into waterways.

The sequence that follows is one of the most tested chains in this course. Excess nutrients trigger an **algal bloom**. When the algae die, microbes decompose them, and that decomposition consumes dissolved oxygen. The resulting low oxygen causes large die-offs of fish and other aquatic organisms. Waterways that are low in dissolved oxygen are called **hypoxic**. By contrast, **oligotrophic** waterways have very low nutrient levels, stable algae populations, and high dissolved oxygen.

Trap. The oxygen drop is caused by microbes decomposing the dead algae, not by the living bloom. Students often write that the algae "use up the oxygen," which skips the actual mechanism. The correct order is nutrients, bloom, die-off, decomposition consumes oxygen, hypoxia. If a free-response asks you to explain a fish kill, every link in that chain earns credit.

8.6 Thermal Pollution

Thermal pollution is heat released into water that produces negative effects on organisms in that ecosystem. Power plants are the main source, discharging cooling water that is warmer than the river or lake it enters.

The key mechanism is the relationship between water temperature and dissolved oxygen. Warm water does not hold as much dissolved oxygen as cold water, so a sudden warming lowers the oxygen available to aquatic organisms while their metabolic rates, and therefore their oxygen demand, rise at the same time.

8.7 Persistent Organic Pollutants (POPs)

Persistent organic pollutants (POPs) are synthetic carbon-based molecules, such as DDT and PCBs, that do not easily break down in the environment. Two properties make them dangerous. First, they are soluble in fat, which lets them **accumulate in the fatty tissues** of organisms. Second, they are subject to **long-range transport**: they travel over long distances via wind and water before being redeposited, so they show up in places like the Arctic where they were never used.

8.8 Bioaccumulation and Biomagnification

Bioaccumulation is the selective absorption and concentration of elements or compounds by the cells of a living organism, most commonly fat-soluble compounds. It happens within one organism over its lifetime: the longer it lives and the more contaminated food it eats, the higher its body burden.

Biomagnification is the increase in concentration of a substance per unit of body tissue at successively higher trophic levels of a food chain. Each predator eats many prey items and keeps the contaminant, so the top carnivore carries the highest concentration. The classic effects are **eggshell thinning and developmental deformities in top carnivores**, as with DDT and birds of prey. In humans, biomagnified substances cause problems with the reproductive, nervous, and circulatory systems. The substances that bioaccumulate and have significant environmental impacts are DDT, mercury, and PCBs.

Trap. Bioaccumulation is within one organism over time. Biomagnification is up the food chain across trophic levels. If the question describes concentrations rising from plankton to small fish to large fish to eagles, that is biomagnification. If it describes a single fish getting more contaminated as it ages, that is bioaccumulation.

8.9 Solid Waste Disposal

Solid waste is any discarded material that is not a liquid or gas, generated in domestic, industrial, business, and agricultural sectors. Most of it is disposed of in **landfills**, which can contaminate groundwater and release harmful gases.

A **sanitary landfill** is engineered to contain waste. Its design includes a bottom liner of plastic or clay, a storm water collection system, a leachate collection system, a cap, and a methane collection system. The liner and leachate system exist to keep contaminated liquid out of groundwater. **Landfill decomposition** depends on the trash's composition and on the conditions microbes need to break it down; buried waste decomposes slowly because oxygen and moisture are limited.

Incineration disposes of solid waste by burning it at high temperatures. It significantly reduces waste volume, but it releases air pollutants, so the pollution is shifted from land to air rather than eliminated.

Electronic waste (e-waste) means discarded devices such as televisions, cell phones, and computers. It contains hazardous chemicals, including lead and mercury, that can leach from landfills into groundwater if the waste is not disposed of properly.

Illegal waste dumping causes environmental problems when items not accepted in sanitary landfills are dumped anyway. Used rubber tires left in piles, for example, become breeding grounds for mosquitoes that can spread disease. **Ocean dumping** of waste has produced large floating islands of trash; wildlife becomes entangled in the waste and ingests it.

Trap. The two waste laws have opposite jobs. **RCRA** (Resource Conservation and Recovery Act) governs the management of solid and hazardous waste from generation to disposal. Think of it as the law that manages waste while it is being handled. **CERCLA** (Comprehensive Environmental Response, Compensation, and Liability Act) provides for the cleanup of sites already contaminated with hazardous substances and holds responsible parties liable for cleanup costs. Think of it as the law that cleans up the mess afterward.

8.10 Waste Reduction Methods

Recycling processes solid waste materials and converts them into new products. Its main tradeoff: recycling reduces the global demand on minerals, but the process is energy-intensive and can be costly.

Composting lets organic matter such as food scraps, paper, and yard waste decompose; the product can be used as fertilizer, though odor and rodents are drawbacks. **E-waste** can be reduced through recycling and reuse, which keeps lead and mercury out of landfills and groundwater.

Landfill mitigation covers strategies from burning waste for energy to restoring habitat on former sites for use as parks. One specific strategy is **landfill gas to energy**: methane from decomposing landfill waste is captured and burned to drive turbines and generate electricity, which also cuts methane emissions that would otherwise escape into the atmosphere.

Trap. Landfill gas to energy does not reduce the volume of waste in the landfill. Its benefits are electricity generation and reduced methane emissions. If a question asks for a method that reduces waste volume, the answer is incineration or recycling, not gas capture.

8.11 Sewage Treatment

Sewage treatment happens in stages, and each stage removes something different. **Primary treatment** is physical: screens and grates remove large objects, then solid waste settles to the bottom of a tank.

Secondary treatment is biological: bacteria break down organic matter into carbon dioxide and inorganic sludge, which settles out. The tank is aerated to increase the rate at which the bacteria work.

Tertiary treatment uses ecological or chemical processes to remove pollutants left in the water after the first two stages. **Disinfection** comes last: before discharge, the treated water is exposed to chlorine, ozone, or UV light to kill bacteria.

Trap. Know the order and the mechanism. Primary is physical settling. Secondary is the bacterial step, and it is aerobic, which is why the tank is aerated. Tertiary is chemical or ecological polishing. Disinfection kills pathogens but does not remove nutrients or solids. A question that asks which stage uses microorganisms is asking for secondary treatment.

8.12 Lethal Dose 50% (LD50)

LD50 is the dose of a chemical that is lethal to 50 percent of a particular species' population. It is a standard measure of acute toxicity, and it is comparable across chemicals only when it is measured in the same species under the same conditions.

Trap. A lower LD50 means a more toxic substance, because it takes less of the chemical to kill half the test population. Students regularly flip this. If chemical A has an LD50 of 5 mg/kg and chemical B has an LD50 of 50 mg/kg, chemical A is the more toxic one.

8.13 Dose Response Curve

A **dose response curve** is a graph showing an organism's reaction, or a population's mortality rate, based on the amount of a particular toxin or drug. Mortality rises with dose in the characteristic S shape, and the LD50 is read off the curve at the 50 percent mortality point. These curves are how toxicologists turn raw exposure data into a single comparable number.

8.14 Pollution and Human Health

Establishing **cause and effect** between a pollutant and a human health issue is difficult, because humans are exposed to a variety of chemicals and pollutants at once. That difficulty is itself a testable point: correlation in an exposed population does not prove that one specific chemical caused the illness.

The specific health links in this unit: **dysentery** is caused by untreated sewage in streams and rivers.

Mesothelioma is a type of cancer caused mainly by exposure to asbestos. Elevated **tropospheric ozone** causes respiratory problems and reduces overall lung function. The **Delaney Clause** is a provision of the Food, Drug, and Cosmetic Act that prohibits approval of food additives found to cause cancer.

8.15 Pathogens and Infectious Diseases

Pathogens adapt to take advantage of new opportunities to infect and spread through human populations, and they can occur in environments that look sanitary. Two large forces are expanding their reach. As equatorial-type climate zones spread north and south into subtropical and temperate zones, **climate change** carries pathogens and their vectors into areas where the diseases were previously unknown. **Poverty** creates the other opening: low-income areas often lack sanitary waste disposal and have contaminated drinking water, which creates havens for the spread of infectious disease.

The specific diseases: **plague** is a bacterial disease transferred by the bite of an infected organism or through contact with contaminated fluids or tissues. **Tuberculosis** is a bacterial infection that typically attacks the lungs, spread by breathing in the bacteria from the bodily fluids of an infected person. **Malaria** is a parasitic disease caused by bites from infected mosquitoes, most often found in sub-Saharan Africa. **West Nile virus** is transmitted to humans by bites from infected mosquitoes. **SARS** is a form of pneumonia transferred by inhaling or touching infected fluids. **MERS** is a viral respiratory illness transferred from animals to humans. **Zika virus** is caused by bites from infected mosquitoes and can also be transmitted through sexual contact. **Cholera** is a bacterial disease contracted from infected water.

Confusions That Cost Points

PAIR	HOW TO KEEP THEM STRAIGHT
Point vs nonpoint source	Point is a single identifiable source, like a discharge pipe, and it can be regulated. Nonpoint is diffuse, like runoff, and it is harder to control.
Clean Water Act vs Safe Drinking Water Act	The Clean Water Act regulates pollutant discharges into rivers, lakes, and streams. The Safe Drinking Water Act sets standards for drinking water through the EPA.
RCRA vs CERCLA	RCRA manages solid and hazardous waste from generation to disposal. CERCLA cleans up sites already contaminated and makes responsible parties pay.
Bioaccumulation vs biomagnification	Bioaccumulation builds up within one organism over its lifetime. Biomagnification increases concentration up the trophic levels to top carnivores.
Eutrophication sequence	Nutrients, algal bloom, algae die, microbes decompose the dead algae and consume dissolved oxygen, hypoxia. The oxygen loss comes from decomposition, not from the living bloom.
Sewage treatment stages	Primary is physical settling. Secondary is bacterial breakdown with aeration. Tertiary is chemical or ecological polishing. Disinfection kills pathogens last.
Mosquito-borne diseases	Malaria is a parasite. West Nile and Zika are viruses. Cholera and dysentery are bacterial and waterborne, not mosquito-borne.

Practice Questions

Original questions written for this guide in the style of the AP exam. Answers and explanations are on the next page, so complete the questions before checking them.

- 1.** A lake near farmland experiences a large fish kill in late summer. Water testing shows high nitrogen and phosphorus levels and very low dissolved oxygen. Which sequence best explains the fish kill?
 - A. Excess nutrients trigger an algal bloom, algae die, microbes decompose the dead algae and consume dissolved oxygen, and the resulting hypoxia kills the fish.
 - B. Excess nutrients are directly toxic to fish, and the fish die from nutrient poisoning before any algal growth occurs.
 - C. Algae bloom and release oxygen during the day, the excess oxygen suffocates the fish, and the nutrients then wash out of the lake.
 - D. Low dissolved oxygen causes an algal bloom, the bloom releases nutrients as it grows, and the nutrients kill the fish.

- 2.** Researchers measure DDT concentrations in a lake food chain. Plankton contain 0.04 ppm, small fish contain 0.5 ppm, large fish contain 2 ppm, and eagles contain 25 ppm. This pattern is best described as
 - A. bioaccumulation, because each organism absorbs DDT over its lifetime.
 - B. biomagnification, because DDT concentration increases at successively higher trophic levels.
 - C. eutrophication, because the DDT acts as a nutrient that enriches the food chain.
 - D. biodegradation, because each trophic level breaks DDT down further.

- 3.** A municipal wastewater plant processes sewage in several stages. In one stage, the wastewater is held in an aerated tank where bacteria break down organic matter into carbon dioxide and inorganic sludge. This stage is
 - A. primary treatment.
 - B. secondary treatment.
 - C. tertiary treatment.
 - D. disinfection.

- 4.** In laboratory tests on the same species, chemical X has an LD50 of 5 mg/kg and chemical Y has an LD50 of 50 mg/kg. Based on these values,
 - A. chemical Y is more toxic because its LD50 value is larger.
 - B. chemical X is more toxic because a smaller dose is lethal to 50 percent of the population.
 - C. the two chemicals are equally toxic because LD50 measures exposure time, not dose.
 - D. no comparison is possible because LD50 values are only valid for humans.

Answer Key

1. A. The full eutrophication chain is nutrients, algal bloom, algae die, microbes decompose the dead algae and consume dissolved oxygen, hypoxia, fish kill. B is wrong because nitrogen and phosphorus are not directly toxic to fish at these levels; the kill comes from oxygen loss. C reverses the mechanism: the bloom does not suffocate fish with excess oxygen, and the fish die from low oxygen. D runs the chain backward: low oxygen is the result, not the cause, of the bloom.

2. B. The defining feature is the increase in concentration per unit of body tissue at successively higher trophic levels, which is biomagnification. A describes bioaccumulation, which is buildup within a single organism over its lifetime; the data here compare levels across trophic levels, not within one animal. C confuses a contaminant with a nutrient; DDT is not a nutrient and eutrophication is a separate process. D is backwards: DDT is a persistent organic pollutant precisely because organisms cannot break it down easily.

3. B. Secondary treatment is the biological stage: bacteria break down organic matter, and the tank is aerated to speed up the bacteria. A is physical treatment, screens and settling, with no bacteria involved. C uses ecological or chemical processes to polish the water after secondary treatment. D uses chlorine, ozone, or UV light to kill bacteria at the end; it does not use bacteria to break down waste.

4. B. A lower LD50 means higher toxicity, because it takes less of the chemical to kill half the test population. A flips the relationship, the most common error on this question type. C misstates what LD50 measures: it is a dose, expressed per unit of body mass, not an exposure time. D is wrong because LD50 is measured in a particular test species and is comparable across chemicals tested in that species; it is not limited to humans.

One-Page Recall Check

- Explain why nonpoint source pollution is harder to control than point source pollution, with one example of each.
- Describe what happens to an organism pushed outside its range of tolerance for a pollutant.
- List the ways an oil spill harms marine life, plus one economic consequence.
- Sketch an oxygen sag curve from memory and label where aquatic life is in the most danger.
- Explain how elemental mercury becomes methylmercury in aquatic environments.
- State which law covers factory discharges into rivers and which covers drinking water standards.
- Explain the three ways endocrine disruptors interfere with hormones, plus two effects on wildlife.
- Name three ecosystem services wetlands provide and two threats to wetlands.
- Walk through the full eutrophication sequence and name the step that consumes dissolved oxygen.
- Explain why thermal pollution lowers dissolved oxygen.
- State two properties of POPs that make them dangerous and name two examples.
- Distinguish bioaccumulation from biomagnification in one sentence each, and name three substances that bioaccumulate.
- List the components of a sanitary landfill and explain what the liner and leachate system do.
- Compare incineration and landfill gas to energy on what each one actually accomplishes.
- Distinguish RCRA from CERCLA by what each law does.
- Order the sewage treatment stages and state what each removes.
- Explain what a lower LD50 means and how it is read from a dose response curve.
- Name the transmission route for each: plague, tuberculosis, malaria, West Nile virus, Zika virus, cholera.

Where to go next. Turn every missed item above into flashcards and drill them spaced out over several days rather than in one sitting. In Rycal, open the Aquatic and Terrestrial Pollution deck under AP Environmental Science. The deck covers the terms in this guide, and its practice questions target the same traps named here. If you have a test date, add it in the Test Planner. You can also start your next review with a Brain Dump, then check what you missed against this guide.

Key terms for this unit

Point source pollution, Nonpoint source pollution, Range of tolerance (pollutants), Coral reef damage, Oil spill impacts on marine life, Oil spill economic consequences, Oceanic dead zones, Oxygen sag curve, Heavy metals in groundwater, Litter in aquatic ecosystems, Sediment in waterways, Mercury to methylmercury, Clean Water Act, Safe Drinking Water Act (SDWA), Endocrine disruptors, Effects of endocrine disruptors, Wetlands, Wetland ecosystem services, Threats to wetlands and mangroves, Eutrophication, Algal bloom and oxygen depletion, Hypoxic waterways, Oligotrophic waterways, Anthropogenic causes of eutrophication, Thermal pollution, Water temperature and dissolved oxygen, Persistent organic pollutants (POPs), POPs accumulate in fat, Long-range transport of POPs, Bioaccumulation, Biomagnification, Biomagnification effects on top carnivores, Biomagnification effects on humans, Substances that bioaccumulate, Solid waste, Landfills, Electronic waste (e-waste), Sanitary landfill design, Landfill decomposition, Incineration, Illegal waste dumping, Ocean dumping of waste, CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act), RCRA (Resource Conservation and Recovery Act), Recycling, Recycling tradeoffs, Composting, Reducing e-waste, Landfill mitigation, Landfill gas to energy, Primary sewage treatment, Secondary sewage treatment, Tertiary sewage treatment, Sewage disinfection, LD50, Dose response curve, Pollution and health cause-effect, Dysentery, Mesothelioma, Tropospheric ozone and lung health, Delaney Clause, Pathogen adaptation, Pathogens in sanitary-looking environments,