

Pollution to Solutions

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1. Introduction

There are two types of water-pollution: (1) Human-caused water pollution via dumping waste into bodies of water, and (2) Natural water pollution by Mother Nature passing rain-water through a land containing undesirable (read: polluting) substances (whether the deposition is human-caused or naturally-caused).

2. Pollution

Almost half of the world's population depends on synthetic fertilizers, which account for about 2% of the global energy budget. Much of the fertilizer supply chain is outside the U.S., making it vulnerable to geopolitical disruptions — for example, U.S. fertilizer prices quadrupled in 2022 after the Ukraine invasion. Additionally, two-thirds of applied nitrogen fertilizer escapes into runoff, polluting waterways and wasting a valuable resource.

3. Solutions

Lawrence Livermore National Laboratory (LLNL) researchers Jeremy Feaster and Steven Hawks are working on a two-stage process.¹

3.1. Nitrate Recovery via Electrodialysis

Wastewater from fertilized crops is loaded with nitrates, which are toxic if ingested.

Hawks' team uses a voltage-driven ion-exchange membrane system similar to electrodialysis.

Applying a voltage pushes cations (like nitrate ions) through cation-exchange membranes and anions through anion-exchange membranes, separating them from neutral water molecules.

This produces two streams: one enriched in nitrate ions (hence a concentrated fertilizer source) and one clean water stream.

3.2. Fertilizer Conversion and Recycling

The recovered nitrates are transformed into usable fertilizer forms, such as ammonia, through electrochemical or catalytic processes.

This approach not only cleans the water but also recycles a valuable nutrient that would otherwise be lost to the environment.

3.3. Potential Benefits

Domestic fertilizer production could improve U.S. food security and reduce import dependency.

¹ Ashley Piccone, Lawrence Livermore National Laboratory, California, "Turning wastewater into valuable fertilizer," December 2, 2025, <https://www.llnl.gov/article/53681/turning-wastewater-valuable-fertilizer>

The above-described process has lower energy costs when compared to traditional fertilizer manufacturing. This process also protects the environment by reducing nitrogen pollution in waterways, and also improves economic resilience for farmers, as fertilizer prices are less vulnerable to global supply shocks.

3.4. Next Steps

The LLNL team is refining the process to make it scalable, energy-efficient, and cost-effective for real-world agricultural and municipal wastewater treatment. If successful, this technology could be deployed in California and beyond, helping to close the nitrogen loop in the fertilizer cycle.

In short, LLNL's breakthrough is a sustainable, dual-purpose system — producing clean water and fertilizer from a waste stream that is both a resource and a pollution problem.

4. Non-Point-Source Pollution

Non-point-source pollution is pollutants that don't come from a point source. Point source pollution is contamination that originates from a single, identifiable, and confined location, such as a pipe, smokestack, or drainage outlet.² Any source of pollution that does not meet the definition in the prior sentence, in general, is non-point-source pollution.

An example of a non-point-source pollution source is irrigation run-off carrying agricultural, commercial and industrial waste. The latter two would be from C&I Facilities like watering nice green landscaping (and inadvertently, nearby parking lots driveways and streets) polluted by a nearby gardening or air-born source.

Much of the above text comes from the source referenced here.³

4.1. Information about Nonpoint Source (NPS) Pollution

4.1.1. Overview

NPS pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.⁴

Nonpoint source pollution can include:

- *Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas*
- *Oil, grease and toxic chemicals from urban runoff and energy production*

² <https://www.bing.com/search?q=point+source+pollution&q=LS&pq=point-source++&sc=12-14&cvid=FF7EC5B41CAB4F39BAA77211B46452CF&FORM=QBRE&sp=1&lq=0>

⁴ U.S. Environmental Protection Agency (EPA), Basic Information about Nonpoint Source (NPS) Pollution, November 5, 2025, <https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution>

- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices⁵ and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems
- Atmospheric deposition and hydromodification⁶

States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries and wildlife.

4.1.2. Nonpoint Sources vs. Point Sources

The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act:

The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.



Illustrations of nonpoint and point source pollution along with elements of the hydrologic cycle

Developed by the EPA, Office of Water, Nonpoint Source Program

⁵ Irrigation-induced salinity occurs when soluble salts accumulate in the soil due to irrigation practices that introduce water faster than it can drain, thus it evaporates, leaving salts behind in the root zone. This process is especially problematic in arid and semi-arid regions where rainfall is insufficient to leach salts away.

⁶ Atmospheric hydromodification refers to changes in the timing, volume, and rate of runoff caused by land development and other human activities, which in turn alter the natural water cycle and sediment balance in watersheds.

4.1.3. What We Can Do to Prevent NPS Pollution

In Urban Environments

Keep litter, pet wastes, leaves and debris out of street gutters and storm drains—these outlets drain directly to lake, streams, rivers and wetlands.

Apply lawn and garden chemicals sparingly and according to directions.

Dispose of used oil, antifreeze, paints and other household chemicals properly—not in storm sewers or drains. If your community does not already have a program for collecting household hazardous wastes, ask your local government to establish one.

Clean up spilled brake fluid, oil, grease and antifreeze. Do not hose them into the street where they can eventually reach local streams and lakes.

Control soil erosion on your property by planting ground cover and stabilizing erosion-prone areas.

Encourage local government officials to develop construction erosion and sediment control ordinances in your community.

Have your septic system inspected and pumped, at a minimum every three to five years, so that it operates properly.

Purchase household detergents and cleaners that are low in phosphorous to reduce the amount of nutrients discharged into our lakes, streams and coastal waters.

Forestry

Use proper logging and erosion control practices on forest lands by ensuring proper construction, maintenance, and closure of logging roads and skid trails.

Report questionable logging practices to state and federal forestry and state water quality agencies.

Agriculture

Manage animal manures to minimize losses to surface water and ground water.

Reduce soil erosion and nutrient loss by using appropriate conservation practice systems and other applicable best management practices.

Use planned grazing systems on pasture and rangeland.

Dispose of pesticides, containers, and tank rinse-water in an approved manner.

Work with conservation partners locally including Soil and Water Conservation Districts to understand local strategies.

Stormwater

Stormwater runoff occurs when precipitation from rain or snowmelt flows over the ground. Impenetrable surfaces like driveways, sidewalks, and streets prevent stormwater from naturally soaking into the ground.⁷

⁷ EPA, After the Storm, A Citizen's Guide to Understanding Stormwater, January, 2003, <https://nepis.epa.gov/Exec/ZipPDF.cgi/200049A9.PDF?Dockey=200049A9.PDF>

Stormwater can pick up debris, chemicals, dirt, and other pollutants and flow into a storm sewer system or directly to a lake, stream, river, wetland, or coastal water. Anything that enters a storm sewer system is discharged untreated into the water-bodies we use for swimming, fishing, and providing drinking water

Polluted stormwater runoff can have many adverse effects on plants, fish, animals, and people.

- *Sediment can cloud the water and make it difficult or impossible for aquatic plants to grow. Sediment also can destroy aquatic habitats.*
- *Excess nutrients can cause algae blooms. When algae die, they sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other aquatic organisms can't exist in water with low dissolved oxygen levels.*
- *Bacteria and other pathogens can wash into swimming areas and create health hazards, often making beach closures necessary.*
- *Debris—plastic bags, six-pack rings, bottles, and cigarette butts—washed into waterbodies can choke, suffocate, or disable aquatic life like ducks, fish, turtles, and birds.*
- *Household hazardous wastes like insecticides, pesticides, paint, solvents, used motor oil, and other auto fluids can poison aquatic life. Land animals and people can become sick or die from eating diseased fish and shellfish or drinking polluted water.*