Renewable Energy Farmers of America

Solar Panels and Chemical Safety

Solar panels are primarily composed of glass (75 to 80 percent), aluminum (8 to 14 percent), silicon (3 to 5 percent) and polymers. The trace metals sometimes cited as concerns, including lead, cadmium, copper and tellurium, are present in very small quantities and sealed within multiple protective layers.

Many rural residents have questions about whether solar panels could leach chemicals into soil or groundwater. The concern is understandable. Farmland is precious, and protecting soil health matters for generations to come. Here is what the research shows.

The Two Main Panel Types

Crystalline Silicon Panels (c-Si): These represent about 95 percent of the global market. They contain less than 0.1 percent lead by weight, primarily in the tin-lead solder used to connect cells. This lead is encapsulated within non-porous glass. For comparison, the lead content in a solar panel is about 1/750th of what is in a car battery.

Cadmium Telluride Panels (CdTe): The semiconductor layer is only 3 percent the thickness of a human hair. Cadmium and tellurium form a stable compound that is insoluble in water and has a very high melting point. This compound is sealed between two sheets of heat-strengthened glass bonded under high pressure. Research shows that CdTe as a compound is 99 percent less toxic than elemental cadmium.

Understanding the Four Types of Concern

Public discussion often mixes together several different questions about solar panel safety. Scientists separate these into distinct categories because the evidence differs for each:

1. **Chemical leaching from intact, operational panels** during normal use
2. **Chemical leaching from broken or damaged panels** after storms or accidents
3. **Fire safety** during panel fires
4. **End-of-life disposal** when panels reach the landfill

Each of these scenarios has a different risk profile and different evidence behind it. The sections below address each one.

Intact Operational Panels: What the Field Research Shows

This is the most studied scenario. Three peer-reviewed field studies have measured metal concentrations in soil at operating solar facilities:

- Robinson and Meindl (2019) examined soil near crystalline silicon installations
- Yandem et al. (2025) studied metal concentrations including technology-critical elements
- Yousuf et al. (2024) assessed soil pollution near fence-type solar installations

None of these studies found chemical leaching directly attributable to intact, operational panels. The encapsulation design works as intended: chemicals remain sealed within the panel structure during normal operation.

Why encapsulation matters: Solar panels are built to withstand harsh environmental conditions for 25 years or more. The chemicals are sealed between two layers of plastic (typically ethylene-vinyl

acetate, or EVA), then protected on top with tempered glass and on the back with a polymer sheet. This laminated structure makes panels difficult to break open even when damaged, similar to how car windshields crack but stay intact.

Broken or Damaged Panels: What Modeling Studies Show

When severe storms damage solar panels, some residents worry about chemical release. No post-storm environmental sampling study has been published for a real-world breakage event. However, multiple modeling studies have examined this scenario:

The International Energy Agency's Task 12 research program has modeled worst-case broken-panel scenarios. The findings consistently show that even under extreme assumptions, exposure levels remain below EPA health thresholds.

Sinha et al. (2012) conducted fate and transport modeling for cadmium telluride panels specifically, finding that potential exposures stayed well below regulatory limits even in breakage scenarios. **The short answer:** While damaged panels look concerning, the combination of encapsulation, low chemical concentrations and dilution means that even broken panels are not expected to cause health or environmental harm.

Fire Safety

Solar panel fires are rare. A joint study by Fraunhofer ISE and TÜV Rheinland analyzed fire data across Germany and found that only about 0.006 percent of solar installations (roughly 1 in 10,000) cause fires with significant damage. The researchers concluded that "photovoltaic systems are different, but not more dangerous, than traditional electrical installations." For comparison, electrical malfunctions cause about 6 percent of all U.S. residential fires each year according to NFPA data.

When fires do occur:

- First responders can access training through the Department of Energy's fire safety guide and the Solar Training and Education for Professionals (STEP) program
- Standard firefighting equipment effectively manages any risks
- The panels themselves do not ignite or accelerate fires under normal conditions

Panels sold in the U.S. must meet strict fire safety standards. UL 61730 certification (which replaced UL 1703) requires testing for electrical insulation, grounding and fire protection before panels can reach the market.

End-of-Life Disposal: The TCLP Test

When solar panels reach the end of their useful life, they must be tested to determine whether they qualify as hazardous waste. The EPA's Toxicity Characteristic Leaching Procedure (TCLP) is the standard test for this determination.

The TCLP test subjects materials to conditions far more extreme than real-world exposure:

- Panels are crushed into small pieces
- Exposed to acidic solutions designed to simulate worst-case landfill conditions
- Agitated for extended periods

What the testing shows: A 2025 database analysis by Arizona State University and EPRI compiled TCLP results from multiple studies. For crystalline silicon panels (95 percent of the market), most panels tested passed EPA hazardous waste thresholds.

When researchers used TCLP inputs in worst-case exposure models, lead, cadmium and selenium levels remained below EPA thresholds according to the IEA's module disposal risk assessment.

Important context: The hazardous waste classification is based on potential future leaching in landfills, not operational safety. Even panels that fail TCLP testing have disposal pathways, and proper recycling programs are being developed to recover valuable materials. The EPA is developing new rules to improve solar panel recycling nationwide.

Ongoing Research

The Argonne National Laboratory Solar Soil Database represents the most significant ongoing effort to collect data on carbon, nutrients, metals, pesticides and other constituents in solar site soils. As of February 2026, the database included data from more than 25 solar energy facilities across the U.S. This type of long-term monitoring helps fill research gaps and provides landowners, regulators and communities with real-world data on solar facility impacts.

What This Means for Farmers and Ranchers

Solar panels installed on your property:

- Do not pose chemical leaching risks to soil, crops or livestock under normal operating conditions, based on available field research
- Are designed with multiple safety layers specifically to prevent chemical release
- Meet strict safety standards before reaching the market
- Can operate safely for 25 years or more when properly installed and maintained

When evaluating a solar lease, chemical safety is one of many factors to consider. The evidence shows that properly installed and maintained solar panels do not contaminate agricultural land during operation.

REFA Briefs provide factual information to help farmers and ranchers make informed decisions about renewable energy. For questions or additional resources, contact REFA at 630-299-8615 or visit renewableenergyfarmers.org.