

Heavy Metals in Fertilizers, 1960–2025

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THE CLAIM

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The metal in the food is the tail of a process that began in the soil, often before the crop was planted. The governments that regulate the fertilizer reason in decades and in cumulative loading. A certificate that tests the product once, for four metals, is blind to a pathway it never measured.

Abstract

The heavy metals a laboratory finds in a finished food are, more often than a factory audit implies, an inheritance from the field. [Cadmium](#) arrives in the phosphate rock that fertilizer is made from; cadmium, [lead](#), and [nickel](#) arrive again in the sewage-sludge and compost amendments spread as soil conditioners; and where irrigation runs on municipal wastewater, several metals arrive together in the water itself. None of this is a manufacturing defect. It is the slow loading of agricultural soil across the decades of intensive fertilization that followed 1960, and the crop draws the metal back out of the soil years or decades later. The governments that regulate these inputs, Canada, the European Union, the United States, China, do not write product-concentration caps in isolation; they reason in cumulative kilograms per hectare over a forty-five-year horizon, precisely because the contamination persists. This briefing traces that upstream pathway and the standards written to govern it, and sets out why a finished-product certificate that tests only the food, only for four metals, and only once is measuring the end of a process it never looked up.

The field, not the factory

A heavy-metal result on a finished food invites a factory explanation: a bad ingredient lot, a contaminated line, a supplier that slipped. Sometimes that is what happened. But for the metals that dominate the food-safety conversation, cadmium above all, and lead, nickel, and [chromium](#) alongside it, the more common origin is upstream of any factory, in the soil the crop grew in and the inputs that loaded that soil over many seasons. The contamination is agronomic before it is industrial.

This matters for certification because the two origins behave differently. A factory contamination event is acute and local: it starts, it can be found, and it can be stopped. A soil-loading pathway is chronic and distributed: it accumulates over years, it is invisible in any single lot, and stopping the input today does not unload the field. A testing regime built to catch the first will systematically miss the second, and the second is where most of the dietary burden of cadmium is made.

Cadmium comes with the phosphate

The clearest case is cadmium and phosphate fertilizer. Phosphate fertilizers are manufactured from mined phosphate rock, and phosphate rock naturally carries cadmium as a geochemical companion of phosphorus. The cadmium load depends on the deposit: sedimentary rock, which supplies most of the world's phosphate, tends to be cadmium-rich, while igneous rock is comparatively clean. Every application of a cadmium-bearing phosphate fertilizer adds a small increment of cadmium to the topsoil, and because cadmium is retained in the plough layer rather than flushed away, the increments accumulate. Across the sixty-five years of intensive phosphate use that followed 1960, that accumulation became a measurable rise in the cadmium content of arable soils, and cadmium is efficiently taken up by staple crops, wheat, potatoes, leafy greens, sunflower, so the soil burden transfers to the diet.

The European Union treated this as a regulatory problem in its own right. Regulation (EU) 2019/1009, the Fertilising Products Regulation, sets a maximum cadmium content of 60 milligrams per kilogram of P_2O_5 for inorganic phosphate fertilisers containing at least 5 percent P_2O_5 , applicable from 16 July 2022, and creates a voluntary “low cadmium” label for products at or below 20 milligrams per kilogram of P_2O_5 , with a built-in clause to review the feasibility of lowering the limit further ^[2]. The limit exists because phosphate fertilizer is the dominant controllable route by which cadmium enters European farmland; the regulation is, in effect, a government stating on the record that the metal in the crop is coming from the input.

The cumulative-loading logic

The fertilizer standards share a design feature that a food-product limit does not have: they regulate the metal on a cumulative-loading horizon, not as a one-time concentration. Canada's consolidated standard, CFIA Trade Memorandum T-4-93, is the clearest example. It does not set a single product cap; it sets a maximum acceptable cumulative addition of each metal to soil over a forty-five-year period, expressed in kilograms per hectare, and derives an allowable product concentration from that ceiling and the product's stated application rate. Cadmium is capped at 4 kilograms per hectare over forty-five years, which works out to roughly 20 milligrams per kilogram in a product applied at high rates, with parallel ceilings for [arsenic](#) (15), lead (100), nickel (36), and [mercury](#) (1) kilograms per hectare, and the standard applies on a total-metal basis to all fertilizers and supplements, including processed sewage sludge and compost ^[1].

The United States regulates the same soil-loading pathway for land-applied biosolids under 40 CFR Part 503. It sets ceiling concentrations that sewage sludge may not exceed, cadmium 85, lead 840, and mercury 57 milligrams per kilogram on a dry-weight basis, among others for arsenic, copper, nickel, selenium, and zinc, together with cumulative pollutant loading rates that cap the total mass of each metal that may be added to a site over its lifetime; the rule's original chromium ceiling was removed in a 1995 amendment, so chromium is no longer among the federal limits ^[3]. China governs contaminants in fertilizers through GB 38400-2019 ^[4]. Four jurisdictions, one logic: the metal is regulated where it enters the soil, and the accounting is done in decades, because the metal does not leave.

What the input regulations concede

Two admissions are worth reading out of these standards, because they are exactly what a finished-product test tends to obscure.

The first is that the contamination is cumulative and persistent. A forty-five-year loading ceiling is a formal acknowledgment that a field's metal burden is the integral of its history, not a property of this season's inputs. A lot of grain that tests clean today was grown in a soil whose cadmium was set by decades of prior application, and a field that is loaded but not yet expressing the burden in the crop will not be cleared by stopping the input. Persistence is the whole reason the horizon is measured in decades.

The second is that the pathway is multi-metal and reported on a total basis. The Canadian standard limits arsenic, cadmium, chromium, lead, mercury, nickel, and selenium together, because the inputs carry them together, and it does so for total chromium rather than the hexavalent species: the standard is explicit that its chromium limit is total chromium, not Cr(VI) ^[1]. For a certifier, that has a precise operational meaning: a total-chromium exceedance on a crop with a fertilizer or biosolids history is a trigger for speciation follow-up, not a hexavalent-chromium finding on its own.

Wastewater closes the loop

The sharpest version of the pathway is irrigation with municipal wastewater or sewage-receiving effluent, where the water delivers several metals to the same crop at once. The evidence base held at the Heavy Metal Index synthesizes this pathway across independent studies from four regions: a PRISMA meta-analysis of 24 studies across 13 countries quantifies the wastewater-to-soil-to-crop lead nexus ^{[5][6]}, and field surveys document multi-metal co-elevation, lead, cadmium, chromium, and nickel rising together, in the same wastewater-irrigated vegetable, concentrating most strongly in leafy greens grown on peri-urban plots. A single composite of African spinach from an irrigation farm in Bauchi, Nigeria carried lead at 6.60, cadmium at 1.00, and nickel at 7.70 milligrams per kilogram on the study's dried basis ^[7].

One result from that literature should sit with every surveillance program. In a wastewater-irrigated vegetable system in Blantyre, Malawi, cadmium, chromium, and lead were below detection in the irrigation water and below the applicable limits in the soil at the time of sampling, and the vegetables still exceeded the food limits, because the exposure is the accumulated result of years of soil loading and root uptake, not the instantaneous concentration of the water ^[8]. A monitoring program that clears an irrigation source by testing the water, or a field by testing the topsoil once, can pass a plot whose crops are non-compliant. The metals in that study, as throughout this literature, are reported as total chromium and are not speciated to Cr(VI).

Why a finished-product, four-metal, one-time test is blind to this

Put the pathway beside a conventional certificate and three mismatches appear. The pathway is multi-metal, so a four-metal screen that stops at lead, arsenic, cadmium, and mercury is silent on the nickel and the chromium that the same water and the same sludge delivered. The pathway is origin-driven, so the risk lives

in a sourcing region's water-and-soil history rather than in any single lot, and a one-lot test cannot see a field's decades of loading. And the pathway is cumulative, so a clean point-in-time result characterizes the sample, not the field it came from.

What closes the gap is not a stricter number on the same narrow test; it is a wider and more origin-aware one. Reading fertilizer and irrigation provenance as a category-level risk descriptor, high-cadmium phosphate sourcing, biosolids-amended ground, documented wastewater irrigation, and letting that provenance trigger a full multi-metal panel rather than a single-analyte check is what makes a certificate responsive to where the contamination actually comes from. Total-chromium exceedances reflex to speciation; the metals the input regulations name are the metals the panel measures.

Closing

The regulators who wrote the fertilizer standards understood the thing a product label tends to hide: the metal in the food is the tail of a process that started in the soil, often before the crop was planted, and it is patient. They reasoned in decades and in cumulative kilograms per hectare because that is the timescale on which the contamination is made. A certificate that wants to speak honestly to that pathway has to be as patient as the pathway is: multi-metal, origin-aware, and candid that the field, and not the factory, is where much of this began. The Heavy Metal Tested & Certified program cites this evidence base, maintained at the Heavy Metal Index, rather than reproducing it, and reads fertilizer and irrigation provenance as an upstream risk descriptor in the standard.

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References

Works cited in this briefing's text, in first-appearance order. This is not the full evidence base for the underlying pathway; it is only what the prose above draws on. Where a work carries a DOI or a public URL, its title and domain link to it; primary legal documents and published standards are named but not linked to a corpus record. The wastewater-irrigation literature is held and maintained at the Heavy Metal Index, which this briefing cites rather than re-hosts.

[1] [T-4-93 — Safety Standards for Fertilizers and Supplements](#)

GOVERNMENT

Canadian Food Inspection Agency (CFIA). Maximum acceptable cumulative metal addition to soil over 45 years (kg/ha): cadmium 4, arsenic 15, lead 100, nickel 36, mercury 1; total-metal basis; applies to sewage sludge and compost; chromium limit is total chromium. · inspection.canada.ca

[2] [Regulation \(EU\) 2019/1009 laying down rules on the making available on the market of EU fertilising products](#)

LEGISLATION

European Parliament and Council, 2019. Cadmium limit 60 mg/kg P₂O₅ for inorganic phosphate fertilisers (≥5% P₂O₅), applicable from 16 July 2022; voluntary "low cadmium" label at ≤20 mg/kg P₂O₅; review clause. · [eur-](#)

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- [3] **40 CFR Part 503 — Standards for the Use or Disposal of Sewage Sludge** [↗](#) REGULATION
- U.S. Environmental Protection Agency. §503.13 ceiling concentrations (dry weight): cadmium 85, lead 840, mercury 57 mg/kg, with limits for arsenic, copper, nickel, selenium, zinc; plus cumulative pollutant loading rates. The original chromium ceiling was removed by a 1995 amendment. · ecfr.gov [↗](#)
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- [4] **GB 38400-2019 — Limits of Toxic and Harmful Substances in Fertilizers** STANDARD
- Standardization Administration of China. National standard setting limits for toxic and harmful contaminants, including heavy metals, in fertilizer products.
- NO SOURCE RECORD — PUBLISHED STANDARD, NOT CORPUS LITERATURE
-
- [5] **Wastewater-Irrigation Multi-Metal Crop Pathway (evidence synthesis)** [↗](#) SYNTHESIS
- Heavy Metal Index. Synthesis of the wastewater-and-sewage-effluent irrigation pathway that co-elevates lead, cadmium, chromium, and nickel in the same crop, concentrating in leafy greens; the underlying literature baseline is held at the Index. · heavymetalindex.com [↗](#)
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- [6] **Meta-Analysis of Public Health Risks of Lead Accumulation in the Wastewater, Irrigated Soil, and Crops Nexus** [↗](#) REVIEW
- Ali AS, Bayih AA, Gari SR. Frontiers in Public Health, 2022. Systematic review and random-effects meta-analysis of 24 studies across 13 countries; half of untreated wastewater samples exceeded the WHO/FAO irrigation-water lead standard. · doi.org [↗](#)
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- [7] **Levels of Heavy Metals and Their Health Risk Assessment from Wastewater-Irrigated Spinach, Bauchi, Nigeria** [↗](#) STUDY
- Adebayo RK et al. International Journal of Advanced Chemistry Research, 2020. Single composite spinach: lead 6.60, cadmium 1.00, nickel 7.70 mg/kg (dried basis); total chromium, not speciated. · doi.org [↗](#)
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- [8] **Assessment of Heavy Metal Accumulation in Wastewater-Receiving Soil-Vegetable Systems, Blantyre, Malawi** [↗](#) STUDY

Chiutula C et al. International Journal of Environmental Research and Public Health, 2025. Cadmium, chromium, and lead below detection in the wastewater and below limits in the soil at sampling, yet vegetables exceeded the food limits — the pathway is the integral of years of soil loading. · [doi.org/](#)

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