HEAVY METAL CERTIFIED · RESEARCH ANALYSIS

Cutting Arsenic in Rice Can Raise Cadmium: Why One Limit Fails

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Abstract

Yes — in rice, the water management that lowers one toxic metal tends to raise another. Soil redox chemistry, set in practice by the irrigation regime, drives inorganic arsenic and cadmium in opposite directions: continuously flooded paddies push arsenic into the grain while suppressing cadmium, and the drier, water-saving regimes promoted as climate adaptation do the reverse. Field experiments at the University of Delaware measured grain arsenic falling by roughly 30 to 50 percent under alternate wetting and drying, while the driest paddies breached the Codex cadmium maximum of 0.4 mg/kg in both study years. The certification consequence is direct: a standard that limits only arsenic rewards a grower for draining the field even as cadmium climbs past its own ceiling. Only a standard that caps every relevant metal at once — the structure of the Heavy Metal Certified rice standard — stops one number being optimized at the expense of another. The full anchor-source evidence base lives on the Heavy Metal Index, the independent literature reference this analysis cites one way.

The Rice Irrigation Trade-Off

In rice, inorganic arsenic and cadmium are governed by the same variable pulling in opposite directions. Soil redox potential, set in practice by how a paddy is irrigated, determines which of the two metals ends up in the grain. A flooded, oxygen-poor paddy mobilises arsenic and moves it into the grain while locking cadmium into insoluble sulfides; drain the paddy and the chemistry reverses, suppressing arsenic uptake but freeing cadmium for the plant to absorb.

Companion field studies at the University of Delaware quantified the swing across six irrigation treatments. Grain inorganic arsenic ranged from roughly 20 to 90 µg/kg dry weight — highest under continuous flooding, lowest under aerobic management — while cadmium ran the opposite way, from about 10 to 150 µg/kg dry weight, lowest when flooded and highest when the soil was kept aerobic [1]. A second experiment five growing seasons later, sampled across a soil redox gradient from roughly " 177 to +623 millivolts, confirmed the same trade-off at a wider range: the driest paddies exceeded the Codex cadmium maximum for polished grain in both years even as grain arsenic stayed within limits [2][3].

Climate-Smart Water Saving Moves the Risk

The trade-off would be an agronomic curiosity if the drier end of the gradient were not exactly where climate adaptation is pushing rice. Alternate wetting and drying (AWD), promoted by the International Rice Research Institute and adopted at scale across South and Southeast Asia and in US production, saves water and cuts methane by periodically draining the paddy. In the Delaware work, AWD reduced grain inorganic arsenic by roughly 30 to 50 percent against continuous flooding while holding cadmium below the EU's 100 µg/kg maximum for polished rice in most replicates [1][4] — the current best-available compromise.

The warning sits at the drier end. Under the aggressive water-saving conditions consistent with row rice and drought-driven management, the same paddies breached the Codex 0.4 mg/kg cadmium ceiling in both years while arsenic stayed below its own Codex limit throughout [2][3]. The drier a grower runs the field in service of climate goals, the more the dominant contamination risk migrates from arsenic to cadmium — and the regulatory architecture, which has historically treated rice as an arsenic story, is calibrated against the wrong analyte for the emerging system. One caution belongs here: this has been demonstrated in experimental paddies at one university, not yet in commercial AWD rice as it reaches consumers [2].

The Same Signal in Freshwater Fish

The rice trade-off is one instance of a broader pattern: climate forcing is reshaping which metals accumulate in food. A separate line of evidence concerns methylmercury in freshwater fish. Analysing roughly 13,000 fish-mercury samples from 164 sites in China between 2005 and 2020, a 2025 study found that freshwater wild fish already carry methylmercury at 2.9 to 6.2 times the level of farmed freshwater fish, with a mean of 30.9 μg/kg wet weight in typical adult-sized fish — comparable to US shrimp [5].

Coupling the data to climate scenarios, the same study projects national-average methylmercury in freshwater wild fish rising by roughly 60 percent by 2031–2060 under both moderate and high-emission pathways, driven mainly by increased solar radiation enhancing photochemical methylation [5]. The mechanism differs entirely from the rice case — aquatic methylation at the watershed scale rather than soil redox at the paddy scale — but the lesson converges: the mercury profile of a food matrix is not fixed, and a baseline drawn on early-2000s fish is already drifting.

Baselines Drawn on a Moving Floor

Both matrices in question — infant rice cereal and the freshwater fish eaten by children — are among the most heavily regulated foods, and both are calibrated against historical occurrence data. Infant rice cereal sits under the FDA's Closer to Zero programme and EU maximum levels [6]; fish methylmercury underlies national consumption advice for pregnant women and young children. The difficulty is that an occurrence baseline built from a historical contamination floor goes stale at the rate that floor moves. A limit anchored to early-2000s rice arsenic, or early-2000s freshwater-fish methylmercury, drifts away from the system it is meant to characterise as climate adaptation proceeds.

The point for a standards body is not that any particular number is now wrong, but that the direction of drift is documented as of 2026 and is analyte-shifting: in rice, the very practices adopted to cut arsenic and methane are the ones that raise cadmium. A standard that watches a single metal cannot see that shift happen.

What this means for certification

The certification consequence follows directly from the trade-off. If a rice standard limits only arsenic, a grower can lower that number by draining the paddy and be rewarded for it — while cadmium rises toward, or past, its own ceiling entirely outside the standard's view. A single-metal limit does not just miss the second metal; it actively rewards the agronomic move that raises it. The honest instrument is a standard that caps every relevant metal at once, so that no grower can optimise one number at the expense of another.

That is how the Heavy Metal Certified rice standard is built. Each product and analyte is held to the strictest maximum level set by a credible government regulator, converted to the product's own basis. Because inorganic arsenic and cadmium are both among the four Tier-1 toxics the programme treats most strictly, each is set to the stricter of that government maximum and the cleaner end of the occurrence evidence — and both ceilings apply simultaneously to the same lot. A grower cannot pass by trading one down and the other up. Rice-based infant cereal carries the same multi-metal discipline for the same reason. The finding is not that AWD rice is unsafe; it is that arsenic and cadmium move together in opposite directions, and only a standard that measures both can tell whether a lot is actually clean.

Frequently asked questions

Does draining a rice paddy to reduce arsenic increase cadmium?

Generally, yes. Soil redox chemistry drives inorganic arsenic and cadmium in opposite directions, so the drier, more aerobic management that suppresses arsenic uptake tends to free cadmium for the plant to absorb. University of Delaware field studies measured grain arsenic from roughly 20 to 90 µg/kg dry weight and cadmium from roughly 10 to 150 µg/kg dry weight running the opposite way across the same irrigation treatments.

What is alternate wetting and drying (AWD) and why does it matter for heavy metals?

AWD is a climate-smart rice practice, promoted by the International Rice Research Institute, that periodically drains the paddy to save water and cut methane emissions. In the Delaware experiments it reduced grain inorganic arsenic by about 30 to 50 percent versus continuous flooding while keeping cadmium below the EU's 100 µg/kg limit in most replicates. At the driest end of the gradient, however, cadmium breached the Codex 0.4 mg/kg maximum, so the water saving that lowers arsenic can push cadmium up.

Is cadmium in AWD rice actually exceeding legal limits in stores?

Not established. The cadmium breach was demonstrated in experimental paddies at one university, under the driest water-saving conditions, not yet in commercial AWD rice as it reaches consumers. The trade-off mechanism is well documented at the experimental scale; whether it shows up in branded AWD supply, and how much it varies by variety and geography, is work that has not yet been done.

Why can't a rice certification just set a limit on arsenic?

Because a single-metal limit can be gamed by the trade-off. A grower who drains the field to lower arsenic is rewarded for it even as cadmium rises past its own ceiling outside the standard's view. Only a standard that caps arsenic and cadmium simultaneously prevents one number being optimized at the expense of the other.

References

[1] Controlling exposure to arsenic and cadmium from rice via irrigation management. Limmer and Seyfferth, 2024. Across six irrigation treatments in University of Delaware paddy mesocosms, grain inorganic arsenic (~20–90 µg/kg dw) and cadmium (~10–150 µg/kg dw) moved in opposite directions; alternate wetting and drying cut arsenic by 30–50% while keeping cadmium below the EU 100 µg/kg limit in most replicates.

[2] Arsenic, mercury and cadmium in rice grain across variably flooded paddies. Seyfferth et al., 2025. Across a soil redox gradient from roughly " 177 to +623 mV, the driest paddies exceeded the Codex 0.4 mg/kg cadmium maximum for polished grain in both study years while grain arsenic stayed within limits.

[3] Codex maximum level for cadmium in polished rice. Codex Alimentarius. Maximum level of 0.4 mg/kg for cadmium in polished rice.

[4] EU maximum level for cadmium in polished rice. European Union. Commission Regulation (EU) 2023/915. 100 µg/kg (0.10 mg/kg) maximum for cadmium in polished rice.

[5] Climate change and methylmercury in Chinese freshwater fish. Wu et al., 2025. From ~13,000 fish-mercury

samples across 164 Chinese sites, freshwater wild fish carried methylmercury 2.9–6.2× above farmed fish (mean 30.9 µg/kg ww); climate-scenario modelling projects a ~60% rise by 2031–2060, driven mainly by solar-radiation-enhanced methylation.

[6] FDA Closer to Zero action plan and EU maximum levels for toxic elements in foods for infants and young children. US Food and Drug Administration and European Union. Programme and maximum levels governing toxic elements, including arsenic and cadmium, in infant and young-child foods such as rice cereal.

[7] Heavy Metal Index — climate adaptation and heavy-metal trade-offs (synthesis with full anchor-source records). The independent literature synthesis this analysis reframes, carrying the three anchor studies and their per-record source pages. · heavymetalindex.com

Cite this analysis