HEAVY METAL CERTIFIED · RESEARCH ANALYSIS

Why Seaweed Testing Must Measure Cadmium and Inorganic Arsenic

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Abstract

Edible seaweed and kelp are a systematic dietary pathway for cadmium and arsenic. Three independent A-tier datasets — a New Zealand kelp survey, a 43-site Salish Sea assessment, and the EFSA CONTAM Panel's full European exposure opinion — converge on the same result: commercial seaweed products carry elevated cadmium and arsenic that conventional terrestrial-food surveillance does not capture. The cause is biology, not pollution. Brown algae concentrate cadmium from seawater by a factor of roughly 100,000 to 1,000,000, so even a clean-water harvest yields a high-cadmium product, and arsenic co-accumulates through the same physiology. For certification this means a seaweed standard cannot lean on total arsenic; because the toxic hazard is the inorganic fraction, it has to measure cadmium and speciated inorganic arsenic directly. The full anchor-source evidence base lives on the Heavy Metal Index, the independent literature reference this analysis cites one way.

Three Datasets, One Signal

The signal comes from three independent A-tier datasets in different ocean basins, and they agree. A 12-site spatial and temporal survey of New Zealand Ecklonia radiata kelp reported a mean total arsenic of 49 ppm dry weight (site range 40.0 to 64.4 ppm) and a mean cadmium of 1.2 ppm dry weight (range 0.4 to 2.2 ppm), with lead low at 0.3 ppm and mercury below 0.04 ppm at every site [1]. A 43-site assessment of three edible brown seaweeds across the Salish Sea found cadmium exceeding international regulatory limits at every site for at least one species, with bull kelp averaging 5.69 mg/kg dry weight and total arsenic reaching 37 mg/kg [2]. And the EFSA CONTAM Panel, drawing on 2,093 cadmium and 920 inorganic-arsenic occurrence points, concluded that seaweed — especially dried Asian-style products and seaweed food supplements — is a meaningful contributor to dietary cadmium and inorganic-arsenic exposure in Europe [3].

The agreement across geography is the load-bearing observation. The elevation is not one bad bay set against several clean ones; the regional baseline itself sits at or above consumption-safety limits for cadmium, across sites and across species.

Why Cadmium and Arsenic Accumulate

Seaweeds are biological accumulators of trace elements from the water they grow in, and two mechanisms drive the metals that matter here. Brown algae bind cadmium through the alginate polysaccharides of the cell wall, a chemistry that holds across species and ocean basins. Arsenic is taken up through the same metabolic machinery that handles phosphate and is stored largely as arsenosugars and arsenolipids. The two metals therefore co-elevate through fundamental physiology rather than local contamination, and their concentration tracks ocean chemistry rather than any farming or processing step [3].

The magnitude follows from the biology. The accumulation factor from typical coastal seawater cadmium to product tissue is on the order of 100,000 to 1,000,000, so even nominally clean ocean water delivers enough cadmium to push tissue concentrations above the regulatory limits written for terrestrial commodities [2]. This is the decisive difference from land crops: a rice plant in low-cadmium soil makes low-cadmium rice, but a kelp frond from a clean coastal site is not low in cadmium. Cadmium in seaweed is a feature of the product class, not a quality-control failure — which is why sourcing alone cannot fix it and direct measurement is unavoidable.

Why Total Arsenic Is the Wrong Number

Most of the arsenic in brown algae is organic — arsenobetaine, arsenosugars, arsenolipids — and the New Zealand kelp survey, like most occurrence studies, reported only total arsenic without speciation [1]. That is exactly the problem. The toxicologically relevant quantity is inorganic arsenic, and the inorganic fraction in seaweed is not zero. Kombu and kelp rank among the highest inorganic-arsenic food matrices in the entire EFSA dataset, and the panel found that inorganic arsenic from seaweed food supplements can approach or exceed its BMDL01 reference exposure for high-consumption scenarios [3].

The arithmetic shows why total arsenic cannot stand in for the hazard. A hypothetical inorganic fraction of just 1 percent applied to the New Zealand kelp mean of 49 ppm total arsenic would leave roughly 490 ppb inorganic arsenic dry weight; on a modest 5 g dried-kelp serving that is about 2.45 µg of inorganic arsenic per serving [1]. A total-arsenic figure cannot tell a buyer whether the inorganic fraction is 1 percent or several times that. Only speciation can, which is why a total-arsenic screen is not a substitute for measuring inorganic arsenic directly.

Lead Runs the Other Way

Not every metal follows the accumulation story, and saying so is part of reading the evidence honestly. Lead is not bioaccumulated by brown algae through a comparable high-affinity pathway, so background lead in seaweed is generally low. Where it spikes — the Salish Sea survey recorded a maximum of 13.2 mg/kg dry weight at an industrial-adjacent site — it reflects proximity to a point source such as industrial outflow, antifouling paint, or harbour sediment rather than a biological feature of the product [2]. Lead in seaweed is therefore a conventional sourcing-and-screening problem; cadmium and inorganic arsenic are not. A standard should keep the two logics separate rather than treating every heavy metal as one undifferentiated hazard.

The Surveillance and Regulatory Blind Spot

Conventional food-safety surveillance is built around terrestrial matrices — cereals, produce, meat, dairy, fish — and seaweed enters most national databases either as a minor "other algae" entry or not at all. EFSA's occurrence dataset had to be assembled from many specialized sources rather than a routine monitoring stream, and general food-composition databases carry little structured seaweed-specific heavy-metal data [3]. A high-magnitude contamination problem thus sits behind a low-surveillance signal and a positive "sea vegetable" consumer perception.

The regulatory picture is asymmetric. The EU has issued a formal CONTAM scientific opinion on heavy metals in seaweed and sets food contaminant limits through Regulation (EU) 2023/915 [4]. The US FDA has acted on inorganic arsenic in infant rice cereal under its Closer to Zero plan but has no comparable seaweed-specific product limit in force [5], leaving US seaweed-snack and kelp-supplement products with cadmium and inorganic-arsenic content unconstrained by any federal product-specific ceiling; California's Proposition 65 is the main operative pressure, and it works through warning-level exposure rather than a food maximum [6]. The published literature makes the exposure foreseeable regardless of which jurisdiction acts.

What this means for certification

The finding sets a clear requirement for how a seaweed standard is written. Because cadmium and inorganic arsenic in seaweed are a biological feature of the product class, sourcing and screening cannot substitute for measurement, and total arsenic cannot substitute for speciation. A credible seaweed and kelp standard therefore has to require direct occurrence testing for cadmium and for speciated inorganic arsenic — not total arsenic — because the hazard is the inorganic fraction.

On the number itself, the Heavy Metal Certified default is the strictest maximum level set by a credible government regulator, converted to the product's own basis. Cadmium and inorganic arsenic are both among the four Tier-1 toxics — lead, cadmium, inorganic arsenic and methylmercury — that the program treats most strictly, so their seaweed ceilings may be set to the stricter of that government maximum and the cleaner end of the occurrence evidence documented here [4][3]. Lead, a Tier-1 toxic as well, behaves in this category as a point-source sourcing issue rather than an accumulation one and is handled accordingly. The finding is not that seaweed is unsafe to eat; it is that seaweed is a distinct exposure distribution, and the analytes and methods that certify it have to come from that distribution.

Frequently asked questions

Is seaweed high in cadmium and arsenic?

Yes. Independent surveys of New Zealand kelp and Salish Sea brown seaweeds, together with the EFSA CONTAM Panel's European exposure opinion, all find commercial seaweed and kelp carrying systematically elevated cadmium and arsenic. Bull kelp averaged 5.69 mg/kg cadmium dry weight in one survey, and kombu and kelp rank among the highest inorganic-arsenic food matrices in the EU dataset.

Why isn't total arsenic enough to test seaweed?

Because the toxic hazard is inorganic arsenic, and most of the arsenic in seaweed is organic. A total-arsenic number cannot tell you what fraction is inorganic — that fraction can vary widely — so only speciated testing that measures inorganic arsenic directly characterizes the real exposure. A total-arsenic screen is not a substitute.

Is cadmium in kelp caused by pollution?

Generally no. Brown algae bind cadmium through cell-wall alginates and concentrate it from seawater by a factor of roughly 100,000 to 1,000,000, so even a clean-water harvest yields a high-cadmium product. Cadmium in seaweed is a biological feature of the product class rather than a site-specific contamination event, which is why sourcing alone cannot remove it.

Are there US limits for heavy metals in seaweed?

There is no federal product-specific limit for cadmium or inorganic arsenic in seaweed. The FDA has acted on inorganic arsenic in infant rice cereal under its Closer to Zero plan but has issued no comparable seaweed maximum, so California's Proposition 65 warning-level enforcement is the main operative US pressure. The EU, by contrast, has a formal CONTAM opinion and a contaminants regulation.

References

[1] Trace-element composition of New Zealand Ecklonia radiata kelp across twelve sites. Nepper-Davidsen et al., 2023. Mean total arsenic 49 ppm and cadmium 1.2 ppm dry weight in North Island kelp, with significant temporal

variation in arsenic.

[2] Heavy metals in edible Salish Sea brown seaweeds across forty-three harvest sites. Hahn et al., 2022. Cadmium exceeded international limits at every site; bull kelp averaged 5.69 mg/kg and a lead spike reached 13.2 mg/kg dry weight near industry.

[3] EFSA scientific opinion on heavy metals and iodine in seaweeds and halophytes as food. EFSA CONTAM Panel, 2023. Assessed 2,093 cadmium and 920 inorganic-arsenic occurrence points; kombu and kelp among the highest inorganic-arsenic food matrices in the EU.

[4] Maximum levels for contaminants in food. European Union. Commission Regulation (EU) 2023/915. The EU framework setting category maximum levels for cadmium, lead and arsenic in food.

[5] US FDA Closer to Zero action plan and inorganic-arsenic guidance. US Food and Drug Administration. Action on inorganic arsenic in infant rice cereal, with no seaweed-specific product limit in force.

[6] California Proposition 65 exposure warnings for cadmium and arsenic. California Office of Environmental Health Hazard Assessment. Warning-level exposure enforcement, the main operative US pressure on seaweed heavy-metal content.

[7] Heavy Metal Index — seaweed as a cadmium and arsenic pathway (synthesis with full anchor-source records). The independent literature synthesis this analysis reframes, carrying every anchor source and its per-record page. · heavymetalindex.com

Cite this analysis