Molybdenum

HEAVY METAL INDEX · REFERENCE

November 2026

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CITE AS

Pendergrass, K. (2026). Molybdenum. Heavy Metal Index. https://heavymetalindex.com/metals/molybdenum

CORRESPONDENCE

Corrections are logged publicly on the article page, each with its date, the affected value, and the source that resolved it.

KEYWORDS

heavy metals, food safety, dietary exposure

PUBLICATION HISTORY

This revision 2026-11-03.

Abstract

An essential enzyme cofactor, molybdenum requires distinct interpretation in excess exposure and animal-feed occurrence.

This page draws on evidence from EFSA, together with 8 peer-reviewed studies and 2 other cited sources. The complete citation list is at the bottom of the page.

1 | Overview

Molybdenum is an essential cofactor for enzymes including sulfite oxidase, xanthine oxidase, aldehyde oxidase, and mitochondrial amidoxime reductase. The cited toxicology chapter attaches molybdenum as an essential--metal-with-toxicity-potential node and notes that excess molybdenum can resemble copper deficiency 2.

Molybdenum is an essential trace element for human health, and the enzymes xanthine dehydrogenase, sulfite oxidase and aldehyde oxidase that depend on it play key roles in metabolism 3. A survey of British drinking water cites an estimated adult daily requirement of 75 to 250 micrograms and notes that recognized cases of molybdenum toxicity in humans are rare 3. In oxygenated water above pH 5 it occurs mainly as the molybdate oxyanion 3.

The chemical form strongly affects how much molybdenum an animal absorbs and how toxic it is: soluble sodium molybdate is readily taken up, while molybdenum disulfide, the main mineral form in molybdenite ore, has low bioavailability 4.

2 | Toxicology

Chronic occupational exposure has been linked to fatigue, loss of appetite, anorexia, joint pain and tremor, and exposure may also cause molybdenum-induced copper deficiency and pneumoconiosis; the chemical state, the route of exposure and dietary copper and sulfur all likely influence toxicity 3. These statements are summaries of earlier assessments rather than new data. A Beijing cohort report similarly summarizes earlier

work that excessive intake can cause joint pain, high urinary uric acid, hallucinations and seizures, and that excess molybdate promotes formation of copper sulfide, leading to copper deficiency 5.

An older report, summarized in a Bangladeshi food study, linked a very high incidence of gout in parts of Armenia to molybdenum-rich soils and plants, with intakes of 10 to 15 mg per day in affected areas against 1 to 2 mg per day nearby 6. This is a secondary citation and has not been checked against the original.

Animal studies

In young northern bobwhite quail fed for 30 days, soluble sodium molybdate reduced growth at 2000 mg molybdenum/kg feed and above, raised molybdenum in serum, kidney, liver and bone, and the effects reversed after 5 days on clean feed; molybdenum disulfide caused no adverse effects even at 5000 mg/kg feed 4. No treatment-related deaths or tissue lesions occurred with either form 4. In rainbow trout held for 96 hours in water with up to 1000 mg/L molybdenum as sodium molybdate, gill, plasma, liver and muscle took up molybdenum, but none of the stress hormones, blood measures or stress proteins measured changed 7.

STUDY / LOCATION	MATERIAL / DESIGN	METAL SPECIES	VALUE (UNITS AND BASIS)	N	INTERPRETATION / LIMITATION
4, United States (laboratory)	Bobwhite quail, 30-day diet	Sodium molybdate dihydrate	No-observed--adverse-effect concentration 1200 mg/kg feed (134 mg/kg body weight/day); lowest-observed 2000 mg/kg feed (253 mg/kg body weight/day)	12 birds per group	Growth endpoints only; far above dietary levels; industry-funded
4, United States (laboratory)	Bobwhite quail, 30-day diet	Molybdenum disulfide	No adverse effect at 5000 mg/kg feed (about 545 mg/kg body weight/day)	12 birds per group	Highest dose tested; low bioavailability
4, United States (laboratory)	Quail long bones, day 30	Sodium molybdate vs molybdenum disulfide	551.9 ng/g dry weight (control); 57,750 ng/g (3000 mg/kg molybdate); 1278 ng/g (5000 mg/kg disulfide)	6 birds per group	Shows form-dependent accumulation
7, British Columbia (laboratory)	Rainbow trout, 96 h waterborne	Sodium molybdate	No stress response up to 1000 mg/L; control white muscle 46.5 ng/g dry weight	6 fish per group	Acute exposure only; one species

Low intake

A single-author perspective proposes that molybdenum deficiency, by lowering activity of the molybdenum-dependent enzyme xanthine oxidase-dehydrogenase, could allow certain dietary purines to accumulate in the brain and initiate Parkinson's disease with dementia 8. The argument is extrapolated from sheep studies and ecological data from Guam; it is a hypothesis, not an established effect 8.

3 | Typical exposure routes

Food is described as the major source of molybdenum for people 6, and a Beijing cohort report names water and diet as the primary sources 5. Both statements are secondary summaries.

Drinking water

In England and Wales, treated water from 12 public supply works and water from 24 household taps all contained less than 2 micrograms of molybdenum per liter, less than a tenth of the World Health Organization health-based value of 70 µg/L 3. Groundwater draining a mineralized catchment gave the highest value, and household plumbing had no meaningful effect on molybdenum, unlike copper, zinc, nickel, lead and cadmium 3.

Groundwater in parts of Argentina can be much higher. Two pooled samples from farm wells near Eduardo Castex, La Pampa, contained 65.0 and 92.5 µg/L molybdenum, close to or above the former WHO value; the authors attribute the elevated molybdenum to volcanic ash in the local sediments, and the same water carried high arsenic and vanadium 9. The British survey also cites an Argentinian groundwater study reporting up to 990 µg/L under oxic, alkaline conditions 3.

STUDY / LOCATION	MATERIAL / DESIGN	METAL SPECIES	VALUE (UNITS AND BASIS)	N	INTERPRETATION / LIMITATION
3, England and Wales	Treated public supply water, four rounds 2007 to 2008	Total dissolved molybdenum	Below 0.03 to 1.51 µg/L	12 supply works	Purposive sampling of higher-risk sources
3, Haverhill, Mickleover, Bangor	Household tap water, pre-flush and post-flush	Total dissolved molybdenum	0.911 to 1.00 µg/L; 0.522 to 0.557 µg/L; below 0.03 µg/L	24 taps	Three towns only; no pipework effect on molybdenum
9, La Pampa, Argentina	Pooled farm-well groundwater	Total molybdenum	65.0 ± 0.6 and 92.5 ± 2.4 µg/L	2 pooled samples	Not a well survey; high arsenic and vanadium also present

Uptake into plants from water

Cress grown in La Pampa groundwater accumulated 1.89 and 4.59 mg/kg molybdenum (dry weight), well below plants grown in synthetic solutions of similar strength, which the authors attribute to competition from co-occurring elements such as vanadium and arsenic 9. In spiked laboratory solutions, cress molybdenum rose from 1.29 to 821 mg/kg dry weight as the solution concentration increased, with toxicity signs only at 5000 µg/L and above 9.

Other routes

A Beijing cohort report notes, as background, that molybdenum is used in metallurgy and electronics and occurs in some everyday items, including toys, clothing and household and plant care products 5. Occupational exposure is discussed under Toxicology.

4 | Food sources

In Bangladeshi market foods measured by x-ray fluorescence, pulses held the most molybdenum (group mean 2.51 mg/kg fresh weight), followed by cereals (1.50 mg/kg), with milk products, eggs, fruits, fish, vegetables and meat all below 0.3 mg/kg 6. One rice variety reached 4.44 mg/kg while local and milled rice were 0.75 and 0.49 mg/kg 6. A Beijing cohort report lists beans, wheat, oats, asparagus, milk and cheese as molybdenum-rich foods and notes that food levels depend on the soil and water where the food was grown, citing earlier work 5.

STUDY / LOCATION	MATERIAL / DESIGN	METAL SPECIES	VALUE (UNITS AND BASIS)	N	INTERPRETATION / LIMITATION
6, Bangladesh	Pulses: green gram, lathyrus pea, black gram, lentils, Bengal gram (chickpea)	Total molybdenum	3.18, 2.93, 2.85, 2.83, 0.77 mg/kg fresh weight	3 each	Small samples; uncertainty is counting statistics
6, Bangladesh	Rice (IRRI, local, sunned milled) and coarse wheat flour	Total molybdenum	4.44, 0.75, 0.49 and 0.31 mg/kg fresh weight	15, 12, 10, 5	Market samples; dates and sites not stated
6, Bangladesh	Milk products, eggs, fruits, fish, vegetables, meats (group means)	Total molybdenum	0.26, 0.18, 0.13, 0.12, 0.08, 0.07 mg/kg fresh weight	3 to 15 per item	Group means do not always match item values
6, Bangladesh	Tea	Total molybdenum	0.34 mg/kg fresh weight	3	As-sold basis not described further

The same study multiplied these concentrations by food-group consumption and estimated daily molybdenum intakes of 0.45 mg for children, 0.83 mg for adult women and 1.16 mg for adult men, attributing the higher intakes mainly to cereals and pulses in a diet that is about 90% cereals, pulses and vegetables 6. These are author-derived estimates.

Animal feed

Texas mineral feed products had molybdenum mean 4.078 mg/kg, SD 6.222 and median 1.3 (N=55; Table 3) 10. A table footnote incorrectly reports nondetection in several other groups with positive summary rows. Both reports remain visible as a source contradiction. These are feed-material summaries with zero substitution below quantitation 10.

5 | Regulatory limits

The World Health Organization's drinking-water guidelines keep a health-based value of 70 µg/L for molybdenum but no longer set a formal guideline value, on the grounds that such concentrations are rarely found in drinking water 3; see WHO drinking-water guidelines. The British study notes that this removes the need for routine national regulation while leaving local surveillance for high-risk sources 3. For irrigation water, a study from Argentina cites an FAO limit of 10 µg/L molybdenum 9; see FAO water quality for agriculture.

In the European Union, molybdenum is authorized as a feed additive only as sodium molybdate dihydrate for sheep, at a maximum of 2.5 mg molybdenum/kg complete feed, and the European Food Safety Authority's feed panel concluded in 2026 that this level is safe for the environment 1. The assessment covers environmental safety only, not consumer safety.

STUDY / LOCATION	MATERIAL / DESIGN	METAL SPECIES	VALUE (UNITS AND BASIS)	N	INTERPRETATION / LIMITATION
3, WHO (cited)	Drinking water	Total molybdenum	Health-based value 70 µg/L; not a formal guideline value	not applicable	Secondary statement of WHO position
9, FAO (cited)	Irrigation water	Total molybdenum	10 µg/L	not applicable	Secondary citation
7, British Columbia	Freshwater, aquatic-life protection	Molybdenum	2 mg/L	not applicable	Environmental guideline, not for human health
1, European Union	Complete feed for sheep	Sodium molybdate dihydrate	Maximum 2.5 mg/kg complete feed	not applicable	Feed authorization; environmental safety only
1, European Union	Natural background (90th percentile)	Total molybdenum	Soil 1.81 mg/kg dry weight; groundwater 2.14 µg/L; freshwater 1.07 µg/L	840; 8841; 807	Reference values for the feed assessment

The Bangladeshi food study compares estimated intakes with older United States Food and Nutrition Board safe levels of 0.30 mg per day for children and 0.50 mg per day for others 6. The cited evidence does not state a current tolerable upper intake level for molybdenum.

6 | Testing

Most of the cited studies measured molybdenum by ICP-MS: drinking water with a detection limit of 0.03 µg/L and a certified river-water reference material 3, groundwater and plants with a solution detection limit of 0.1 µg/L 9, and maternal plasma with a detection limit of 0.04 ng/mL 5. The Bangladeshi food study used energy-dispersive x-ray fluorescence on carbonized food pellets, with a stated detection limit of 0.08 mg/kg, and checked accuracy against rice flour and bovine liver reference materials 6.

The British survey heated acidified water samples at 80 °C before analysis to dissolve particles and trace elements held on bottle walls 3. None of the cited studies separated molybdenum species in food.

7 | Microbiome effects

The cited evidence does not establish any effect of molybdenum on the gut microbiome. The only microbial evidence cited concerns soil and plant bacteria and is described under Mitigation 11.

8 | Vulnerable populations

Pregnancy

In a Beijing nested case-control study, maternal plasma molybdenum rose from a median of 2.07 ng/mL in the first trimester to 2.59 ng/mL in the third, and women in the highest first-trimester quartile (2.584 ng/mL or more) had about twice the odds of spontaneous preterm birth after adjustment 5. The authors call the result preliminary, note that reference ranges for blood molybdenum in pregnancy are not defined in China, and did not record supplement use 5.

STUDY / LOCATION	MATERIAL / DESIGN	METAL SPECIES	VALUE (UNITS AND BASIS)	N	INTERPRETATION / LIMITATION
5, Beijing, China	Maternal plasma, first trimester, cases vs controls	Total molybdenum	Median 2.12 vs 2.02 ng/mL (P = 0.027)	236 vs 236	Observational; sources of molybdenum not assessed
5, Beijing, China	Maternal plasma, highest vs lowest first-trimester quartile	Total molybdenum	Adjusted odds ratio 2.074 (95% CI 1.212 to 3.550) for spontaneous preterm birth	472	Single hospital; association, not causation

Other groups

The Bangladeshi intake estimates cover children, adolescents, pregnant women and lactating women as well as adults, and all exceed the older United States safe levels the authors cite 6. Many rural areas of La Pampa have limited or no access to treated water and rely on groundwater wells for livestock and irrigation, which the authors identify as a possible route for molybdenum to accumulate in foods used by animals and people; human intake was not measured 9. The deficiency hypothesis under Toxicology would, if correct, put people with low dietary molybdenum at risk 8.

9 | Mitigation

The cited evidence does not establish a processing or cooking method that reduces molybdenum in food. In British homes, flushing taps lowered copper, zinc, nickel, lead and cadmium but did not change molybdenum, so flushing is not a molybdenum control 3.

A cited review 11 covers vegetable-associated metal exposure assessment and microbial/agronomic risk-management approaches. Chinese and Russian case-study values are secondary reports; they remain traceable to the cited studies and are not counted as new independent occurrence samples. Supports exposure-method and remediation literature discovery. Bacterial effects can increase as well as decrease uptake depending on organism, metal and plant; the review does not establish a universal inoculant intervention. Secondary model outputs are not contemporary health or certification thresholds 11.

10 | Open questions

- The literature set behind this page was drawn only from open-access PubMed Central articles, so major subscription-journal studies and agency assessments on molybdenum intake, food occurrence and toxicity are likely missing.
- No current human tolerable upper intake level or reference dose is cited; the only intake comparisons use older United States values.
- Food occurrence data come from one Bangladeshi market study with small samples; there are no cited data for Europe, North America or infant foods.
- Total-diet or national intake estimates are not cited apart from author-derived Bangladeshi figures.
- Human toxicity evidence is secondary or observational; dose-response data in people are absent.
- The preterm-birth association has not been tested for causation or for the contribution of diet, water and supplements.
- The deficiency and Parkinson's disease hypothesis is untested in humans.
- No gut microbiome evidence is cited.
- No food processing or remediation method specific to molybdenum is established.
- Speciation of molybdenum in food is not addressed.

11 | Frequently asked questions

What is molybdenum and what does it do in the body?

Molybdenum is an essential trace metal that acts as a cofactor for several enzymes, including sulfite oxidase, xanthine oxidase, aldehyde oxidase, and mitochondrial amidoxime reductase Ufelle & Barchowsky 2021. It is categorized as an essential metal that also carries toxicity potential.

Can too much molybdenum be harmful?

Yes. Although molybdenum is an essential nutrient, it is described as an essential metal with toxicity potential, and excess molybdenum can resemble copper deficiency Ufelle & Barchowsky 2021. The page does not provide specific intake levels or dose thresholds.

How does excess molybdenum affect copper in the body?

According to Ufelle & Barchowsky 2021, excess molybdenum can resemble copper deficiency. The page does not detail the underlying mechanism beyond noting this interaction.

12 | What remains uncertain

The strongest measured evidence here is environmental and regional: British drinking water is well characterized, while food data rest on one Bangladeshi market study whose uncertainties reflect counting statistics rather than variation between samples. Concentrations elsewhere, and in foods eaten by infants, are unknown from this evidence.

Health statements about excess molybdenum in people are mostly secondary summaries of older assessments. The animal studies use doses far above normal diets, and the one human study is an observational association in pregnancy. Whether the main concern for most people is excess or insufficient intake cannot be settled from the cited evidence.

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STATUS AND LICENCE

Editorially reviewed in-house; no external peer review has been completed on this reference. Published as an institutional technical report with its review state tracked on the article page. Released under CC BY 4.0.

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DATA AVAILABILITY

Every source behind this reference is listed with its own source record at https://heavymetalindex.com/metals/molybdenum#sources.

PUBLICATION HISTORY

This revision 2026-11-03. The full dated record is maintained at https://heavymetalindex.com/metals/molybdenum.