

# TURN DOWN THE HEAVY METAL:

Reducing the Levels of Toxic  
Elements in Plant Nutrients



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## Public awareness of heavy metal toxicity has grown over the past few decades.

Episodes such as the water crisis in Flint, Michigan, have catapulted the dangers of lead poisoning back into the headlines. Arsenic, an object of pop-cultural fascination as a favored weapon in the murder-mystery canon, is now linked to staple foods like chicken, apple juice and rice.<sup>1,2,3</sup> Concerned about the health consequences of mercury—which has made its way into dental fillings, lightbulbs and skin-lightening products—consumers are now drastically reducing their tuna-fish consumption to minimize their exposure. This heightened sensitivity to chemical toxicity begs the question: Why do toxic heavy metals still appear in detectable amounts in fertilizers?

In this white paper, we look at the impact that toxic heavy metals have on plant and human life, then examine the particularities of cannabis, which is a strong accumulator of undesirable trace elements. We also consider the ways that labeling requirements—or a lack thereof—obscure potentially dangerous levels of heavy metals, causing growers to inadvertently contribute to their accumulation in irrigation and agricultural systems. Finally, we discuss the benefits of choosing a nutrient program that provides plants with the right essential and beneficial nutrients in the right concentrations—no toxic heavy metals included.

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1 Marian Burros, "Chicken With Arsenic? Is That O.K.?" *The New York Times*, 2006, <https://www.nytimes.com/2006/04/05/dining/chicken-with-arsenic-is-that-ok.html>.

2 Jesse Hirsch, "Arsenic and Lead Are in Your Fruit Juice: What You Need to Know," *Consumer Reports*, 2019, <https://www.consumerreports.org/food-safety/arsenic-and-lead-are-in-your-fruit-juice-what-you-need-to-know/>.

3 "Arsenic in Rice – Is It a Cause for Concern?," British Nutrition Foundation, 2017, <https://www.nutrition.org.uk/nutritioninthenews/headlines/arsenicinrice.html>.

## WHAT ARE TOXIC HEAVY METALS?

Heavy metals—defined as chemical elements with high weight and density at least five times greater than water—are found almost everywhere, including in manures and fertilizers, and are concentrated in soils depending on their geological characteristics.

In industrialized countries, toxic heavy metals—or toxic levels of otherwise non-toxic heavy metals, if they are overused—leech into water supplies, pollute the air and can even be found in consumer goods. These metals are released into the environment via industrial activities such as mining, smelting and petroleum combustion. Today, they can also be found in many plastics, textiles and electronics.

Their impact on living organisms should not be understated. Some toxic heavy metals, such as mercury and cadmium, are bioaccumulative, meaning that the body absorbs them more quickly than it can eliminate them. They cause detrimental effects to all life forms, although their consequences for human health are best known, including neurological impairment, memory loss and damage to the liver and kidneys. The degree to which these metals are harmful to humans depends on the dose as well as on the rate and duration of exposure (i.e., acute or chronic).

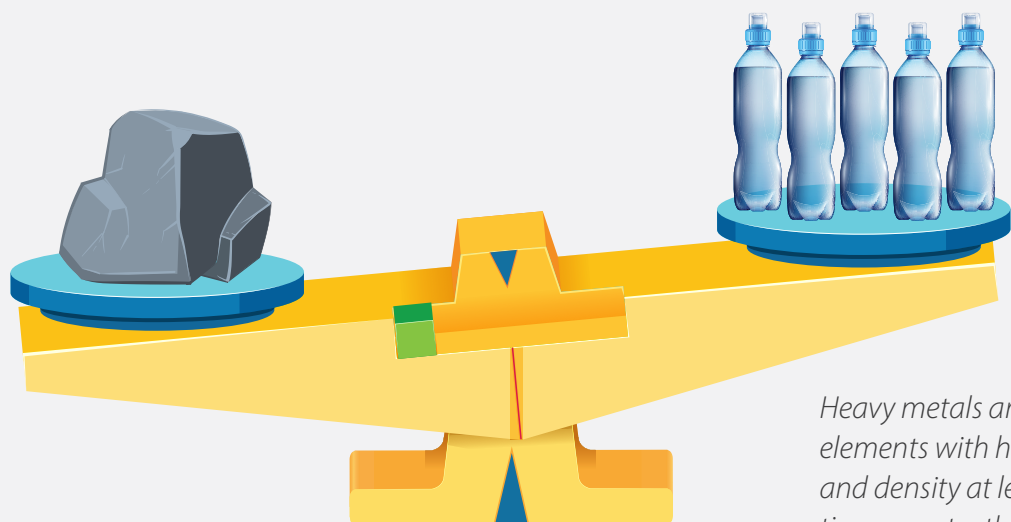
### Types of Heavy Metals

#### Essential

- Calcium
- Magnesium
- Potassium
- Sodium
- Zinc

#### Toxic

- Mercury
- Lead
- Cadmium
- Aluminum
- Arsenic



*Heavy metals are chemical elements with high weight and density at least five times greater than water.*

Children are particularly at risk because they consume larger amounts of food in proportion to their body mass. Toxicity impairs the development of young bodies and brains, leading to a rash of undesirable outcomes including intellectual disability, behavioral disorders, respiratory dysfunction and weak bone development. Prenatal maternal exposure to toxic heavy metals has been associated with increased risk of miscarriage, stillbirth, preterm delivery and low birth weight.

It may come as a surprise then that, despite growing public awareness, fertilizer manufacturers still sell products containing detectable amounts of dangerous metals. In the United States, where cannabis is not yet legal on the federal level, an absence of regulatory standards has made it possible for leading fertilizer brands to peddle products with detectable levels of cadmium, mercury, arsenic and lead. These elements not only impair plant growth and pose health risks to people who consume them, but they also accumulate in growing media, perpetuating a cycle of contamination.

## **PLANT TOXICITY: MORE THAN MEETS THE EYE**

As anyone who's ever taken an iron or zinc supplement knows, some heavy metals are required to sustain human life. The same is true for plants. Aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, selenium, silicon and zinc are metals or metalloids (elements having characteristics of both metals and non-metals) that are considered essential or beneficial plant nutrients.<sup>4</sup> Such elements facilitate the production of enzymes and are crucial to the functioning of mitochondria and chloroplasts, the photosynthetic process and other aspects of plant life.<sup>5</sup>

However, more is not always better. In excess, these elements can inhibit plant growth and derail cellular processes. To complicate matters, toxicities in cannabis are notoriously hard to identify because of the crop's high tolerance for heavy metals. In plants whose growth is not visibly impaired by toxicities, it is difficult for growers to grasp the dangers of heavy metals. In one study, heavy

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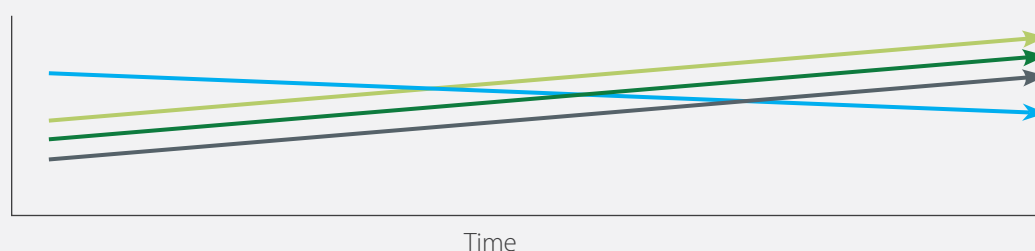
4 "Many heavy metals are essential for plants and animals when present in the growing medium in low concentrations (micronutrients: Cu, Zn, Fe, Mn, Mo, Ni, and Co); they become toxic only when a concentration limit is exceeded (in which case the term 'heavy metals' rather than 'micronutrients' is used)." Z. Rengel, "Heavy Metals as Essential Nutrients," in *Heavy Metal Stress in Plants* (Berlin, 1999), 231–51.

5 Iwona Morkunas et al., "The Role of Heavy Metals in Plant Response to Biotic Stress," *Molecules* 23, no. 9 (2018): 2320, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6225295/>.

metal pollution reduced peppermint and cornmint yields by 9-16%.<sup>6</sup> In another, the application of mercury reduced the biomass and yield of cowpea, radish, spinach, chickpea, pea and wheat plants.<sup>7</sup> Yet another indicated that chromium decreased maize and spring wheat yields by up to 20%.<sup>8</sup> Cannabis yields are also significantly impacted: In one German study from 2005, a control group achieved nearly double the biomass of a cadmium-polluted cannabis crop.<sup>9</sup>

## Heavy Metals vs Yield

■ Mercury ■ Chromium ■ Lead ■ Yield



However, yield reduction is but one consequence of the many undesirable effects high levels of heavy metals may have on plant development, independently and in tandem with one another. These include but are not limited to the following:

**Impaired seed germination:** Contaminated growing media set up crops for failure right from the start. Different metals prevent seeds from germinating by different mechanisms. For example, excess nickel disrupts the production of enzymes that help plants mature, and lead alters the physiological structure of seedlings and impairs root elongation.<sup>10</sup>

6 Valcho D. Zheljzakov and Niels E. Nielsen, "Effect of Heavy Metals on Peppermint and Cornmint," *Plant and Soil* 178 (1996): 59–66, <https://link.springer.com/article/10.1007/BF00011163#citeas>.

7 P.K. Aggarwal, "Effect of Heavy Metals on Biomass and Yield of Different Crop Species," *Indian Journal of Agricultural Sciences* 76, no. 11 (2006): 688–91, <https://www.researchgate.net/publication/285935208.Effect.of.heavy.metals.on.biomass.and.yield.of.different.crop.species>.

8 Grzegorz Kulczycki and Elzbieta Sacala, "Sulfur Application Alleviates Chromium Stress in Maize and Wheat," *Open Chemistry* 18, no. 1 (2020).

9 P. Linger, A. Ostwald, and J. Haensler, "Cannabis Sativa L. Growing on Heavy Metal Contaminated Soil: Growth, Cadmium Uptake and Photosynthesis," *Biologia Plantarum* 49, no. 4 (2005): 567–76, <https://www.alchimiaweb.com/blogfr/wp-content/uploads/2016/08/Cannabis-sativa-L.-growing-on-heavy-metal-contaminated-soil-growth-cadmium-uptake-and-photosynthesis-2005.pdf>.

10 Sunil Kumar Sethy and Shyamasree Ghosh, "Effect of Heavy Metals on Germination of Seeds," *Journal of Natural* 4, no. 2 (2013): 272–75, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3783763/>.

**Disrupted photosynthesis:** Excess heavy metals interfere with the physical and functional mechanisms by which photosynthesis takes place, primarily by impeding the activities of photosynthetic enzymes and chloroplast membranes.<sup>11,12</sup>

**Oxidative stress:** Plants exposed to high levels of heavy metals produce excessive amounts of Reactive Oxygen Species (ROS). At normal levels, ROS signal biological processes that take place in all healthy plants; in excess, however, ROS can overwhelm plants' antioxidant defense system and cause irreparable damage.<sup>13,14</sup> It should be noted that excess ROS damage human cells in the same manner, as a result of metal toxicity and a host of other reasons.

**Premature senescence:** Impairment of growth and photosynthesis and increased oxidative stress are all associated with plant senescence, or aging.<sup>15</sup>

It bears repeating that plants have remarkable mechanisms for subverting or even tolerating heavy-metal toxicity, so it can be difficult for growers to know when there's a problem. Yellowing, "burning" and other visible indications may not occur, increasing the need for vigilance in choosing a clean nutrient line and in conducting appropriate testing for heavy metals. Because cannabis is a particularly resilient crop, it is imperative that growers perform due diligence to avoid undesirable consequences.

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11 Anjali Aggarwal et al., "Metal Toxicity and Photosynthesis," in *Photosynthesis: Overviews on Recent Progress & Future Perspective*, First (New Delhi: IK International Publishing, 2011), 229–36, <https://www.researchgate.net/publication/231608518-Metal-Toxicity-and-Photosynthesis>.

12 Romika Chandra and Hoduck Kang, "Mixed Heavy Metal Stress on Photosynthesis, Transpiration Rate, and Chlorophyll Content in Poplar Hybrids," *Forest Science and Technology* 12, no. 2 (2016): 55–61.


13 Nalini Pandey et al., "Heavy Metals, Co, Ni, Cu, Zn and Cd, Produce Oxidative Damage and Evoke Differential Antioxidant Responses in Spinach," *Brazilian Journal of Plant Physiology* 21, no. 2 (2009): 103–11, <https://www.scielo.br/pdf/bjpp/v21n2/v21n2a03.pdf>.

14 Richard L. Auten and Jonathan M. Davis, "Oxygen Toxicity and Reactive Oxygen Species: The Devil Is in the Details," *Pediatric Research* 66 (2009): 121–27, <https://www.nature.com/articles/pr2009174>.

15 Fazal Ur Rehman Shah et al., "Heavy Metal Toxicity in Plants," in *Plant Adaptation and Phytoremediation*, 2010, 71–97.

## HEAVY METALS AND HUMAN HEALTH

Heavy metals accumulate in glands in the body, disrupting the functioning of vital organs and displacing nutrients required for biological functioning. Unfortunately, exposure to harmful heavy metals is all but inevitable for individuals living in the industrialized world. While many metals appear naturally in the earth's crust, those that are the most harmful to human health occur as a result of human activity. Disposal of industrial and municipal waste into waterways ultimately pollutes water used to grow crops, and air pollution precipitates into toxic rainfall. Toxic metals have also made their way into countless everyday consumer products, unbeknownst to many consumers. As Anyanwu et al. write in their review of the toxic effects of these metals, "Given that Pb, Hg and Cd<sup>[16]</sup> are widely distributed in the environment through various sources, human exposure is inevitable because these metals are non-degradable, environmentally persistent, and can accumulate in ecosystems at very low levels."<sup>17</sup>



*While many metals appear naturally in the earth's crust, those that are the most harmful to human health occur as a result of human activity.*

This is especially the case in developing countries. In parts of the world where population density is highest and pollution goes unchecked, these metals contaminate the food supply. What's more, while the use of lead paint is on the decline in most developed

<sup>16</sup> Lead, mercury and cadmium, respectively.

<sup>17</sup> Brilliance Onyinyechi Anyanwu et al., "Heavy Metal Mixture Exposure and Effects in Developing Nations: An Update," *Toxics* 6, no. 4 (2018): 65, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6316100/>.



countries, lead can still be found in paint, piping, ceramics, tools and many other items much more frequently in the developing world. Leaded gasoline is also used at much higher rates in these countries than in Europe and North America. Unfortunately, research into and monitoring of the health consequences of pollution in the developing world is scarce, but elevated incidence of miscarriage and stillbirth, cancer and premature deaths has been well documented.<sup>18,19</sup>

## FOUR TO WATCH

The World Health Organization's list of 10 "chemicals of major health concern" features four common heavy metals: arsenic, cadmium, lead and mercury (sometimes referred to as the "big four").<sup>20</sup> In the US, these four are also the most commonly measured and regulated trace elements on the state level. It is important to bear in mind that regulators should monitor and growers should seek to eliminate many other common toxic metals, including chromium, and to reduce metals that are essential nutrients but can be toxic at excessive concentrations, such as copper, nickel and zinc.

Below, we provide an overview of the methods of accumulation and human health outcomes linked to each of four major offenders pervasive in our agricultural systems:

**Arsenic (As):** A naturally occurring metalloid found in the earth's crust, arsenic poses a danger to life forms at high amounts in its inorganic form, which is a known carcinogen. Toxicity has been linked to several types of cancer, heart disease, skin lesions and other ailments. Today, contaminated water is most often responsible for arsenic toxicity. A 2017 survey revealed that some 2.1 million Americans across 25 states were exposed to dangerously high levels of the metal in their drinking water.<sup>21</sup> Crops irrigated with

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18 Cecilia Nwadiuto Amadi, Zelinjo Nkeiruka Igweze, and Orish Ebere Orisakwe, "Heavy Metals in Miscarriages and Stillbirths in Developing Nations," *Middle East Fertility Society Journal* 22, no. 2 (2017): 91–100, <https://www.sciencedirect.com/science/article/pii/S1110569017300377>.

19 Anyanwu et al.

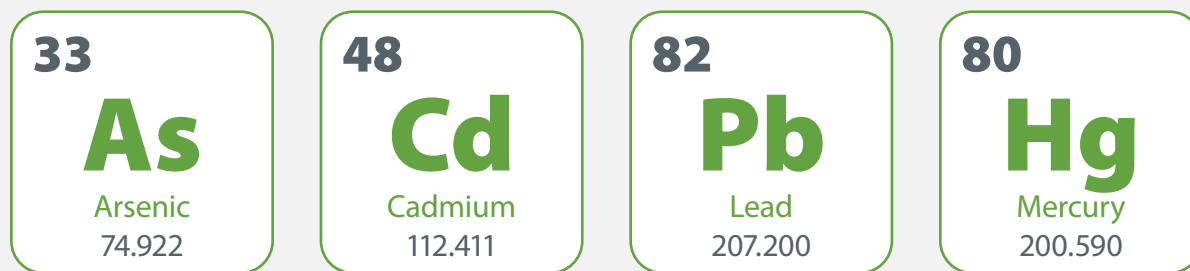
20 The WHO also includes "highly dangerous pesticides" on its top-ten list. It is important to note that heavy metals in certain pesticides contribute to their hazardousness. According to one study, "in the recent past, about 10% of the chemicals [...] approved for use as insecticides and fungicides in the United Kingdom were based on compounds which contain Cu, Hg, Mn, Pb, or Zn." "Ten Chemicals of Major Public Health Concern," World Health Organization, n.d., [https://www.who.int/ipcs/assessment/public\\_health/chemicals\\_phc/en/](https://www.who.int/ipcs/assessment/public_health/chemicals_phc/en/); Slavko Smiljanić et al., "The Main Sources of Heavy Metals in the Soil and Pathways Intake," in *Engineering, Environment and Materials in Processing Industry* (Sarajevo, 2019).

21 Joseph D. Ayotte et al., "Estimating the High-Arsenic Domestic-Well Population in the Conterminous United States," *Environmental Science Technology* 51 (2017): 12443–54, <https://pubs.acs.org/doi/abs/10.1021/acs.est.7b02881>.

arsenic-contaminated water are most likely to pose a health risk to humans; for this reason, rice is a particularly egregious offender.

**Cadmium (Cd):** Found in certain batteries, paints and plastics, cadmium is a carcinogen that damages the kidneys and can contribute to renal failure. Cigarette smokers are at the greatest risk for cadmium toxicity, but because the metal is absorbed in soil, common foods such as root vegetables, nuts, legumes and leafy

## The Big Four



greens can also take it up. A study at Harvard University suggested that there may be a correlation between cadmium exposure and ADHD in children, leading *Scientific American* to argue that the element could be considered “the new lead.”<sup>22,23</sup> Because the study did not look at children with significantly elevated levels, these findings are particularly striking and suggestive of a potentially widespread problem.

**Lead (Pb):** Lead is a highly toxic chemical element known to cause serious harm to nearly every organ in the human body, with symptoms ranging from peripheral neuropathy and brain fog to kidney damage, reproductive abnormalities, cardiovascular problems and even death. Its effects are particularly devastating in children, whose physiological and cognitive development are often severely

22 Carol Kelly, “Children Exposed to Cadmium May Be at Higher Risk for Learning Disabilities,” *Environmental Factor*, 2012, <https://factor.niehs.nih.gov/2012/3/science-cadmium/index.htm#:~:text=Children and teens with higher, Timothy Ciesielski%2C M.D.%2C Sc>.

23 Maria Cone, “Is Cadmium as Dangerous for Children as Lead?,” *Scientific American*, 2012, <https://www.scientificamerican.com/article/is-cadmium-as-dangerous-for-children-lead/>.

impaired. Humans are exposed via myriad sources, including food and water, smoking and even contaminated household items; in the US alone, more than 200,000 tons of lead are released into the environment each year by way of vehicle exhaust.<sup>24</sup> The US federal government banned the sale of lead-based paint to consumers in 1978 and the use of lead pipes in 1986 (although it allowed pipes currently in use to remain in the ground). The United Nations reports that over half a million individuals die worldwide as a result of lead poisoning each year.<sup>25</sup>

**Mercury (Hg):** Mercury wreaks havoc on the human body according to the method of exposure; in its various forms, it can impair the nervous system, damage the lungs and kidneys, and corrode the skin. Tuna and other fish containing methylmercury—rather than ethylmercury, which does not pose a health risk and is used in some vaccines—are the best-known culprits for mercury poisoning in the United States because the metal bioaccumulates in shellfish and fish found high on the food chain. Consumers also come into contact with mercury in batteries, thermometers and barometers, and dental amalgams (tooth fillings). Coal burning and some industrial activities release mercury into the air, which then makes its way into soil and water.

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24 Monisha Jaishankar et al, "Toxicity, Mechanism and Health Effects of Some Heavy Metals," *Interdisciplinary Toxicology* 7, no. 2 (2014): 60–72, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4427717>.

25 "Despite Bans, Most Countries Still Have Lead Paint," UN Environment Programme, 2018, <https://www.unenvironment.org/pt-br/node/23772>.

## CANNABIS: A REGULATORY WILD WEST

Because cannabis is not yet legal on a federal level, regulation is carried out on a state-by-state basis. This burdens cannabis growers and producers of cannabinoid products with a tremendous responsibility to protect the health of their customers in the absence of federal oversight. It should also be noted that CBD, although now legal (with some restrictions) in all fifty states, remains largely unregulated across the country.

As Robert Thomas, author of *Measuring Heavy Metal Contaminants in Cannabis and Hemp*, writes in *Analytical Cannabis*, state regulatory standards are often derived from the food and beverage, dietary supplement, pharmaceutical and cosmetics industries. While cannabis manufacturing processes may resemble processes employed in these industries, Thomas writes, “Consumers of cannabis and hemp products are using them very differently and in very different quantities, particularly compared to pharmaceuticals, which typically have a maximum daily dosage.” Toxicological data gathered from these industries cannot simply be transferred to cannabis and its myriad consumer uses, Thomas adds.<sup>26</sup>

Given that cannabis is primarily legal in the United States for medical use, it is particularly alarming that heavy-metal testing is not universal. When patients take cannabinoid products for therapeutic purposes, they presume that they are choosing alternatives to pharmaceutical drugs free of harmful chemicals or unpleasant side effects. Unfortunately, in an effort to cater to their customers, growers may be inadvertently endangering them: Growing for higher concentrations of THC leads to higher concentrations of heavy metals and pesticide residue.<sup>27</sup>

Cannabis is such a strong accumulator of heavy metals that it is used in bioremediation, the process of using living organisms to remove contaminants from the environment. In the 1990s, for example, cannabis was planted to extract heavy metals from soil near the site of the Chernobyl nuclear reactor.<sup>28</sup> (Evidently, crops used for this purpose cannot be processed for consumer use, but they offer potential as sources of biofuel or biodiesel, as demonstrated by

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26 Robert Thomas, “Regulating Heavy Metals in Cannabis: What Can Be Learned from the Pharmaceutical Industry?,” *Analytical Cannabis*, 2020, <https://www.analyticalcannabis.com/articles/regulating-heavy-metals-in-cannabis-part-i-what-can-be-learned-from-the-pharmaceutical-industry-312336>.

27 Brian Handwerk, “Modern Marijuana Is Often Laced With Heavy Metals and Fungus,” *Smithsonian Magazine*, 2015, <https://www.smithsonianmag.com/science-nature/modern-marijuana-more-potent-often-laced-heavy-metals-and-fungus-180954696/>.

28 Citterio et al.



researchers in China who successfully used hemp as a bioremediator of cadmium-contaminated soil.<sup>29</sup>) Bioremediation with cannabis is something of a balancing act; because heavy metals may stunt plant growth, they may in fact hinder a crop's capacity to extract these harmful trace elements from the soil.<sup>30</sup> However, research indicates that certain stress-tolerance genes may bolster a plant's ability to take up undesirable metals from the soil.<sup>31</sup>

### **A regulatory wild west:**

*Heavy metal testing is NOT universal. Cannabis is not legal on a federal level in the US, so regulation is carried out on a state-by-state basis.*

*The differences state to state, and country to country, can burden industry manufacturers and cannabis consumers.*



For acolytes of the cannabis industry, the ability to detoxify soil is yet another of the crop's superpowers. But the potential for toxicity via this poorly regulated agricultural product should remain at the forefront of growers' minds. Commercial growers must be vigilant in their choice of growing medium and nutrients in order to protect the health of their customers.

The degree to which heavy metals pose dangers to the health of living organisms depends on their concentration and the duration of exposure. In simple terms, the dose makes the poison. But products laced with toxic heavy metals never exist in a vacuum, and this is

29 Gangrong Shi et al., "Cadmium Tolerance and Bioaccumulation of 18 Hemp Accessions," *Applied Biochemistry and Biotechnology* 168 (2012): 163–73, <https://link.springer.com/article/10.1007/s12010-011-9382-0#page-2>.

30 Richwell Alufasi, Bagar Tanja, and Walter Chingwaru, "Potential Applications of Cannabis Sativa in Environmental Bioremediation: A Review," in *6th Scientific Conference with International Participation All about People: Challenges For Science and Education* (Maribor, 2018), <https://www.researchgate.net/publication/323868395-Potential-Applications-of-Cannabis-sativa-in-Environmental-Bioremediation-A-Review>.

31 Rafiq Ahmad et al., "Phytoremediation Potential of Hemp (Cannabis Sativa L.): Identification and Characterization of Heavy Metals Responsive Genes," *CLEAN - Soil Air Water* 44, no. 2 (2015), <https://www.researchgate.net/publication/281651509-Phytoremediation-Potential-of-Hemp-Cannabis-sativa-L-Identification-and-Characterization-of-Heavy-Metals-Responsive-Genes>.

particularly true of fertilizers, whose trace elements compound damages to crops when combined with polluted growing media. By peddling products with detectable levels of heavy metals, fertilizer companies raise the dosage of potentially harmful chemicals that we already absorb from food, water, cosmetics, personal care products, cleaning products and other everyday items. Next, let's review existing standards for heavy metals in American fertilizers and discuss the ways in which they fall short of protecting consumers.

## REGULATING FERTILIZERS AND NUTRIENTS

Countless variables beyond growers' control may introduce heavy metals into crops, particularly if those crops are grown in soil rather than in water. However, one factor that growers can manage is their choice of fertilizer or feeding program. American growers have the choice between products that contain measurable levels of toxic heavy metals or those derived from clean, high-quality ingredients.

While regulation of heavy metals remains in the hands of individual states, the American Association of Plant Food Control Officials (AAPFCO) provides guidelines for heavy-metal upper limits in fertilizers containing guaranteed amounts of phosphates and micronutrients (Figure 1). Fertilizers above these limits are considered adulterated.<sup>32</sup> (American fertilizer brands are not required to abide by these standards except on a state-by-state basis.)

32 "Statement of Uniform Interpretation and Policy (SUIP) #25 - The 'Heavy Metal Rule,'" Association of American Plant Food Control Officials, n.d., <https://www.aapfco.org/rules.html>.

Figure 1: AAPFCO Upper Levels for Heavy Metals in Fertilizers

Metals	ppm per 1% P <sub>2</sub> O <sub>5</sub>	ppm per 1% micronutrient <sup>(3)</sup>
Arsenic	13	112
Cadmium	10	82
Cobalt	136 <sup>(6)</sup>	2,228 <sup>(6)</sup>
Lead	61	463
Mercury	1	6
Molybdenum	42	300 <sup>(4)</sup>
Nickel	250	1,900
Selenium	26	180
Zinc	420	2,900 <sup>(4)</sup>

As the table indicates, fertilizers containing measurable levels of arsenic, cadmium, lead, mercury and several other dangerous metals are still considered safe according to AAPFCO's guidelines. AAPFCO cites a white paper produced by "FDA consultants" The Weinberg Group on behalf of The Fertilizer Institute (TFI). In a 2008 report of dispute over a study of BPA in plastics, *The Washington Post* described The Weinberg Group as "a Washington firm that employs scientists, lawyers and public relations specialists to defend products from legal and regulatory action."<sup>33</sup> According to the white paper, "The RBC [risk-based acceptable concentration] values derived for the nine metals [...] are considered to be health protective and applicable at a nationwide level. Products with levels of metals at or below the proposed AAPFCO standards are considered safe for professional applicators, farm families, home gardeners and the general public."<sup>34</sup>

To be clear, not a single reputable fertilizer brand currently markets products whose levels exceed or even come close to AAPFCO's. However, many major brands continue to sell products derived from inexpensive and impure ingredients, resulting in detectable amounts of these metals. Due to the tendency of these metals to accumulate over time, the exceptional ability of cannabis to extract them from growing media and their severe, well-documented consequences for human health and wellbeing, we believe that it is incumbent upon growers to protect their consumers and avoid them entirely. While cannabis testing limits vary by state, it is crucial to note that no amount of arsenic, cadmium, lead or mercury is beneficial to the human body. On this point, national and global health authorities are in agreement.

## ARE LOW LEVELS STILL SAFE?

There is no such thing as a safe amount of an unsafe chemical if exposure is prolonged. Even small amounts of harmful heavy metals that linger in the environment pose a threat to human health. Below, we examine the guidelines set by global health authorities to determine how much is too much of a bad thing.

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33 Lyndsey Layton, "Studies on Chemical In Plastics Questioned," *The Washington Post*, April 27, 2008, <https://www.washingtonpost.com/wp-dyn/content/article/2008/04/26/AR2008042602126.html?sid=ST2008042602242>.

34 The Weinberg Group, "Scientific Basis for Risk-Based Acceptable Concentrations of Metals in Fertilizers and Their Applicability as Standards," 2001, <https://www.aapfco.org/pdf/rbc-white.pdf>.

**Arsenic:** It doesn't take a PhD in chemistry to know that drinking water shouldn't be laced with arsenic, and in 2001, the United States Environmental Protection Agency lowered its standard for arsenic in drinking water from 50 to 10 parts per billion. However, a 2012 study revealed that water polluted with that level of arsenic diminished the amount of nutrients in the blood and breast milk of mice, leading their offspring to display significant developmental deficits. As the lead author of the study stressed, based on these findings, humans should be cautious of their arsenic intake, particularly if they are pregnant or breastfeeding.<sup>35</sup>

### How low is low enough?



*Safe limits set for lead and arsenic levels in food and water are often based on what is feasible to achieve rather than what is ideal for human health.*



**Cadmium:** In 2010, the Joint Expert Committee on Food Additives of the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) adjusted the Provisional Tolerable Weekly Intake (PTWI) for cadmium from 7 micrograms per kilogram of body weight ( $\mu\text{g}/\text{kg}$  bw) to a monthly intake of 25  $\mu\text{g}/\text{kg}$  bw due to the metal's long half-life in human kidneys.<sup>36</sup> However, research reflects that this upper limit may still be too high to be considered safe, particularly for older individuals, whose kidneys are in greater danger due to the tendency of the metal to accumulate over time.<sup>37</sup>

<sup>35</sup> "Safe' Levels of Arsenic in Drinking Water Found to Compromise Pregnant/Lactating Mothers, Offspring," *Science News*, 2012, <https://www.sciencedaily.com/releases/2012/05/120531200820.htm>.

<sup>36</sup> Rodjana Chunhabundit, "Cadmium Exposure and Potential Health Risk from Foods in Contaminated Area, Thailand," *Toxicological Research* 32, no. 1 (2016): 65–72, <https://www.researchgate.net/publication/294727511-Cadmium-Exposure-and-Potential-Health-Risk-from-Foods-in-Contaminated-Area-Thailand>.

<sup>37</sup> Soisungwan Satarug et al., "Cadmium, Environmental Exposure, and Health Outcomes," *Ciência & Saúde Coletiva* 16, no. 5 (2011).



**Lead:** Research surrounding lead toxicity leaves no room for misinterpretation, and the WHO minces no words: “There is no level of exposure to lead that is known to be without harmful effects.”<sup>38</sup> And yet regulatory bodies continue to suggest that there may be an acceptable lower limit that simply has not yet been identified. “No safe blood level in children has been identified,” the US Centers for Disease Control (CDC) now states, after evidence of harm was found at <10 µg/dL, its previous “level of concern.”<sup>39,40</sup>

**Mercury:** Whether the health benefits of seafood outweigh the risks of mercury consumption remains a topic of some controversy. However, in a 2012 update to its advice for the safe consumption of mercury in food, the European Food Safety Agency noted that “new studies indicate that beneficial effects related to long chain omega 3 fatty acids present in fish may have previously led to an underestimation of the potential adverse effects of methylmercury in fish.”<sup>41</sup> On this matter, the CDC’s “Mercury Factsheet” notes, “Defining safe levels of mercury in blood continues to be an active research area.”<sup>42</sup>

Legislative efforts to quantify “safe” levels of these unsafe trace elements may be misleading; attempts to define “tolerable” amounts may more accurately reflect the inherent dangers of these metals. However, as the authors of a 2020 study on the accumulation of heavy metals in urban community gardens note, such guidelines should vary according to each individual’s diet and weight. Furthermore, they add, “safe limits set for lead and arsenic levels in food and water are often based on what is feasible to achieve rather than what is ideal for human health, leading to less regulation than might otherwise be expected.”<sup>43</sup>

Ultimately, an absence of strict federal regulation and pervasive efforts on the part of lobbyists to maintain lax standards place

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38 “Lead Poisoning and Health,” World Health Organization, 2019, <https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health>.

39 “Blood Lead Levels in Children,” Centers for Disease Control and Prevention, 2021, <https://www.cdc.gov/nceh/lead/prevention/blood-lead-levels.htm>.

40 “CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in ‘Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention,’” 2012, <https://stacks.cdc.gov/view/cdc/37586>.

41 “Mercury in Food – EFSA Updates Advice on Risks for Public Health,” European Food Safety Authority, 2012, <https://www.efsa.europa.eu/en/press/news/121220>.

42 “Mercury Factsheet,” Centers for Disease Control and Prevention, 2017, <https://www.cdc.gov/biomonitoring/Mercury-FactSheet.html>.

43 Andrew M. Cooper et al., “Monitoring and Mitigation of Toxic Heavy Metals and Arsenic Accumulation in Food Crops: A Case Study of an Urban Community Garden,” *Plant Direct* 4, no. 1 (2020), <https://onlinelibrary.wiley.com/doi/full/10.1002/pld3.198>.

consumers in peril. Yet major brands continue to sell products with detectable levels of these metals, bolstered by findings such as those in the Weinberg report. With so much controversy surrounding regulation—and with so many environmental factors at play—practical efforts to curb toxicity now abandon the goal of “safe” for “safe enough.”

## HOLDING FERTILIZERS TO A HIGHER STANDARD

While public awareness about the dangers of heavy metals has grown, American regulators have done little to reduce the steady stream of toxic chemicals Americans receive via their food and water in comparison with their counterparts elsewhere in the world, such as the European Union. As the Pacific Northwest Pollution Prevention Center put it in one report, “States often regulate the easy issues (e.g., cadmium in children’s jewelry) while ignoring real exposure-driven issues (e.g., cadmium in baby food or teething biscuits that come from fertilizer).”<sup>44</sup> Therefore it is incumbent upon fertilizer brands to eschew inexpensive mineral ingredients in favor of higher-quality, if potentially more expensive, materials that protect the health and safety of consumers.

Choosing a clean feeding program should not require extensive guesswork on the part of growers. We believe that growers have the right to know exactly what is in their fertilizers and supplements and precisely what purpose it serves.

When selecting a product line, don’t compromise on the following:

**A transparent ingredient list.** Source ingredients derived from high-quality materials and label information free of confusing language.

**Heavy-metal testing results that clearly indicate an absence of trace metals.** Each product label should provide the URL for test results on AAPFCO’s website or to an equivalent page on the brand’s website.

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<sup>44</sup> “FAQs About Cadmium in Fertilizer: Fertilizer Laws and Limits” (Seattle, 2017), <https://pprc.org/wp-content/uploads/2017/07/Cd-in-Fertilizer.Limits-and-Laws.Final.7-17-17.pdf>.

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**An intelligible week-by-week feeding chart.** Cannabis requires different nutrients at different levels during different phases and stages of its life cycle. If a brand fails to provide clear instructions and feeding charts for each week of the crop's life, you may inadvertently expose the plant to harm and compromise crop yield or quality.

**Knowledgeable and readily available customer service.** If you have any questions about what's in your fertilizer, what purpose each ingredient serves or how it was derived, a brand representative should be able to address them swiftly and honestly.

Don't forget that many heavy metals are actually necessary for plant growth. Cobalt, copper, iron, manganese, molybdenum, nickel and zinc all play an essential role in the development of hydroponic and outdoor crops. The right nutrient program will supply these metals in safe amounts and at exactly the right times in the crop life cycle for them to confer maximum benefit, and it will do so without any guesswork on the part of growers—and without anxiety about toxicity or ingredient quality.



Emerald Harvest takes great pride in using only pure, high-quality ingredients that protect consumers and deliver outstanding results for hydroponics growers. Our products are derived from 90–95% pure salts to ensure a minimum of heavy metals and chloride, in many cases with below-detectable levels of dangerous metals like lead and cadmium.

Where minimal amounts of trace elements are present, Emerald Harvest's test results fall far below AAPFCO limits. We not only meet industry standards; we exceed them. Consumers deserve to enjoy cannabis products without fear of negative consequences for their health so Emerald Harvest works diligently to help provide the peace of mind that comes with using only the very best source ingredients.

Contact Emerald Harvest directly for more information about our clean, high-quality base nutrients and supplements.

To set up an appointment with a representative, call 1.866.325.8235 or email [info@emeraldharvest.co](mailto:info@emeraldharvest.co).

