# FAQs About Cadmium in Fertilizer:

# Fertilizer Laws and Limits

## Why do we need limits on cadmium in fertilizer?

Cadmium, a naturally present metal, is known to build up in and have adverse effects on the human body. In 2010, the World Health Organization (WHO) indicated that a growing segment of the population has little to no margin of safety from the adverse effects of cadmium. The WHO also noted a gradual increase in cadmium levels in agricultural soils and crops due to atmospheric deposition of the metal along with the deliberate application of municipal sewage sludge and phosphate fertilizer.[1]

In the last 15 years, biomedical research has shown a strong correlation of cadmium body burden in humans to adverse health effects. Because correlation does not mean causation, research continues on the mechanisms that contribute to the role of toxicants in chronic diseases. Nonetheless, research has concluded that cadmium is a major human toxicant; there is a need to limit exposure from as many sources as possible.[2]

Although cadmium is used in a variety of manufactured products, for most people the primary source of exposure is food. The natural presence of cadmium in phosphate rock, which is used to make fertilizer, becomes a problem when plants accumulate the metal in their biomass. More detail about plant contamination can be found in another report in this series, *FAQs About Cadmium in Fertilizer: Cadmium Contamination in Plants.* Vegetables and grains are the most common sources of fertilizer-derived cadmium in the diet. Fertilizer runoff into surface waters may also contribute to high levels of cadmium in fish and shellfish.

Based on the evidence presented in this FAQ report and the others in the series, we believe that states need to adopt more stringent limits that will reduce exposures and prevent adverse health effects. Current fertilizer manufacturing processes remove very little cadmium and, in some cases, actually concentrate it.[3] However, removing cadmium from fertilizer in processing is the most effective way to reduce cadmium in our food.

# What types of fertilizer limits currently exist?

Cadmium in fertilizer—phosphate rock, animal manures, and land applied municipal sewage sludge (hereafter referred to as biosolids)—is increasingly regulated in different parts of the world. Initially, cadmium was regulated primarily because of concerns about the metal leaching from fertilized soil into ground and surface waters. However, as knowledge increased about cadmium as a major human toxicant in our food, the emphasis on allowable cadmium in fertilizer has shifted to the amount of uptake seen in agricultural commodities grown on soils that include added cadmium in fertilizer.

The limits on cadmium in fertilizer have taken several forms, most commonly:

- A limit on the amount of cadmium allowed per unit of phosphorous (mg Cd/kg P).
- A limit on the amount of cadmium allowed per unit of phosphorous oxide (mg Cd/kg $P_2O_5$). This limit is used because American Plant Food Control officials have adopted $P_2O_5$ as the standard for guaranteed analysis of phosphorous content based on an older measurement technique. The method has been replaced, but the designation is still used to represent the percentage of phosphorous content of fertilizer (the middle number on a bag of fertilizer) in the US. This measure may be a bit confusing because the actual phosphorous applied to soil is about 44 % of the $P_2O_5$ weight percentage designated on the bag.
- A limit on total cadmium that can be applied to an agricultural field each year, expressed as pounds Cd per acre or kilograms per hectare (kg Cd/ha).

A limit based on mg Cd/kg P or mg Cd/kg $P_2O_5$ generally prohibits the sale and application of fertilizer that does not meet that limit in a given jurisdiction. For states that require registration and licensing of fertilizers, these limits are easily enforceable. A limit that mandates a maximum total amount of Cd that can be applied per year is more flexible and allows a farmer to adjust the amount of phosphorous fertilizer applied depending on plant needs and the cadmium loading in the fertilizer. However, this latter type of limit requires more diligent record keeping than a sales restriction and is much much less likely to be enforced.

## Are fertilizer limits effective?

All types of fertilizer limits can be effective if:

- a.) They are sufficiently stringent to protect both public health and the environment, the corollary of which is that they must be reviewed every few years and updated when needed based on new information;
- b.) They require metals analysis with detection limits that are low enough to be meaningful and enable people to choose the lowest metal concentrations, the corollary of which is that detection limits should be no greater than 0.1 mg Cd/kg fertilizer product. For example, a detection limit of 1 ppm Cd in a 2 % $P_2O_5$ product will only indicate cadmium concentrations greater than 50 mg Cd/kg $P_2O_5$;
- c.) They are easily implementable and can be readily understood both by the industry and the public; and
- d.) They are actively enforced, the corollary of which is that if the limits are based on total cadmium applied per unit area, the information on the cadmium applied for each farm should be readily available to the enforcing agency and the public.


## How do you compare different limits and measurements?

Comparing different types of limits is sometimes difficult and may require conversions between P and $P_2O_5$ or back calculating mg Cd/kg $P_2O_5$ based on an assumed fertilizer application rate. Phosphorous pentoxide ($P_2O_5$) is 44% P (take the Cd/kg P and divide it by 2.29 to get Cd/kg $P_2O_5$).

For the purposes of this fact sheet, the cadmium limits are compared based on the US standard units of mg Cd/kg $P_2O_5$. For limits based on total annual cadmium applied, we assume an annual $P_2O_5$ application rate of 100 kg per hectare.[3] This assumed annual application rate is higher than typical for wheat but lower than that typical for vegetables; if you apply only half of the assumed application rate to wheat, the limit would appear twice as high, and if you apply twice the assumed application rate to vegetables the limit would appear only half as high.

A further complication arises when trying to compare the cadmium content listed in state fertilizer databases to a cadmium limit based on mg Cd/kg $P_2O_5$. The requirement for reporting metals in states with fertilizer registration databases is often based on the amount of cadmium in the product, not per kg of $P_2O_5$. For those interested in comparing the fertilizer they use to worldwide standards, the conversion must use the guaranteed amount of phosphorous (as $P_2O_5$) as per standard reporting methods.

# What are the current limits? ...

A summary of the limits for cadmium in fertilizers is provided in the table on page 6. A more detailed explanation of some of the limits and how they developed is provided below. The limits are addressed from most stringent (EU) to least stringent (EPA Biolsolids).

**European Union**

The EU and member states have been studying cadmium exposure for almost two decades and have recently implemented food safety standards and fertilizer limits that are much more stringent than any standards existing in the United States. These limits appear to be based on sound science.

Initially, the EU concern about cadmium in food was triggered by a rising body burden in some segments of the population that approached the level of onset of adverse health effects. In 2000, the average cadmium levels in fertilizer and the resulting levels in cultivated soil tended to be lower in the countries of northern Europe (about 2.5 mg Cd/kg P in fertilizer and 0.21 mg Cd/kg soil) and much higher in other parts of Europe (about 138 mg Cd/kg P in fertilizer and 0.5 mg/kg soil). It was concluded that this average cadmium content of European fertilizers, 138 mg Cd/kg phosphorous (or 60 mg Cd/kg $P_2O_5$), would lead to a radical increase in the concentrations of cadmium in soil and crops, and in cadmium leaching.

The highest impacts, based on average European fertilizer levels of the metal, were estimated at a 125% increase in soil concentrations in potato fields, a 34% increase in the concentration in wheat grain, and a 124% increase in cadmium leaching. At the Finnish national limit of 50 mg Cd/kg P (21.5 mg Cd/kg $P_2O_5$), the corresponding impacts were estimated to increase 43%, 12%, and 42% respectively. In 2000, the Finnish Environmental Institute compared the estimated increases to the observed 30% increase of cadmium in soil over a 13-year period from 1974 to 1987, when the cadmium levels in fertilizer were notably higher (closer to the EU average). They concluded that the noted increases adversely affected soil health, aquatic health through leaching, and human health through diet. While the overall average cadmium intake from food alone does not pose a risk to most people in Finland, certain populations are considered at higher risk. For example, vegetarians may consume more of the metal due to their diet, women may increase absorption of the metal due to low levels of iron, and smokers are exposed to an additional source of cadmium.[4] It should also be noted that two scenarios evaluated in this assessment -- the EU average cadmium concentration in fertilizer and the Finnish national limit for cadmium in fertilizer -- may result in lower cadmium exposures than any of the existing fertilizer limits in the U.S.

In the spring of 2016, the European Commission proposed a regulation that will phase in increasingly stringent limits of cadmium in fertilizer. According to the proposal, an initial limit of 60 mg Cd/kg P2O5 will apply as soon as the regulation comes into force. A more stringent limit of 40 mg Cd/kg P2O5 will phase in three years later, and the lowest limit of 20 mg Cd/kg P2O5 will come into force nine years after the initial effective date.[5] As of this report's publication, however, EU member states are still split regarding their support of the proposed limits and the regulation's timeline.[6]

**California**

California established non-nutritive standards for cadmium in fertilizer. The standard is set at 4 ppm cadmium for each 1% of $P_2O_5$ in the fertilizer.[6] For example, a fertilizer with a guaranteed $P_2O_5$ content of 10% is allowed a concentration limit 10 times 4ppm or 40 ppm; or a fertilizer with a guaranteed $P_2O_5$ content of 50% is allowed a concentration limit 50 times 4 ppm or 200 ppm. These examples translate to an equivalent of 400 mg Cd/kg $P_2O_5$. The California standard, the most stringent standard in the US, is far less (20 times less) protective than the final EU standard.

California requires that fertilizers sold or applied in the state be registered and licensed. A search of the registered products may be conducted on the state's Fertilizing Materials Program database.[7]

### Oregon

Oregon also established non-nutritive limits for cadmium in fertilizer. The type of standard is similar to California but less stringent. The limit is set at 7.5 ppm cadmium for each one percent of $P_2O_5$ in the fertilizer. The allowed concentration is calculated in the same manner as California. However, for purposes of calculating the maximum allowed concentration of a metal in the product if the guaranteed $P_2O_5$ in a product is less than 6%, the minimum multiplier used is 6. When the fertilizer has no guaranteed analysis of $P_2O_5$ but does have a guaranteed analysis of one micronutrient, the limit is set at 61 ppm for each percent of the micronutrient. The Oregon limit for fertilizers containing phosphate translates to an equivalent of 750 mg Cd/kg $P_2O_5$.[8]

Oregon requires that fertilizers be registered. The registration process includes a requirement for submitting a heavy metals laboratory analysis report. The detection limit required for cadmium is 5 ppm (this detection limit is, in our opinion, too high to evaluate potential exposures). More information may be found on the state's registered product database.

### Washington

Washington regulates cadmium in fertilizer under the Washington Fertilizer Law, Revised Code of Washington, Chapter 15, Section 54. Standards have been established for allowable levels of nonnutritive substances in commercial substances. The code adopts Canadian standards: "These standards are Canadian figures for agricultural and agri-food Canadian maximum acceptable metal additions to soil established under Trade Memorandum T-4-93 dated August 1996.[9]

"The maximum acceptable cumulative metals additions to soil means the amount of total metals that can be added to soil over a forty-five-year period of time without exceeding the Canadian standards..." [9]

The maximum application rate of cadmium is 0.079 lbs Cd/year. Waste-derived and micronutrient fertilizers must be tested by the Toxicity Characteristic Leaching Procedure (TCLP) method, which determines levels of hazardous waste. As measured by TCLP, the Maximum Allowable Metals Standard for cadmium is 1.0 ppm. Washington also requires that fertilizers be registered. As part of the registration process, fertilizer registrants are required to submit information regarding the levels of metal in each of their fertilizer products. Metals are reported in mg/kg of fertilizer (ppm). More information may be found on the state's Department of Agriculture Product Database.

As with Oregon, Washington's loose limit on cadmium application (0.079 lbs Cd/yr) translates to an equivalent of about 889 mg Cd/kg $P_2O_5$.

### EPA Biosolids Limits

The EPA limits on cadmium and other metals for the land application of biosolids are quite high when compared to chemical fertilizer limits, but the actual amount of phosphorous in biosolids is variable and relatively low compared to chemical fertilizer. The EPA considers land application of biosolids a recycling method and allows use of biosolids as a fertilizer or soil amendment for conventional farming. The National Organic Standards Program, however, precludes the use of biosolids for organic farming.

# What are the current limits? continued

**Table 2.1 Restrictions on Cadmium in Fertilizers [3]**

| Jurisdictions | Limit in mg Cd per kg $P_2O_5$ |
|---|---|
| Netherlands | 17.5 |
| European Union | 60 >> 40 >> 20 |
| Finland | 21.5 |
| Sweden | 44 |
| Denmark | 48 |
| Belgium | 90 |
| Austria | 120 |
| Australia | 131 |
| Japan | 148 |
| California* | 400 (by rule 4 ppm per %) |
| Oregon* | 750 (by rule 7.5 per %) |
| Washington** | 889 (by rule 0.079 lbs/acre) |
| Canada** | 889 (by rule 0.079 lbs/acre) |
| US EPA (biosolids)*** | 1.9 kg Cd/ha |

*These limits are 2.29 times higher than the numbers cited in the table presented by Roberts in *Cadmium and Phosphorus Fertilizers: The Issues and the Science.* The administrative rules for both CA and OR indicate limits of 4 ppm & 7.5 ppm respectively, per 1% guaranteed $P_2O_5$ rather than P.

**The allowable limit in the rule is total cadmium that can be applied to agricultural fields per year.

***The EPA limit is for the land application of biosolids used for fertilizer and/or soil amendment on agricultural land, the EPA does not limit Cd in fertilizer.

# Why are limits so different between countries and states?

Differences in cadmium limits are difficult to explain because they imply unequal protectiveness for different populations. Varying growing conditions can explain part of the variety of limits, but real differences in regulation appear due to differences in regulatory philosophy.

Europe, both the EU and the member states, places a high value on human health and quality of life for everyone. A philosophy of prevention guides protection of public health and the environment. The EU monitors health, including measuring the body burden of toxics as an indicator of health, and it creates laws based on these indicators. The rulemaking process incorporates rigorous risk assessments accompanied by a thorough analysis of monitoring data along with implementation of the "Precautionary Principle" for unknowns. The cost for protectiveness may be reflected in the price of the product—as the price of fertilizer across the EU could become more expensive than in the US—but the long term health benefits, and associated cost savings, should outweigh the additional cost of fertilizer.

In contrast, the US has not regulated toxics in an equally meaningful way. This is true even when substances and chemicals have been demonstrated to be harmful and when exposure can be prevented. 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. See the FDA's *Total Diet Study* for listings of cadmium measures in food products).

If as a nation we value profit maximization over adopting precautionary practices, then our nation's health will suffer. The long-term cost of caring for those who develop disease from preventable exposures is likely to continue to escalate.

The California Office of Environmental Health Hazard Assessment (OEHHA) is well known for the quality and rigor of its risk assessments of toxic materials. The state's Proposition 65 law may warn rather than restrict, but the Proposition 65 safe harbor level (the maximum allowable dose for reproductive toxicity) for cadmium is 4.1 µg/day (oral).[11] Although the California limits on cadmium in fertilizer are more restrictive than other states, these limits remain unlikely to achieve the safe harbor level for cadmium.

Regulations in other parts of the world tend to fall somewhere between the more protective levels of the EU and the less protective levels of the United States. Japan is a notable exception. Although the country has experienced some notable toxic incidents involving cadmium, the government quickly investigated and reacted to prevent reoccurrence. China, on the other hand, suffers from serious soil contamination, mostly from industrial pollution, that is affecting the country's food. Cadmium contamination is becoming an increasingly acute health concern in China. Because the US lacks the capacity to produce organic foodstuffs to meet the rising demand, the US imports organic vegetables from China.[12]

## Are limits protective of human health?

The answer to that question for the US in general, and the Northwest in particular, is likely no. Several strong indicators explain why:

- The body burden of cadmium in limited samples in Washington (measured by the Washington Department of Health) is higher than the country's average, which in turn is higher than the EU average. No data exist for other states in the Northwest.
- In the US, the body burden of cadmium in vegetarians, or the population that eats the most vegetables, is second only to smokers.[14, 15]
- Cadmium in food, especially vegetables and grains, is not only common but often above food safety limits (see another report in this series, *FAQs About Cadmium in Fertilizer: Cadmium Contamination in Plants*) and advisory intake levels.
- The Washington Department of Ecology estimated that 27% of the annual loading of cadmium in Puget Sound occurs via irrigation runoff from cadmium in fertilizer. This is not an issue only for Puget Sound but for all surface water.[16]
- Health effect studies continue to inform us about the harmful levels of cadmium in our bodies.

## If limits aren't adequate, how do we change them?

PPRC has broadly considered a number of options for reducing cadmium exposures by limiting cadmium in food. Our preliminary conclusion is that the best way to manage long-term cost is by removing cadmium at the source, namely in fertilizer used for crops. Reducing exposure could also be done by establishing stringent food safety limits. But this would require strict monitoring for food safety limits and would be significantly more expensive.

To change the limits, which have been created by both statute and regulation, will be a lengthy process, but not an impossible one. It takes a village, so to speak, and this village includes scientists, consumers, regulators, the regulated community, and legislators (in this case, mostly at the state level). The first step is educating people at all levels and demonstrating why change is needed. The EU has done a lot of that work for us and has taken more than a decade gathering consensus. Because the EU pioneered the way, the path toward more responsible limits should be easier in the US unless the regulated community pushes back by saying that work done in Europe does not apply to America. Many multinational companies are used to working with European data and regulations, but the agriculture community tends to favor a uniquely American approach. Such an insular attitude could severely hurt regulation progress because repeating the work already done well by the EU could take the US at least a decade.

At a time when protections of health and the environment are poorly funded, gathering and analyzing the available information, as PPRC has done, is a good place to begin. However, making legislative changes will require support from everyone, especially from local communities, but also from environmental and health activist organizations, tribal fisheries, organic producers, farm service agencies, and Agricultural Extension Offices.

## How can I help?

Every individual can help:

- 1.)Learn more about cadmium in fertilizer and food and tell your friends (contact PPRC if you have questions).
- 2.) Talk to your produce manager about cadmium in fertilizer and food. State your preference for low to no measurable cadmium and encourage stores to buy from growers willing to certify low cadmium. Customers can motivate retailers, and retailers can motivate producers.
- 3.) Talk to your local farm service agencies and help educate them on cadmium.
- 4.) Talk to your political representatives and ask them to support adopting new cadmium limits for fertilizer following the EU. Please feel free to use this FAQ report as well as others in this series.
- 5.) To the extent that you can, grow your own vegetables using very low (less than 20 mg Cd/kg $P_2O_5$) cadmium fertilizer. Note that this number is different than the numbers in the online fertilizer databases from Oregon and Washington that are based on cadmium per weight of the whole product. For help in understanding and translating the numbers, please call PPRC at 206-352-2050 or a local Agriculture Extension Office.

## Conclusion

Current limits on cadmium on fertilizers in the US are insufficient to meet health and environmental protection goals. The states that have previously established limits need to review recent research on the health effects of cadmium, the buildup of cadmium in soils, and the contribution of fertilizer to cadmium loading in surface waters. These states should lead the way toward health protection by by adopting more stringent limits that will reduce exposures and prevent adverse health effects. ~

### *Disclaimer*

This series of fact sheets on cadmium in fertilizer is not intended to discourage growing or eating vegetables. Vegetables are critical to life; the healthiest and tastiest ones often come from gardens. The information presented here is intended to help provide a better understanding of cadmium, how it gets into our food supply, how it can affect our health, and how we can minimize our exposure.

### *Writing Credits*

Research and writing by: Marjorie MartzEmerson
Edited by: Cyrus Philbrick
Additional data analysis provided by: Michelle Gaither

**** For more information on cadmium and other heavy metals, visit www.pprc.org***

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