



Managing Metals in Vietnamese Agriculture

Consumer demand for better quality produce is increasing.

Some metals are not desirable in agriculture because they may harm the environment or humans. Because of this, the concentrations of metals in soils and foods should be regularly monitored.

This brochure tells you why you should be concerned about metals in your farm soil and farm produce and how to manage the situation so that it does not become a problem.



Key points

- Metals are a potential problem in Vietnamese agriculture. They can cause decreases in yield and make produce unsuitable for humans to eat.
- However, metals in soils and agricultural produce can be safely managed by using simple and effective farm practices such as selection of crops, liming, adding organic matter, and controlling inputs to your soil.
- Farm produce contaminated by metals may not be saleable on the domestic and export markets thus potentially affecting the profitability of your farm.

Background

Apart from the soils of the Mekong River and the Red River, Vietnamese soils generally have low pH, low organic carbon, low clay contents and are deficient in nitrogen, phosphorus, calcium, and magnesium. In order to maintain or increase the current levels of agricultural production, a variety of additives, such as fertiliser must be added to Vietnamese soils. Without these additives, crop yields rapidly reduce to low levels. Unfortunately, these soil additives can be contaminated with metals that can have negative effects on crop quantity and quality.

What metals are we referring to?

In this brochure, we will discuss the metals arsenic, cadmium, cobalt, chromium, copper, lead, mercury, nickel, and zinc. Some of these metals are essential for plant and human nutrition, for example copper and zinc, and therefore small amounts are required in the soil and in the human diet. However, excessive amounts of any essential metals can produce toxic effects. Other metals, for example cadmium, chromium (for plants), lead, and mercury, are not essential and exposure to even small amounts can produce toxic effects to all life-forms. It is important therefore, to correctly manage inputs of metals onto agricultural soils.



How are metals introduced to agricultural soils and crops?

The metals found in agricultural soils and crops are introduced from a number of different sources, some natural and some from man's activities. These sources are discussed below.

Soil - Metals naturally occur in soils. Natural (background) concentrations of metals in soils depend on the parent rock from which the soil originated and are highly variable.

Water – Rain and irrigation water generally have very low metal concentrations. Care should be exercised if water from a mine, industry, sewage treatment plant, intensive agriculture, or river water downstream of any of the above is being used to irrigate crops. This is because the water may be contaminated with metals.

Fertilisers – The metals present in fertilisers are generally deliberately added in order to improve plant growth and yields. However, cadmium is not desirable and is the main metal contaminant in fertilisers that is of concern. It occurs naturally with deposits of zinc and phosphorus and is therefore present in fertilisers that contain phosphorus. Cadmium levels can vary in fertilisers containing phosphorus depending on the source of rock phosphate used in manufacturing.

Trace element fertilisers and phosphogypsum may also contain high concentrations of cadmium and other non-essential metals. Normally, nitrogen and potassium fertilisers, limes, and natural gypsum have very low cadmium levels.

It is recommended that you use fertilisers that have the lowest possible cadmium concentrations.

Animal manures – These may contain a variety of metals (eg. cadmium, copper, and zinc) as impurities (Table 1). Metal contents in manures depend mainly on the amount of metal in the food and supplements given to the animals. Copper and zinc food supplements are common for pigs which results in high copper and zinc concentrations in their manure (Table 1). Chicken manure has high concentrations of cadmium.

Sewage sludges (biosolids) - Sewage sludge in Vietnam is a combination of household, commercial, and industrial waste. Compared to the manures it has intermediate metal contents, except for lead which is relatively high (Table 1).



Table 1: Typical concentrations of copper (Cu), lead (Pb), zinc (Zn), and cadmium (Cd) in different types of organic wastes in Vietnam.

Organic waste	Cu (mg/kg)	Pb (mg/kg)	Zn (mg/kg)	Cd (mg/kg)
Sewage sludge	45	25	150	0.4
Pig manure	250	15	550	0.7
Goat manure	20	8	80	0.2
Chicken manure	65	15	220	1.5
Cow manure	65	20	155	0.5

Atmosphere – Metal concentrations can be high near industrial activities such as smelting, casting, or major roads. In most other agricultural regions the amount added to the soil from the atmosphere is minimal.

Miscellaneous – Farm rubbish tips and discarded metallic objects such as galvanised iron may be a source of metals.



Why are metals a problem in agricultural soils and crops?

Metals are elements and as such they do not breakdown but rather persist in the environment essentially forever. Therefore, even if only a small amount of a metal is added each year to a soil its concentration will slowly increase over time. The only natural way that the total concentrations of a metal can decrease over time is physical removal from a site by processes such as erosion and leaching.

Plants accumulate many metals and nutrients from soils. As the concentrations of metals in soils increases, the uptake of metals into plants also generally increases.

Surveys have shown that the levels of metals, particularly cadmium, in some crops have approached safe food limits. Therefore, it is important to minimise cadmium uptake by plants to protect human health.

How do plants take up metals? What factors control this uptake?

The potential paths of metal uptake by plants are shown in Figure 1.

- Plants mainly absorb metals from the soil through their roots.
- Metals present in crops can also come from soil or dust present on the surface of the crops.
- Many metals readily attach to clay particles and organic matter in soil, making them less available for uptake by plants. Sandy soils with low clay content and organic matter are likely to result in a higher uptake than soils with high clay content and organic matter.
- Uptake of metals to plants decreases as soil pH increases, or as soils become more alkaline.
- Metals that have been added to soil tend to remain in the top 10 cms where they are available to plants. They can be removed by erosion or leaching from very sandy, acidic soils.
- Higher concentrations of chloride in the soil increases uptake by plants. This can occur through irrigation with saline water, in areas subject to dryland salinisation, or the intensive use of chloride based fertilisers.
- Uptake of metals varies considerably between different plant species and between varieties or cultivars (Figure 2).

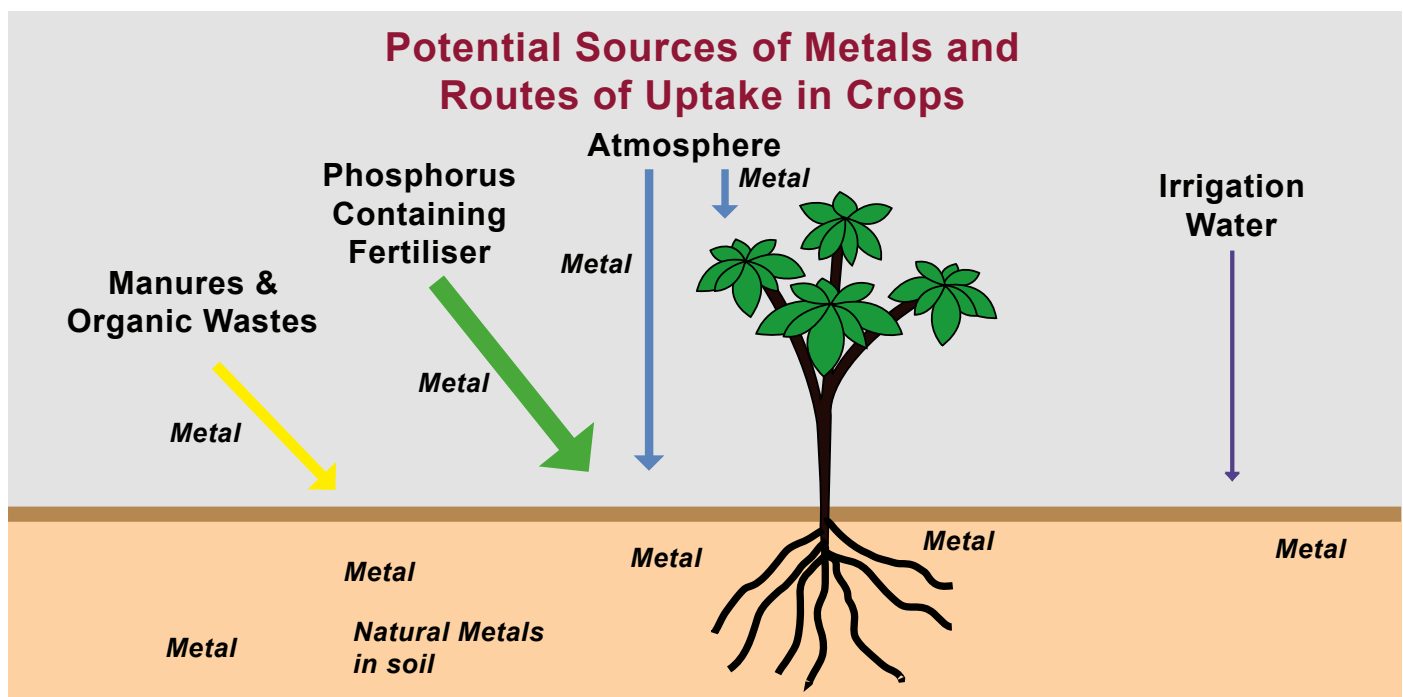


Figure 1. Potential pathways by which metals are taken up by plants.

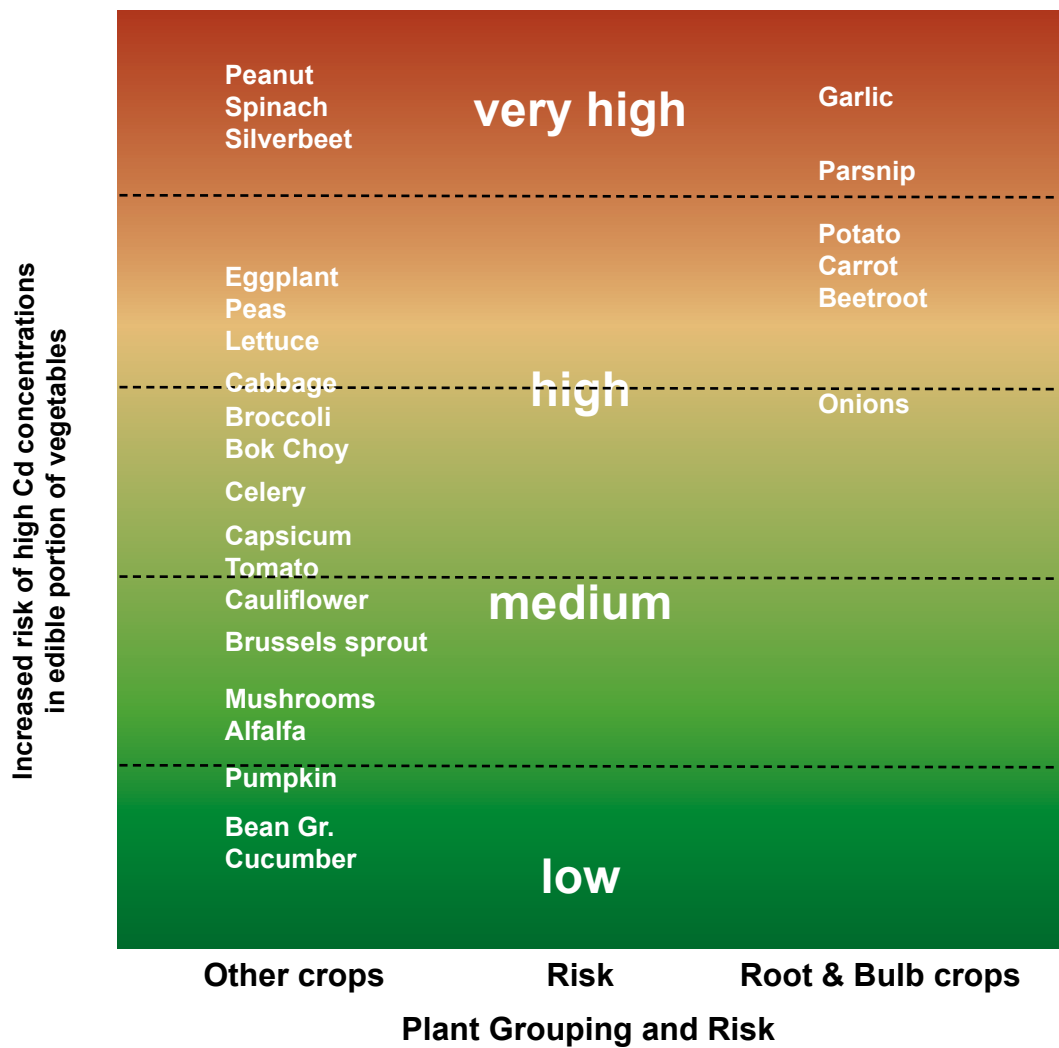


Figure 2. Diagram of the potential danger posed by various crop species when grown in cadmium contaminated soil.

What are the effects of excessive metal concentrations in soils?

The listed metals may cause two main types of problems if their concentrations in agricultural soil are too high:

1. decreasing plant germination, growth, and yields; decreasing the activity of beneficial soil microorganisms (eg. bacteria) and decreasing survival and reproduction of soil animals (eg. earthworms); and
2. reducing food quality for livestock and human consumption.

The first problem is mainly caused by cobalt, chromium, copper, mercury, nickel, lead, and

zinc. The second problem is mainly caused by cadmium and can also be caused by arsenic. These metals are unusual because the concentrations of cadmium and arsenic in plant tissues that causes toxic effects to humans is well below that which will harm plants. Whereas for the other metals, plants are affected at lower concentrations than humans. Thus, it is difficult for metals in crops (other than cadmium and arsenic) to cause human health issues and as a general statement, the more of these metals that are present in crops, the better it is for humans. This makes cadmium and arsenic a greater potential danger than the other metals listed above.

How to manage metal concentrations

There are several approaches to managing metal inputs and uptake in agriculture:

1. Reducing inputs to soil
2. Growing appropriate crops
3. Improving soil conditions
4. Deep tillage

Reducing inputs to soil

Anything that you add to the soil can increase the concentration of metals in the soil. The potential danger that additives pose depends on the concentrations of metal in the additive and the amount and frequency with which the additive is added to the soil. Table 2 shows the relative danger of adding various additives to soil due to their typical level of metal contamination.

You need to be aware of metal impurities in these products and should use those with the lowest concentrations of metals that still meet your crops nutrient needs.

Ensure you test your soil prior to adding any phosphorus containing product. Do not add excessive phosphorus, in whatever form, to the soil because you will:

- add too much cadmium to your soil and cause future contamination problems; and
- waste your money if you add phosphorus in excess of your crop's needs.



Table 2. The relative danger posed by adding different additives to agricultural soils.

Types of soil additives	Relative danger of adding
Industrial wastes; canal sediments; aquaculture wastes; single superphosphate, trace element fertilisers and phosphogypsum with high cadmium concentrations	High
Sewage sludge with industrial inputs, other fertilisers	Medium
Animal manures (not from intensive feedlots), sewage sludge, nitrogen and potassium fertilisers, clean organic matter, and composts	Low

Growing appropriate crops

If metal concentrations in your soil are lower than the investigation levels presented in Table 3, then they are unlikely to have been contaminated by metals and therefore you should not experience any problems growing crops. If however, the concentrations of metals in your soil exceeds the investigation levels in Table 3, then your soil may have had additional metals added to it and it could be approaching the concentrations that cause harmful effects on some crops (such as a reduction in yield). In such cases, it is recommended that you should discuss your situation with your local Ministry of Agriculture and Rural Development staff. If the total metal concentrations in your soil are greater than the maximum acceptable concentrations for any of the metals presented in Table 3, then you should not be growing crops on

the soil. You should immediately contact your local Ministry of Agriculture staff.

The uptake of cadmium varies considerably between different plants with some taking up much more than others even at the same soil concentrations. If you are growing crops which have a medium to very high uptake (Figure 2) and you exceed the investigation level (Table 3), then there is the potential for your crops to contain cadmium at concentrations that may not be suitable for humans. Again, consulting with your local Ministry of Agriculture and Rural Development staff is advised under these circumstances.

Table 3. Investigation levels and the maximum acceptable concentrations for arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn) in Vietnamese soils.

Measure	Total metal concentrations in soil (mg/kg dry weight)								
	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Zn
Investigation levels	44	0.3	27	145	56.8	0.17	69	43	110
Maximum acceptable concentrations		2			50			70	200



Improving soil conditions

Adding lime

High acidity (low pH) increases the toxicity of metals in soils. The addition of lime to acid soils (pH less than 7) will greatly reduce the release of cadmium and other metals from soil and therefore reduce the uptake by plants and animals. However, the benefit of decreased metal uptake needs to be weighed against both the cost of liming and the profitability of your farm. Please note that lime will have to be re-applied as its effect decreases over time and the pH will start to decrease.

Approximate amounts of high quality agricultural lime needed to raise soil pH by one unit in the top 15 cm of soil are:

Sand	1.5 - 3 tonnes of lime/ha
Loam	3 - 4.5 tonnes of lime/ha
Clay	4.5 - 6 tonnes of lime/ha

For best results, use finely ground, high quality lime and incorporate it into the soil.

Increasing organic matter content

Maintain or increase soil organic matter, which reduces the uptake of metals to plants. This will result in plants with lower concentrations of metals. If you do this by importing compost or other off-farm organic material, use only material with low cadmium concentrations.

Adding clay

In sandy soils, the practice of clay spreading should help decrease metal uptake by plants, especially if the clay is alkaline.

Using deep tillage

Using deep tillage effectively increases the mass of soil to which the soil additive is being added and this decreases the concentrations of added metals. For example, tilling to 20 cm depth rather than 10 cm should halve the concentrations of any added metals.

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