Organic Waste Products

THE ROLE OF ORGANIC WASTE PRODUCTS in micronutrient input

Organic waste products provide different trace elements (iron, zinc, molybdenum, copper, boron and manganese) in varying quantities and proportions depending on their origin and the way they may be processed.

Organic waste products are generally used to enrich soils with organic matter and/or to fertilise them. They also provide trace elements, but to what extent?

In addition to organic matter, organic waste products provide fertilising elements such as nitrogen, phosphorus and potassium, other macro-elements such as sulphur, calcium and magnesium, as well as trace elements: iron, zinc, molybdenum, copper, boron and manganese.
However, the latter are rarely analysed in waste products. Data focusses on trace metals that are regulated for sludge and compost. Trace metals include copper, zinc and molybdenum; the information available therefore mainly relates to the latter three elements.

What organic waste products supply

The trace elements contained in organic waste products and their quantity can vary tremendously from one case to another, with concentration levels that can go from double to ten times higher than the lower ones. This variability is due to a number of factors, including the origin of the organic waste products (urban, industrial or agricultural) and the possible processing they may have undergone.
Studies like ESCO MAFOR 2014[(1)] have helped to gather data on their composition. Some laboratories, such as Auréa[(2)], have also extracted

from their analyses the quantities of trace elements present by type of organic waste product.

In France, organic waste products from animal origin currently contain the highest levels of trace elements. However, there are very significant variations within this group of organic waste products. Content levels depend more on the livestock farming system than on the product itself: the type of animal, its stage of development, its diet, the absence or presence and type of litter, the way the dung is treated to generate co-products, and when it is used (fresh or after storage) all have an impact.

The animals' diet is probably the most significant variability factor. Copper and zinc, heavily used to supplement the diet of cattle, pigs and poultry, as well as in veterinary products, are found in large quantities in dung and therefore in organic waste products, since 80-90% of trace elements are not digested by the animals.

There are no regulations limiting the amount of copper or zinc contained in manure spread on land. Bibliographical data shows that concentrations are often higher than the figures mentioned by the NFU44-051 standard pertaining to the sale of organic enrichment products, but comply with the stipulations of the 08/01/98 decree, which set the applicable technical requirements for sludge spreading on agricultural land.

Processing produces new organic waste products

The utilisation and processing methods result in the production of new organic waste products, with new compositions. For instance, if phase separation occurs, copper, zinc, manganese and iron are mainly found in the solid phase. In the case of digestates, most of the mineral elements contained in the materials fed into the digester (including trace elements) are retained, without significant losses – except for manganese, which can form precipitates in a digester (struvite). During anaerobic digestion, after carbon matter has been lost in the form of biogas, the mineral elements tend to concentrate. However, analyses show that concentrations remain below regulatory thresholds. The only exceptions are some pig manures, that may result in excess copper and zinc concentrations when spread.

For composts, available data shows great variability due to the difficulty of sampling a solid product, but also to the very varied source materials, that are often used in combination. In recent years, there has been an improvement in the quality of urban composts. French waste treatment facilities currently produce composts that meet the quality criteria set by the NFU44-051 standard (see insert).

In sludge, trace metal concentrations are comparable regardless of the pre-spreading process used (anaerobic digestion, composting, drying). Since 1993, there has been a slight decrease in zinc and stable copper levels. Very little information is available on biochars, charcoals resulting from the pyrolysis of different types of organic matter. Ash composition varies greatly depending on the materials incinerated and the type and temperature of incineration; generally, ash tends to contain a significant concentration of trace metals.

Are the trace elements that have been applied available for crops?

Organic waste product analyses show trace element concentrations that probably cannot be fully taken up by plants. Their bioavailability depends on the form in which an element is present, its mobility in the soil, as well as soil-related factors.

The trace metals present may be water-soluble, exchangeable, linked to the organic matter, part of a co-precipitate with oxides, carbonates or phosphates, or are part of the crystalline structure of the minerals present in the product's composition. The first three forms are those most readily available to the plant.

The distribution of these different forms depends on the soil's properties: its pH, its cation exchange capacity and its organic matter content. However, those three parameters can change gradually, including as a result of organic waste product applications. The availability of a trace element therefore depends on the quantities applied and the effects of the organic waste product on soil properties. As a result, it is very difficult to predict the availability of trace elements brought to the soil by organic waste products.

The ISARD project[3] studied the availability of copper from various composts (household waste, pig slurry and manure) and sludge. It shows the presence of copper, either associated with organic materials or in a soluble form (Cu^{2+}), in different proportions depending on the organic waste product. It is more available in its soluble form than in its associated form, and it seems to be more available when the carbon in the organic waste product is rapidly mineralised.

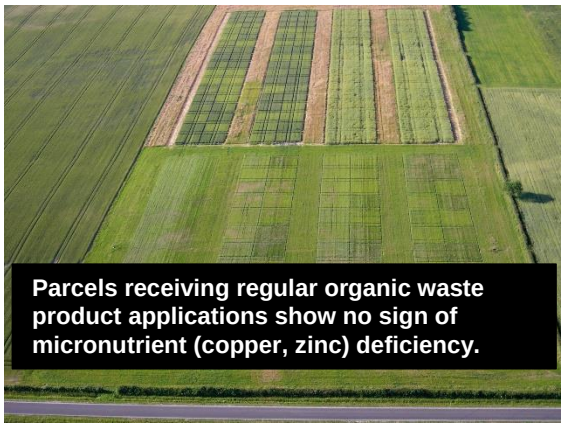
Generally, there is no sign of any deficiency in fields receiving organic waste product applications. This indicates sufficient availability from inputs to meet crop needs. Conversely, trace metals are not very mobile in the soil, and the ground becomes a storage tank. Excessive accumulation can lead to a risk of toxicity.

Long-term trials with organic waste product applications did not show any sign of accumulation leading to toxicity from trace metals such as copper.

Long-term trials confirm the value of organic waste products input

The best resource to monitor the effect of organic waste products on micronutrient accumulation and bioavailability in the field is long-term trials. Twelve-month trials are too short to study this effect.

At Jeux-les-Bois (central France), Arvalis and a group of *Chambre d'Agriculture* of that region conducted a trial in sandy silty soil with 12% clay. After nine years of annual inputs of raw or composted cattle, pig or poultry manure, it showed increases in bioavailable copper, boron and zinc (extraction using the EDTA method), with levels well below toxicity thresholds.



Parcels receiving regular organic waste product applications show no sign of micronutrient (copper, zinc) deficiency.

A CASDAR-ADEME project entitled "Trace metals in the Pig Sector in Southwestern France", carried out over 15 farms that had been receiving pig manure for many years, was completed in 2010. It showed a significant overall accumulation of copper in the soil. Nevertheless, with the quantities applied (30 m^3/ha/year), it would take, in the worst-case scenario, two centuries to reach the maximum copper level allowed for sewage treatment plant sludge, beyond which no organic waste products can be applied. No significant accumulation of zinc was found.

After 20 years of compost applications as part of the Qualiagro (INRA-Véolia collaboration) trial in the Versailles plain near Paris, INRA is seeing significant increases in the total amounts of copper and zinc in the soil layers in which the organic waste products were incorporated. However, in this trial, focussing mainly on the study of carbon storage in the soil, organic waste products are being applied at rates about 1.5 times higher than those recommended for fertilisation. A proportional estimate calculated on the basis of usual application rates shows that there is no risk associated with copper or zinc accumulation, even by 2100.

Trace metal concentration levels in sludge are not significantly affected by the pre-spreading treatment process.

Finally, the Rothamsted (England) trial, where composts and livestock effluent have been applied for 140 years, shows increases in total copper and zinc levels in the soil. However, they remain moderate with just under twice the amount after a very long period of time (110-140 years).

On the whole, the few long-term field experiments measuring trace metals in the soil show that organic waste product applications carried out as part of a balanced fertilisation programme and that comply with regulatory requirements, increase levels, especially in copper and zinc. However, there is no risk of toxicity when applying normal amounts of organic product.

(1) Collective Scientific Investigation in the utilisation of fertilising materials derived from waste. See also: http://institut.inra.fr/Missions/Eclairer-les-decisions/Expertises/Toutes-les-actualites/Expertise-Mafor-effluents-boues-et-dechets-organiques.
(2) Auréa Agri-Environmental Analysis and Consulting Laboratory.
(3) The ISARD project (Ecological Intensification of Agricultural Production Systems through Waste Recycling) is funded by the National Research Agency and implemented by INRA.

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