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The benefits of Copper-containing sewage sludge

What is sewage sludge?

Sewage sludge is the solid residue that remains after municipal and industrial wastewaters have been treated in sewage treatment plants.

What is sewage sludge currently used for?

Sewage sludge is managed in primarily 3 ways: land application, dumping and incineration. The European Commission is currently preparing measures to improve sewage sludge management in Europe and to increase the recycling rates of nutrient (phosphorous and nitrogen) and organic matter contained therein. These measures are intended to encourage the recycling of good quality sludge as a sustainable solution to the problem of nutrient deficiency in arable soils..

What factors influence copper levels in sewage sludge?

Copper levels in sewage sludge mainly depend on the sources of copper entering the sewage treatment plant, the characteristics of the public water supply and the efficiency of the sludge treatment process.

- Broadly, the major sources of copper in a sewage treatment plant fall into three categories:
  - industrial and commercial premises,
  - stormwater and surface run-off, including releases from vehicle brake-pads
  - domestic sources, including releases from plumbing materials, detergents, food residues and faeces.

- The composition and quality of the public water supply has a major influence on the amount of copper released from plumbing materials. In accordance with the EU Drinking Water Directive, waters intended for human consumption should not be aggressive. Waters with a pH above 7.5 and alkalinity between 30 and 150 mg $CaCO_3$/L are the least cuprosolvent (Le. liable to dissolve copper).

- Sewage treatment processes effectively remove a substantial proportion of the copper contained in wastewater. Treated water that is released into receiving surface waters typically contains 5 to 30% of the copper contained in the water originally entering the plant. The major proportion of copper is retained within the sludge.

- Variability in sludge treatment practices automatically entail variability in sewage sludge copper concentrations, when expressed per dry matter sludge. For example, anaerobic (oxygen-free) digestion of sludge will, in most cases, reduce its content of organic matter and hence dry weight by 30 to 50%. This process automatically entails an increase in the sludge's dry weight based copper concentration (not removed by this anaerobic digestion process).This is true for ail metals but also for stable macro-nutrient, such as phosphorous and nitrogen. It is therefore recommended to express copper levels in relation to a stable macro-nutrient, such as phosphorous (mg Cu/kg P).

This recommendation was taken on board by the Commission in its Third Draft Working Document on the Revision to the Sewage Sludge Directive where sludge limit values are expressed as mg metal/kg sludge dry matter or mg metal/ kg P.

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Can the copper in sewage sludge help re-balance the copper-deficiency in soils?

Copper deficiency in agricultural soils is a widespread phenomenon. According to a recent Swedish study[1], approximately 19% of Western Europe's arable land have some form of copper deficiency. The World Health Organisation's International Programme on Chemical Safety[2] also notes that a variety of soil types are deficient in copper for normal crop growth. Copper is therefore intentionally added in the form of fertilisers and manure to amend agricultural soil. In Sweden for example, 34 tonnes of copper are applied to agricultural land, as fertiliser to correct copper deficiency, compared to the 28 tonnes of copper that are, applied in sewage sludge. The use of less bioavailable matrices, such as sewage sludge, manure or compost, may have the advantage of allowing for the slow, gradual release of the necessary copper ions into the soils and crops, compared to providing the soils with shock doses of highly bioavailable copper applied in the form of fertilisers.

Can the application of copper-containing sludge to soil have undesirable affects on crops, animals or humans?

Copper is an essential nutrient for ail living organisms but, as for ail nutrients, exposures to elevated levels can cause toxicity. In a literature review', it was demonstrated that in the various studies where copper containing sewage sludge has been applied to agricultural [and, no reduction in crop yields or any adverse phytotoxic effects have ever been demonstrated, even after long-term applications of very high quantities of copper. Additionally, there are no indications in any published study that copper concentrations in crops, grown with sludge-amended soil, constitute any health risk to humans or animals.

Does copper accumulate in soils - is there such a thing as a "sustainable loading"?

It is recognised that excessively elevated loading levels to soils may cause increases in their copper concentrations. However, it is also important to recognise that for "intensive agricultural practices", small increases in copper levels in soils are often needed to cope against copper deficiency. Therefore, what is important is to avoid the accumulation of copper in soils to levels that may potentially pose future harm to crop cultivation animals or ecosystem functioning.
A literature review[1] revealed that repeated sludge application at 3-4 kg Cu/ha/year is sustainable for agricultural soils. This loading does not have any adverse effects on crops, animals, humans, or ecosystem functions and will not cause continuous unacceptable accumulations of copper in soils. The normal sludge application to arable soils of 3 tonnes dry matter/ha/yr, suggested as limit value in the Third Draft Working Document on the Revision to the Sewage Sludge Directive, corresponds to a copper concentration of 1000 mg Cu/kg dry matter sludge, or 3 kg Cu/ha/year. Values routinely measured in municipal sewage sludge are normally below this concentration. The short and long term target values additionally proposed in the Draft Directive are unnecessarily over-protective.

How does copper age in soils? Is it re-mineralised?

The absence of substantial accumulation in soil - even in the case of repeated applications over a long period of time - can be explained by the natural uptake of this essential trace motel into crops, by erosion of soli surface layers and by the binding of copper in the sub-soils through natural "ageing" mechanisms. During ageing, metals are first bound in the organic fraction of the soil matrix and are subsequently, slowly "re-mineralised" and integrated into the crystal lattices of soil minerals. The metal becomes irreversibly bound and inaccessible for uptake by biota in such a situation, comparable to the original state of the metal in its natural ore.

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What are the sources for copper in the environment?

Metals are a component of the earth's crust. Copper is naturally present in any expanse of water and sediment, in ail soils and in the air (e.g. through volcanic eruptions). In addition, copper enters the environment through a number of anthropogenic sources (Le. related to human activity), and amongst others, through the application of sewage sludge on soils. It has been estimated that the overall amount of copper, annually discharged via rivers to the world's oceans as a result of natural processes, is about four times greater than the total man-made releases.

1 “Copper in Sewage Sludge and Soil” A literature review and critical discussion of disposal of copper-containing sludges to agricultural land. -Swedish Environment Research Group (SERG), Published July 2000.

2 Environmental Health Criteria 2000 “Copper”, International Programme on Chemical Safety, World Health Organisation (WHO), Published 1998.