

# Hazard assessment of heavy metals in sewage sludge

## Bengt Fjällborg

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### ABSTRACT

The aim of this thesis, which is based on six papers (I-VI), was to determine the bioavailability and toxicity of metals in sewage sludge and sludge products and thereby to assess the hazard of using sludge as a fertilizer. Toxicity of fresh sludge or sludge products was studied with growth tests performed with *Avena sativa* (II), *Lactuca sativa* (II), *Raphanus sativus* (II) and *Triticum aestivum* (IV and V). Uptake of metals in plants (wheat meal) was studied with *Triticum aestivum* (IV). The toxicity of sludge leachates was determined for *Daphnia magna* (I-V), *Lemna minor* (I and II) seeds of *Lactuca sativa* (IV and V), seeds of *Raphanus sativus* (I) and seeds of *Triticum aestivum* (IV).

Ammonia toxicity masked other possible toxicants in leachates from fresh sludge. Leachate toxicity, which is dominated by ammonia and metals, is affected by ambient factors like pH, divalent cat ions (Ca and Fe), organic and particulate matter and redox conditions. Total concentrations of metals in sludge leachates are often much higher than those which are toxic in pure water, but the toxicity of the metals are often reduced by ambient factors. A field test with sludge from 12 sewage treatment plants showed that only 2 were acceptable as fertilizers based on effects on wheat, *Daphnia* and lettuce seeds. Sludges from larger treatment plants were better fertilizers. A pilot study showed that pelletized and dried sludge was more toxic than digested sludge, but incinerated sludge could probably be used as a fertilizer under controlled conditions. Leachate metal concentrations and toxicity were affected by weathering and time, which means that climate and season are important. Two of the heavy metals (Cu and Zn) are of major concern in the assessment of hazards in sewage sludge, but both of them are also essential, and their bioavailability is highly dependent upon the ambient factors mentioned above. Also Al and Fe may be of importance, regarding toxicity, in some sludges. Because of the complicated speciation of metals and the hazards associated with so far unknown interactions and the presence of other compounds, it is recommended that bioassays should be used to assess the quality of sewage sludges before they are used in agriculture.

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*Keywords:* *Avena*, bioassays, *Daphnia*, growth test, *Lactuca*, *Lemna*, metal, *Raphanus*, seed test, sewage sludge, sustainable, TIE, toxic unit, *Triticum*