A case study on chemical mixtures in sewage sludge: Chemical composition and toxicity in the environment

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Introduction

- Sewage sludge is used in agriculture as soil improvement and fertilizer, as it contain high amounts of plant nutrients.
- However, sewage sludge also contains a mixture of chemicals and heavy metals and the composition is dependent on the sources contributing to the wastewater.
- Thus, when used in agriculture, sludge can be an important “entry point” for contaminants to the environment.
- Many of the chemicals that are concentrated in sludge are those considered to be persistent and hydrophobic – i.e., highest concern chemicals such as PBT chemicals (Persistent, Bioaccumulative and Toxic).
- Heavy-metals and organic chemicals in sludge are regulated based on Council Directive 86/278/EEC and in Denmark the Statutory Order on sludge (BEK No 1650 of 13/12/2006).
- Regulation set limit values for 4 groups of organic chemicals, and do not take mixture toxicity in to account.

Application of solid sludge on the field (http://www.susana.org/)

Objective

The overall objectives are:

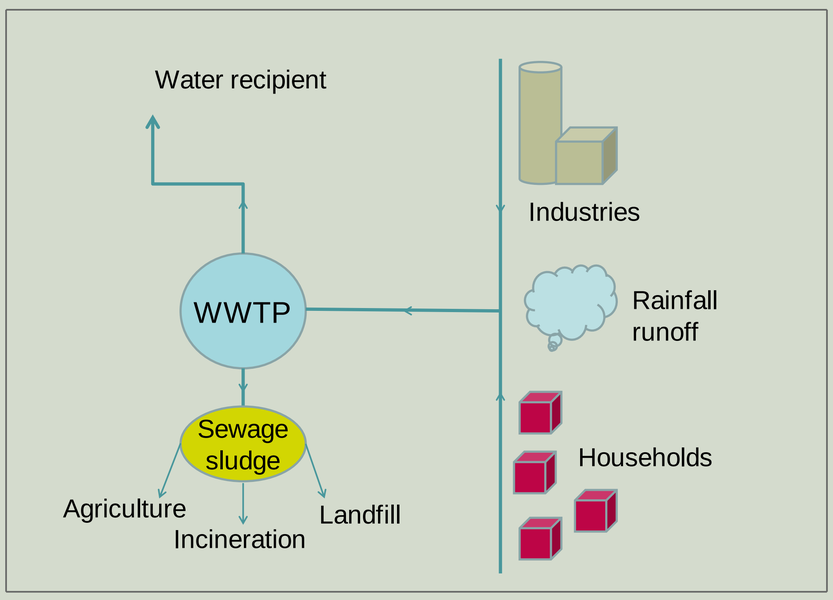
1. To assess how to identify and **choose chemicals for specific mixture toxicity assessment** by using a case study.
2. To **investigate the mixture toxicity of a chemical mixture** that resembles a generic sewage sludge used in agriculture, to terrestrial organisms directly exposed to sewage sludge via experimental work.

By combining the case study and the results from the experimental work data can be used to extrapolate to other cases in a broader context.

Case study

Aim at examining the composition of chemicals present in sewage sludge. The composition depends on a wide range of parameters. The case will be described according to some of these:

- **The type of catchment area of the Waste Water Treatment Plant (WWTP)**. Estimation of the chemical composition in sewage sludge.
- **The environmental fate of the chemicals** after application to the field. This information is crucial for determining which organisms may be exposed to the chemical mixtures and from which exposure pathway: air, water, sediment/food.
- **Type of WWTP**, provide information on treatment efficiency, and contributes to the estimation of the chemical composition of sludge.
- **Data on chemical composition in the sludge and in the catchment** (water, sediment).



Schematic diagram showing the route of organic chemicals discharged in households, industries and from rainfall runoff to agriculture as a recipient

Experimental work

Aim at investigating mixture effects of the chemical mixture in a specific sewage sludge used in agriculture. The choice of organism, test, endpoints and chemical mixture will be based on the literature and the different parameters described in the case.
Preliminary selections of organism, test, endpoint and chemical mixture:

Test organism *Eisenia fetida* and *Folsomia candida.*

Test and endpoint. *F. candida:* Reproduction test in soil.
E. fetida: Effects on growth after 4 weeks of exposure.

Chemicals mixture Will be based on knowledge of chemical composition in sludge from other studies, environmental persistence, bioaccumulation and ecotoxicity. A mixture consisting of 5-6 chemicals will be used e.g:

Phthalates, brominated flame retardants, perfluorochemicals (viz. PFOS and PFOA), polychlorinated alkanes and pharmaceuticals.

Eisenia fetida

Folsomia candida

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Abstract

Sewage sludge is a residual product from the cleaning of wastewater. It contains high amounts of nutrients and is thus used as fertilizer in agriculture. In addition, sludge contains a mixture of chemicals and heavy metals. The composition of sewage sludge is entirely dependent on the sources contributing to wastewater. REACH is likely to have a major influence on the quality and composition of sewage sludge, because REACH regulates the industrial chemicals used in households and industry. The use of sewage sludge is regulated based on Council Directive 86/278/EEC and in Denmark the Statutory Order on sludge (BEK No 1650 of 13/12/2006). These regulations set limit values of chemicals and heavy metals to protect humans and the environment. However, only a limited number of chemicals are regulated. According to establish regulation on mixture toxicity, an important knowledge gap regards the composition of real life mixtures in the environment, and their potential effects on different organisms. This study aims at addressing this knowledge gap in a case based study. The considerations behind selection of a case and the chemicals for mixture risk assessment are of great importance as these will serve as input to make generalizations regarding other cases and to outline procedures for selection of chemicals for mixture risk assessment. This presentation will outline and discuss the selection approach including considerations in regard to those paths that are pursued and those that are not. The parameters discussed include: type of catchment area of the waste water treatment plant, availability of data on chemical composition in sludge and in catchment, and environmental fate of chemicals in the sludge after application to the field. Chemical properties (e.g., hydrophobicity and solubility) will be a determining factor for the fate of the chemicals, and will, as such, provide important information on target compartments (air, water, sediment, soil). This information is crucial for determining which organism may be exposed to a specific chemical mixture and from which exposure pathway. From the case it will be possible to select a relevant mixture and investigate the possible toxicity of the mixture on a chosen organism. We will show how the case can serve as an exemplary case, a case that can be used to extrapolate to other cases in a broader context. This gives a strong foundation for the discussion of implementation of mixture toxicity in European regulation.

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