Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

Risk assessment of organic chemical contaminants in sewage sludge

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Sustainable circular economy – prevent transfer of contaminants from waste resources to fertiliser

Sewage sludge, a valuable resource, contain known and unknown chemicals with a potential environmental, animal and human hazardous treat.

Many present in mg/kg dw levels (Table 1).

Distribution of sewage sludge to:
- agricultural land
- park areas
- commercial soil (sludge mixed with soil) for private household

Risk assessment is required to ensure sustainable reuse of waste resources as fertiliser to prevent transfer of contaminants to environment, food and forage.

VKM has performed a risk assessment of sewage sludge (2009). In addition to metals and selected legacy organic contaminants it included pharmaceuticals.

Risk assessment of environmental contaminants in sludge require information about:

- Chemical properties
- Sources
- Persistence
- Environmental fate processes
- Exposure concentrations in food, drinking water, forage
- Toxicity and health effects

Compounds	Sewage sludge [mg/kg dw]
Azithromycin*	(0.081-0.85) 0.36[1]
Ciprofloxacin*	(1.78-16.0) avg 6.5[1]
Ofloxacin*	(0.15-3.2) avg 0.69[1]/avg 7.8[2]
Tetracycline*	(0.044-0.97) avg 0.24[1]
Atenolol	(0.00-1.65)[3]
Metoprolol	(0.015-0.549) [3]
Hydrochloro-thiazide	(0.00-1.686) [3]
Metformin	(0.149-7.8) [3]
Galaxolide	Avg: 15.6[4]
Tonalide	Avg: 2.32[4]
Triclosan	(0.6-46.4), avg (0.63-38.6)[5]
Deca-BDE (BDE-209)	(0.54-2.8), avg 1.83[6]

[1]Guerra et al. 2014; [2]Huber et al. 2013; [3]Jia et al. 2012; [4]Kupper et al. 2006; [5]HCEC 2012; [6]Norsk Vann report 2013.

*Table 1. Examples of organic contaminants measured in sewage sludge (min-max) average. * antibiotics*

Predicting fate and transfer of contaminants to sludge is an essential step in risk assessment.

A major number of pharmaceuticals and REACH chemicals are ionisable. Models for predicting fate and transfer to sewage sludge for ionisable chemicals have been missing but under development.

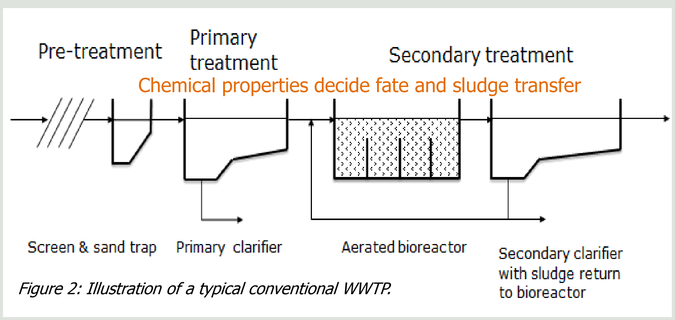


Figure 2: Illustration of a typical conventional WWTP.

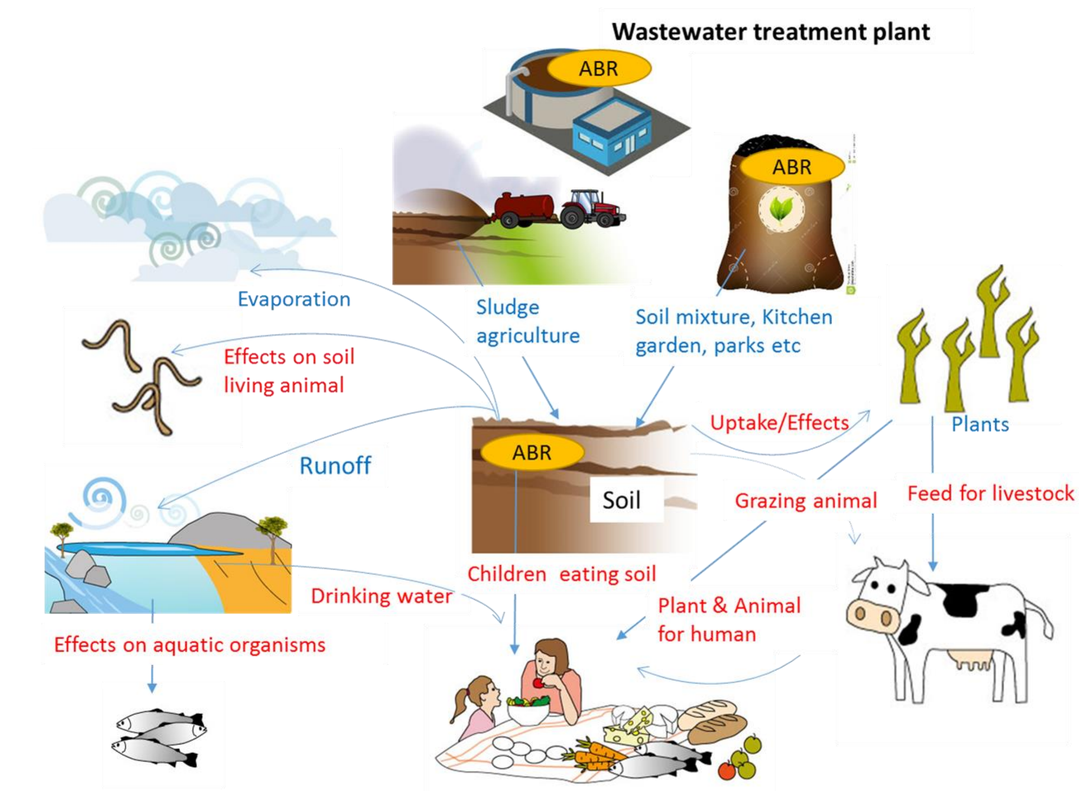


Figure 1: Overview of the 12 exposure routes assessed in Norwegian risk assessment after use of sewage sludge as soil conditioner (VKM 2008). Development and spread of antibacterial (drug) resistance (ABR) is marked; include also spread of residues of antibacterial drugs .

Prioritising of pharmaceuticals

VKM established a Tier approach for predicting pharmaceuticals in sludge in order to prioritise the most important substances.

Estimated transfer to sewage sludge were based on pharmacokinetic studies.

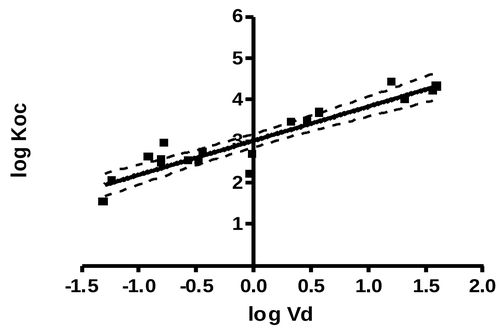
- Based on experimental data a relationship between log K_{ow} and log V_D for 18 drugs (r^2=0.86) was used to estimate transfer of pharmaceuticals to sewage sludge.

- Log K_{oc} = 3.01+0.821*log V_D

Where:

K_{oc} = distribution coefficient of a drug substance between sludge and water

V_D = volume of distribution at equilibrium in the human body (the apparent volume into which a drug distribute in the body at equilibrium.



What is a risk assessement?

- Identify the hazard(s)
- Describe the hazard(s)
- Evaluate the exposure of the hazard(s)
- Describe the risk - evaluate exposure related to effect

Sewage sludge and antimicrobial resistance

According to WHO, antimicrobial resistance is an increasingly serious threat to global public health that requires action across all government sectors and society.

Sewage sludge contains antimicrobials, antimicrobial-resistant bacteria and antimicrobial resistance genes, which can be released into the environment through its land application. This contributes to further development and dissemination of antimicrobial resistance.

Risk assessment of antimicrobial resistance for the human and environmental health, and ecosystem service is needed.

Tier approach for prioritising pharmaceuticals

Exclusion due to relevance →595 → Calc.PEC_{sludge} Applied Cut-Off values →209 → Recal. for transfer to sludge, PEC_{sludge} Appl. Cut-Off values →142 → Recalc. for *in vivo* metabolism PEC_{sludge} Appl. Cut-Off values →22 → Evaluating degr. and removal in WWTP →14

Total number of active substances approved in human and veterinary medicinal products in Norway 1414 (2008). Cut-off value used was 587 µg/kg dry weight (dw) in sludge – corresponding to 100 µg/kg dw in soil. For anticancer drugs, some hormones and antibacterial drugs cut-off value 10 times lower; 59 µg/kg dw in sludge, was used.

Identified lack of knowledge related to contaminants in sewage sludge used as fertilizers and soil conditioners[8,9]

Establishing a guideline for food safety risk assessments of contaminants in organic fertilizers and soil conditioner.

Models for predicting environmental fate and transfer of chemicals from sewage sludge to the food chain.

Methods for risk assessment of combined exposures of chemicals.

Sludge
- Data on presence and concentration of contaminants

Fate processes
- Degradation kinetics under different environmental conditions (temp., redox etc)
- Distribution- and partition coefficients, bioaccumulation data

Plant uptake
- Improvement and evaluation of existing models
- Absorption and translocation of polar and ionisable organic contaminants in plants
- Experimental data for uptake of surface active organic substances
- Plant specific differences in uptake rates

Toxicity
- Predicted No Effect Concentration, PNEC, values for organisms in soil and aquatic environment
- Cocktail effect

Food production animals
- Potential exposure through plant consumption

Humans
- Presence and concentrations in products
- Data on what we eat, how much, and how often

[8] Eriksen, G. S., Amundsen, C.E., Bernhoft, A., Eggen, T., Grave, K., Halling-Sørensen, B., Källqvist, T., Sogn,T., Sverdrup, L. . The Norwegian Scientific Committee for Food Safety (VKM). Risk assessment of contaminants in sewage sludge applied on Norwegian soils. (Oslo, 20 August, 2009)
[9] Research needs and data gaps of importance for food safety and protection of biodiversity. From VKM's scientific opinions in the period 2005 – 2015. VKM report 2016:48.

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