



Safety aspects of recycled fertilizer products

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Acknowledgements

- Two projects...
 - Product development of material flows in biogas processes (BIOVIRTA)
 - Safe fertilizer products from biogas plants (BIOSAFE)
- ...focusing on safety aspects of biogas plant digestate
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Safety aspects

- Phytotoxicity
- Pathogens
- Hazardous organic chemicals
- (Hazardous metals)

Wastes are remarkable source of nutrients'

- Nutrients in Finnish food chain wastes

	Phosphorus t/a	Nitrogen t/a
Manure from agriculture	17 300	100 000
Food industry by-products	6 400	30 800
Municipal biowaste	700	6 000
Municipal sewage sludge	2 800	4 700



- Different technologies are available for utilizing these nutrient resources
 - Biogas process turns organic material into biogas and digestate, while preserving nutrients and improving nitrogen availability to plants



Pathogens and phytotoxicity

Materials for pathogen and phytotoxicity studies



- Three centralized co-digestion plants were sampled for pathogenic microbes and phytotoxicity survey
 - Samples from liquid digestate and from solid and liquid fraction after separation
- Raw materials at biogas plants were mixes of
 - pig manure, biodegradable industrial by-products, municipal and industrial sewage sludges, source-sorted and separately collected organic fraction of municipal solid waste

Results: pathogens

- Salmonella were regularly found in the substrates of biogas plants, but not in digestate
 - Mesophilic process alone is not sufficient to guarantee hygienization
 - Pasteurisation (70°C 60 min) was sufficient treatment
- Pasteurisation efficiently reduced the amount of indicator bacteria, except spore-forming bacteria
 - Digestates' quality complied with legal requirements
 - Spore forming bacteria are common in the environment → are they really problem in digestates?
 - Heat drying process inactivated also growth of heat tolerant spore-forming bacteria
- In order to ensure high quality of the products the following should be considered
 - choice of substrates
 - efficient pre-treatment (e.g. particle size)
 - optimisation of the digestion process (esp. temperature and time)
 - prevention of bypass and cross-contamination

Methods: phytotoxicity

- The test methods are usually originally meant for sludge, compost or growth medium, but can be applied for digestates
- Test methods used
 - Plant growth test (EN 16086-1, 2011)
 - Barley and Chinese cabbage as test plants
 - Germination tests (EN 16086-2, 2011)
 - Cress seeds
 - (Acute toxicity with Kinetic luminescent bacteria test (ISO 21338, 2010))

Results: phytotoxicity

- Digestates did not unfold significant phytotoxic effects when rates were applied to satisfy the nutrient demand of the crop
 - Manure unfold more phytotoxicity than digestates
- The germination rate and root growth of cress seeds were higher in peat amended with digestate than in peat fertilized with NPK.
- → Digestates seemed to offer additional advantages to plant growth that cannot be obtained by using mineral fertilizer alone
 - nutrient effects
 - organic material have positive effects on soil composition through stimulation of microbial activity and root growth

Results: phytotoxicity test methods

- Both plant assay methods were suitable tests to be used for evaluating digestate quality
 - The cress germination test on a Petri dish with its simplicity and sensitivity proved to be the most promising assay for routine quality monitoring of organic fertilizer products.
 - Chinese cabbage was more sensitive test plant than Barley in plant growth test
 - Suitable dilution substrate should be chosen carefully for each test

HOWEVER

- A number of factors, e.g. plant species, growth conditions, composition and electrical conductivity of the test material, and possible natural degradation products affect the results of plant tests → in order to interpret results in a reliable way, it is essential to understand the chemical and physical characteristics of the test and control materials
- In general, evaluation of the quality of organic fertilizer products requires several methods, both chemical and biological or the use of a test battery composed of several complementary assays in order to avoid false results.
 - New and improved tests are under development

Hazardous organic chemicals

Materials and methods: hazardous organic chemicals



- Eight centralized co-digestion plants (altogether ten production lines)
 - Digestate was sampled four times in 2010 and 2011
- Raw materials of biogas plants were mixes of
 - pig manure, biodegradable industrial by-products, municipal and industrial sewage sludges, municipal biowaste
- In our study, we
 - analysed chemical concentrations
 - estimated the load of organic pollutants to agricultural soil after a single addition (15 tonnes/ha) of biogas plant digestate
 - assessed the impact of organic pollutants in digestates on food safety

Compound groups studied

- Polychlorinated dibenzo-p-dioxins and furans (PCDD/F)
- Polychlorinated biphenyls (PCB)
- Brominated flame retardants
 - PBDE, TBBPA, HBCD
- Polycyclic aromatic hydrocarbons (PAH)
- Perfluorinated alkyl compounds (PFC)
- Linear alkyl benzene sulphonates (LAS)
- Nonylphenols (NP) and nonylphenol ethoxylates (NPEO)
- Bis(2-ethylhexyl) phthalate (DEHP)

AND

- 25 pharmaceuticals (only concentrations were analysed)

Results: hazardous organic chemicals

- Hazardous organic chemicals are regularly present in biogas plant digestate
 - Also forbidden compounds (penta-BDE, okta-BDE, NPEO, PFOS)
- No correlation was found between pollutant concentration in digestate and feed materials
- For most of the compounds, the calculated specific load (per ha) was similar to the atmospheric deposition
 - except PBDE was about 1000 times higher than the PBDE air deposition in Finland
- Based on this study, agricultural use of digestates is unlikely to cause immediate hazard to food safety from most of the compound groups studied
 - With PBDEs and PFASs, the impact of the use of digestates on food safety or on human health has not so far been comprehensively assessed.
- Pharmaceuticals were present both in sewage sludge and biowaste-based digestates
 - Veterinary medicine products were present in manure-based digestates

Conclusions

- Pathogens are regularly found in biogas plant substrates, but they can be efficiently inactivated in heat treatment unit of a biogas plant
- Plant bioassays showed that the digestates tested in concentrations used in field conditions promoted the growth of plant similarly to or even better than manure and mineral fertilizer → no significant phytotoxicity
- Biotests can be used together with the chemical analysis or as a test battery in the risk and quality assessment of recycled fertilizers, but the results should be interpreted carefully
- Hazardous organic chemicals and pharmaceuticals do exist in digestates produced from waste-based raw materials, but immediate hazard to the safety of foodstuffs has not been shown so far
 - However, efforts should be made to reduce the amount of harmful chemicals and pharmaceuticals in wastewater and organic wastes so that environmental chemical loading is reduced. Improved treatment methods for wastewater and wastes should also be developed and used.
 - Keep in mind that recycled fertilizers are only one of the various sources of pollutants to the environment!



Thank you!

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