The impacts on human health and environment arising from the spreading of sewage sludge to land (CR/2016/23)

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Project Summary

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1. Background

The recycling of treated sewage sludge to agricultural land has been an important part of Scotland's circular economy for many decades. Sewage sludges are a valuable source of nitrogen and phosphorus, organic matter, major and minor plant nutrients, and can provide long-term benefits to soil structure and fertility. As such, the recycling of sewage sludge to land is recognised as being the best practicable environmental option by the European Union (EU) and UK Government in most circumstances.

It has long been recognised that sewage sludge can contain agents that are potentially harmful to human and environmental health, including heavy metals and pathogens. Measures have been put in place to control against these risks (e.g. ADAS 2001). While these 'traditional' contaminants are well controlled, more recent concerns have been raised regarding 'emerging' issues such as the presence of

pharmaceuticals, ‘novel’ organic compounds, and (anti-microbial) resistance in sewage sludges. Similarly, while ‘traditional’ controls have focussed on potentially hazardous agents with potential to cause physical health outcomes, little has been done to safeguard against outcomes associated with well-being such as nuisance caused by odour and transportation operations.

To address these emerging issues, the Scottish Government Rural & Environmental Science and Analytical Services commissioned The James Hutton Institute along with RSK ADAS and AquaEnviro to undertake a contemporary health risk analysis incorporating both physical and social aspects of the risk profile of sewage sludge.

The scope was limited to human health and well-being outcomes associated with non-occupational exposures from the use of sewage sludge in agriculture in Scotland. The following activities were undertaken:

- A review of sewage sludge production and use in Scotland, including potential system controls (report; Section 2 below)
- A workshop with communities affected by the land-application of sewage sludge to understand more fully the social aspects of health and well-being outcomes associated with sewage sludge use in agriculture (report; Section 3 below)
- A review and associated in-situ field measurements to characterise and understand the odour generation potential of different sewage sludge products (report; Section 4 below)
- A (semi-)quantitative risk assessment to identify and assess a wide range of (emerging) potentially hazardous agents present in sewage sludge, with risk estimates for both physical and well-being outcomes (report; Section 5 below)

1.1. Headline findings

- Due to existing controls, the majority of ‘traditional’ hazards (heavy metals, pathogens) pose minimal risks to human health and well-being.
- The majority of ‘emerging’ hazards (59 hazards quantitatively assessed: primarily organic pollutants, pharmaceutical and personal care products,) also posed minimal risks to human health and well-being in most situations.
- There is no evidence that prions posed human health risks due to spread via sewage sludge
- Ten potentially harmful agents (nine organic and pharmaceuticals plus malodour) were identified as posing a potential risk to human health and well-being under ‘plausible worst case’ situations.
- The impact of malodour on well-being seems to heighten sensitivities and perceptions of risks associated with land-spreading practices (not limited to sewage sludge, but other malodourous practices too).

- Malodour from sewage sludge can be managed through reductions in the use of lime-treated sludge, as well as operational constraints such as avoiding spreading when wind speeds exceed 6 m s^{-1} and ensuring a buffer distance to the nearest residents.
- The nine organic and pharmaceutical agents can be partially controlled through sludge treatment processes such as anaerobic digestion and/or thermal hydrolysis (Table 5-1).
- Due to data/knowledge limitations, it was not possible to fully assess a number of potentially hazardous agents; including microplastics and all 'emerging' pathogens.
- A watching brief should be maintained to assess new information on the hazards included in this study, as well as to identify any further potential hazards as they emerge.

2. Sewage sludge production and controls

There are 32 Scottish Water and 21 public-private partnership (PPP) sewage sludge treatment sites in Scotland. The majority of sludge destined for agricultural use are produced by the PPP sites (~110,000 tonnes dry solids per year).

Regulatory controls for treatment are split between waste water (which must be sufficiently treated to reach standards that allow it to be discharged into surface waters without undue harm), and sewage sludge treatment (which must be sufficiently treated to reach standards that allow them to be used in thermal energy recovery (incineration) or land-based markets – principally agriculture). There is a conflict whereby (for example) approaches that encourage hazards to partition to sludges (thus improving the quality of the treated waste water) can impact negatively on the quality and usability of the sludges.

There are several best practices guidance for the production, transportation, handling, storage and application of sewage sludge. If adopted augment the regulatory controls, especially with regard to the control of odours and other nuisances.

Most sludges supplied for agricultural purposes have undergone advanced anaerobic digestion, have been thermally dried, or lime pasteurised. These processes are undertaken in order to meet the requirements of the Safe Sludge Matrix (ADAS, 2001). While the focus of these treatments is on pathogen reduction (advanced treatment looks to achieve a 6 log reduction in E. coli and zero Salmonella), these treatment processes can also affect concentrations of other potential hazardous agents including those highlighted by the quantitative risk assessment (see Table 5-1).

3. Social aspects of health and well-being

A community engagement was conducted in Avonbridge Community Hall in the Falkirk area. At the request of the steering committee two members of Avonbridge and Standburn Community Council, who were known to be at the centre of complaints around the issue of spreading sewage sludge to land, were contacted. Their activism appears to have helped galvanise local opposition to the practice of sludge spreading and the workshop was mainly attended by local residents with concerns about the practice who had been recruited by the community councillors. The workshop participants were, to varying degrees, already opposed to the practice that they viewed as detrimental to their wellbeing.

Participants regarded the odour nuisance as a severe detriment to their wellbeing. Normal life, from the enjoyment of the outdoors to opening windows at home was said to be compromised by frequent strong and unpleasant odours. Many felt that their health was at risk from a level of odour that made them feel nauseous. It was noted that half the participants thought that there should be a ban on all application until further research can prove that the application of sewage sludge to land carries no risks.

Several participants were particularly agitated about aspects of the transportation of the material. Some had taken it upon themselves to log the frequency, number and times of vehicle movements which they considered to be detrimental to their wellbeing.

Regulatory bodies came in for sustained criticism at the workshop. They were held to be ineffectively carrying out testing and monitoring. There was general agreement that controls need to be improved to better monitor the contractors and enforce good practice.

One key observation that the project team made was that some of the participants aggregated the spreading of agricultural slurry and the spreading of sewage. The overarching matter of odour seemed to compound these two issues. It was difficult to disentangle which was which at the workshop where participants had little specific evidence to present although our experts considered anecdotes relating to wet application to be highly likely to relate to slurry rather than sewage given that sewage is generally converted into dry pellets prior to application to land. This conflation might be a serious obstacle to achieving public support for this practice given that odour appears to be the catalyst for opposition.

4. Odour analysis

The relative intensity of odour emissions from three different types of sewage sludge cake during application to land and after spreading were assessed using standard techniques:

1. Lime treated dewatered cake (LIMED)
2. Anaerobically digested and dewatered sludge cake (AD)
3. Anaerobically digested and dewatered sludge cake following pre-treatment by a thermal
hydrolysis process (THP)

Odour emissions from the LIMED cake were in excess of an order of magnitude higher than from the AD and THP treated cakes. These differences were also reflected in indicative H_2S emission rate measurements. The implications are that there are significantly higher risks of adverse odour emissions from land applications of LIMED cake than from applications of conventional AD or THP digested cakes.

The substantially higher odour emission rates from lime treated cake demonstrate that much more rigorous odour mitigation measures must be used than for digested cake (with or without preliminary THP) if land spreading odour impacts are to be controlled or mitigated. Examples of such additional controls could include:

a) Selecting application sites which are remote from residential settlements and housing,

b) Restricting applications to small areas of land at any one time,

c) Not applying limed cake to grassland or other areas which preclude ploughing-in or cultivation other than in very remote locations.

d) Ploughing- in or incorporating more or less immediately after land spreading to minimise the surface areas of material exposed between spreading and incorporation.

5. Quantitative risk assessment

Table 5-1 summarises the main findings of the (semi-)quantitative risk assessment. The study suggests that malodour is potentially the highest priority issue to tackle. Reduction in odour exposure should improve well-being in affected communities as well as possibly influencing perceptions of risk.

The other nine risks flagged are all organic and/or pharmaceutical chemical agents. Concentrations of these can be reduced or minimised through process controls, and even under worst-case scenario conditions they pose low risks to receptors. It might

be sensible to undertake some monitoring work to keep a watching brief on these agents.

It was not possible to fully assess a number of (high profile) agents including microplastics and anti-microbial resistance. Further data gathering may be required in order to provide a more complete assessment.

Table 5-1 Summary of the outcomes of the (semi-)quantitative risk assessment

Potentially hazardous agent	Outome	Magnitude of risk (worst case)	Uncertainty	Possible mitigation
Malodour	Annoyance	Medium	High	• Distance to residents from spreading operations >3km • Avoid weather conditions that are conducive for exposure (wind speed >6 m s^{-1}; 50% night time cloud cover; partial daytime solar radiation) • Application rate <20 t ha^{-1} • Avoid or restrict the use of lime treated sludge
Nonylphenol	HQ>1	Low	Medium	• AD may reduce concentrations but evidence compounded by ready transformation of NP2EO to NP
Nonylphenol diethoxylate	HQ>1	Low	High	
PBDE-99	HQ>1	Low	Medium	• Partially broken down by AD
PBDE-209	HQ>1	Low	Medium	
Benzothiazole	HQ>1	Low-Medium	High	• Should be removed during aerobic treatment
Triclocarban	HQ>1	Low	Medium	• Partial removal by thermal hydrolysis
Cyclomethicone 5	HQ>1	Low	Medium	• Cycolmethicone 5 readily degraded by aerobic treatment and AD
Cyclomethicone 6	HQ>1	Low	Medium	

				• Cyclomethicone 6 more likely to remain in sludges
Atenolol	HQ>1	Low	High – Very High	• Aerobic waste water treatment followed by anaerobic digestion
Chemical exposures (general)	HQ>1	Low - Medium	Medium – Very High	• Any risks could be further attenuated by restricting sewage sludge use to pasture/forage crops • Extremely precautionary approach

ADAS. 2001. The Safe Sludge Matrix: Guidelines for the Application of Sewage Sludge to Agricultural Land. 3rd Edition, ADAS, Gleadthorpes.

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at

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