REDUCTION OF PATHOGENIC MICROORGANISMS AFTER CONVENTIONAL TREATMENT OF SEWAGE SLUDGE

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Introduction

Sewage sludge must be used in one form or another to close the loop for a sustainable society. Sewage sludge is still used as fertiliser in agriculture but nowadays in even larger extent used at golf courses, as cover of landfills and in other environmental use. Since the sewage sludge is proved to contain pathogens, it may enhance the spread of disease to animals and humans if it is not treated efficiently before use. In Sweden, it was demonstrated that sewage sludge contained more *Salmonella* than expected in contrast to the very few occasions when *Salmonella* was detected in the Swedish food-chain (Sahlström et al., 2004). If contaminated sewage sludge is spread in the environment, it enables infections to be spread to animals and people. This may happen for example through contaminated feed or food, fertilised with sewage sludge, or by rodents or other vectors transmitting the disease from the environment to stables and homes.

In the beginning of the history of the sewage treatment plants (STPs), they were mainly built to stop the transmission of diseases caused by poor sanitation. Today, STPs use different types of treatments to stabilise the sludge and to reduce pathogens. Anaerobic digestion (AD) can be performed either thermophilically (approximately 55°C) or mesophilically (approximately 35°C). Mesophilic AD is a quite common treatment of sewage sludge at larger STPs in Sweden. There are only a few larger STPs working at thermophilic temperatures. Storage and open windrow composting after sedimentation are the most common treatments of sewage sludge at smaller STPs. Pasteurisation at 70°C for 60 minutes is an effective treatment to decrease the pathogen content in biowaste. This is used at full-scale biogas treatment plants, treating mainly manure and organic household waste, but this practice is not applied in Sweden on sewage sludge (Bagge et al., 2005).

The aim of our work is to evaluate treatment options regarding the hygiene of sludge for thousands of STPs dealing with large amounts of sewage sludge.

Methods

In this paper, the hygiene implications of a number of studies focusing hygiene in sludge carried out at the National Veterinary Institute are summarised. In the first study, samples of sewage sludge from eight different STPs in Sweden were analysed for pathogens and indicator bacteria during a two-year study (Sahlström et al., 2004). The STPs differed concerning their treatment of the sludge. This enabled an evaluation of the effect of the microbial survival after different treatment options. Mesophilic and thermophilic anaerobic digestion, sedimentation only, storage and open windrow composting were included. Samples were taken both from untreated and treated sludge to assess the change in content of pathogens and indicator bacteria. Pathogens analysed were *Salmonella*, *Listeria*, *Campylobacter* and VTEC O157, which were analysed quantitatively. Indicator bacteria, which were enumerated, were enterococci, coliform and thermotolerant coliform bacteria, *E.coli*, and C*lostridium perfringens*. In a second study, thermophilic AD is followed up in an analysis of a full-scale digester, where pathogens are monitored every second month during two years (Bagge et al., 2005). In a third study, the effect of storage on the reduction of *Salmonella* and indicator bacteria has been analysed during one year in a full-scale study in Swedish (Uppsala) climate conditions. Storage of sewage sludge is evaluated through enumeration of *Salmonella* and indicator bacteria, including enterococci and coliform bacteria, during one year in full-scale heaps (Berggren et al., 2004). In a fourth study, *Ascaris* eggs have been separately investigated in sludge stored in climate chambers at temperatures 7°, 13° and 21°C during 214 days (Berggren et al, 2004). In all studies, the bacterial analyses have been performed according to standard methods, described in Sahlström et al. (2004) and Berggren at al. (2005).

Results

The survey of sewage sludge from Swedish STPs demonstrated a difference in the reduction of pathogens after different treatment options (Sahlström et al., 2004). It was possible to isolate *Salmonella* from 67% of the raw sludge samples and the different indicator bacteria were enumerated to between 5-6 $\log_{10}$ cfu/g. As expected, thermophilic anaerobic digestion reduced pathogens more than mesophilic AD and sedimentation did. No pathogens were isolated after the thermophilic AD. The content of pathogens and indicator bacteria was not affected after sedimentation and the analysis of indicator bacteria sampled from storage and windrow composts gave very varied results. After two months of storage of sewage sludge no *Salmonella* could be isolated in the heaps of sewage sludge. However, after one year there were still > 3,2 log_{10} cfu/g enterococci present in the stored sludge (Berggren et al., 2005). *Ascaris* eggs were still viable in the end of the laboratory study of stored sludge.

Discussion

Thermophilic AD is recommended as an efficient hygienic treatment of sewage sludge. The thermophilic treatment will also usually render more biogas than the mesophilic AD. However, the running costs are also somewhat higher. The real advantage is the better reduction of pathogens in the thermophilically treated sewage sludge and thereby the reduced risk of disease transmission through sewage sludge.

Storage of sludge is applied at many STPs as a complement to AD or sedimentation. It is a very attractive type of treatment especially for small STPs, mainly because it is a cheap and easy way to handle sludge. However, in the study of Berggren et al. (2005), enterococci were still present in the stored sludge after one year. This would imply that there could still also be other pathogens present in the sludge. According to this, and referring to international research where e.g. *Salmonella* has been re-isolated as long as after one year of storage (Gibbs et al., 1997), storage alone is not recommended as an adequate treatment option.

Our research regarding the hygienic effect of conventional treatment of sewage sludge has contributed to a new proposal for legislation of treatment of sewage sludge in Sweden. This proposal divides different treatment options in three different categories; A, B and C, with restrictions for use depending on the hygienic quality of the sludge. In this proposal, thermophilic treatment is included in category A, with the least restrictions for use. Mesophilic AD will belong to the proposed category B. Storage is included in category C, with the most restrictions for use.

In order to get a sludge with an even and acceptable hygienic quality, which would fulfil hygienic requirements set by authorities, storage must be defined as a treatment method where storage duration, running conditions, and maintenance must be strictly defined. The proposed regulations and categorisation of sewage sludge may cause practical problems with keeping these different categories separated and to not contaminate them afterwards.

The large variation in results from the analysis of the samples from storage and windrow compost could to a great extent be due to the sampling performance. It is difficult to get representative samples from large heaps with a $15m^3$ volume as in the storage trial when you only need a 25 g sample for e.g. *Salmonella* analysis.

The sampling procedures of sewage sludge in windrows and heaps are still to be developed in order to get representative samples for a large batch.

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