How rapidly do pathogens decay in sewage sludge treatment?

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Can sewage sludge be treated for shorter times than those currently required by national regulations? Key plant nutrients are lost by long-term storage of biosolids[1]. Shorter treatment times are desirable, provided microbiological safety is assured. We have, therefore, investigated decay times of key pathogens present in raw sewage.

Introduction

Raw sludge can potentially contain pathogenic microorganisms, including viruses, bacteria, protozoa and helminths. Enteric viruses found in biosolids can be divided into two major groups: enteroviruses such as poliovirus, coxsackievirus, hepatitis A viruses and echovirus, and a heterogeneous group including adenovirus, human rotavirus and astroviruses. Bacterial organisms found in sewage sludge include *Salmonella* spp. and *Campylobacter* spp., which cause gastroenteritis in humans. The most common protozoan parasites of concern in sludge are *Cryptosporidium* spp. and *Giardia lamblia,* which cause diarrhoeal illness. Helminths such as *Ascaris lumbricoides* may also be present in Australian sewage, although in very low numbers[2].

Results

Field studies

We have evaluated the decay of indicator microorganisms during the sludge air drying and stockpiling processes at two wastewater treatment plants (WWTPs) in the greater Melbourne area. These plants use anaerobic digestion, followed by pan drying and storage in stockpiles for at least three years. *Escherichia coli* and *Salmonella* spp. were indicators for pathogenic enteric bacteria and coliphages represented enteric viruses.

In drying-pans from both WWTPs, *E. coli* showed substantial decay during pan drying. Levels of *E. coli* dropped from 1 x 10^6 cfu/g DS (T3 treatment grade, restricted use) on entry into the drying pan to <100 cfu/g by 8 to 10 months (T1 treatment grade, unrestricted use). There were only minor differences between the two WWTPs plants in the length of time required to reach each treatment grade. The decay rate of *Enterococcus* spp, was slightly less than for *E. coli,* while coliphages decayed at the slowest rate, Figure 1[3]. *Salmonella* spp. was not detected in a selected range of drying-pans and stockpiles.

Laboratory simulation

We chose seven pathogens and indicators, to assess pathogen decay in sewage sludge treatment by experimental simulation. Three of these were present in the field sewage; *E. coli*, Coliphage and *Enterococcus* spp. (Figure 1). Also included was

Salmonella Typhimurium, *Ascaris suum*, enteric adenoviruses (porcine adenovirus and human adenovirus type 40/41), and the protozoan pathogen *Cryptosporidium parvum*. The data enabled us to compare $\log_{10}$ reductions and derive decay coefficients for indicators in the field and in the laboratory, and pathogens in laboratory simulations.

Large tanks (25 L) or containers (5 L) were used to follow the decay of indicators and bacterial pathogens, while assay chambers (0.5 mL volume) were used for seeding biosolids with human adenovirus (HadV type 41), porcine adenovirus (PAdV-3), oocysts of *Cryptosporidium parvum* and eggs of *Ascaris suum*, due to restricted availability of pathogens or to improve their recovery.

Estimating the decay of indicators and pathogens

The falling numbers of indicators and pathogens over treatment time in biosolids treatment can be estimated using the following equation (1)

$$N_t = N_0 * e^{-DC*t}$$

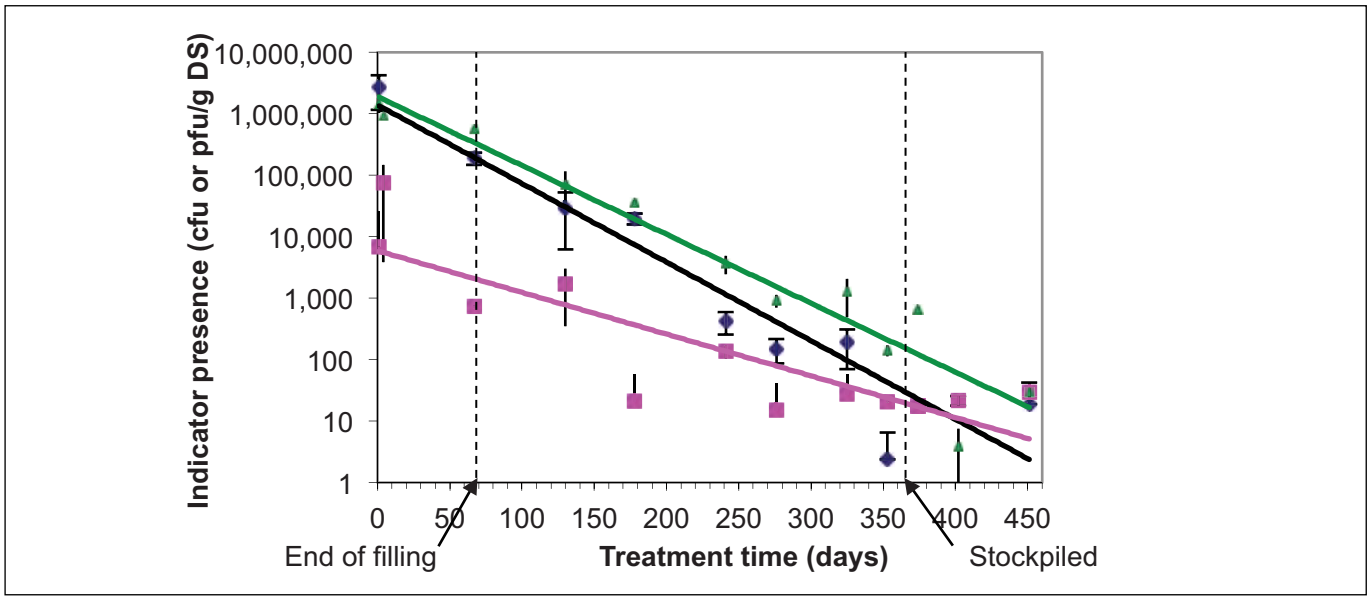

Figure 1. Indicator decay in WWTP 1 pan 23 (full year drying). Drying time (by days). Symbols: ◆, *E. coli;* ■, K-12 Coliphage; ▲, *Enterococcus* spp. At time zero the sludge from an anaerobic digester was used to start filling a drying pan. Error bars show +/-1 STD. Limit of detection is 20 cfu/g dry solids (DS) for bacteria and 20 pfu/g DS for bacteriophages.

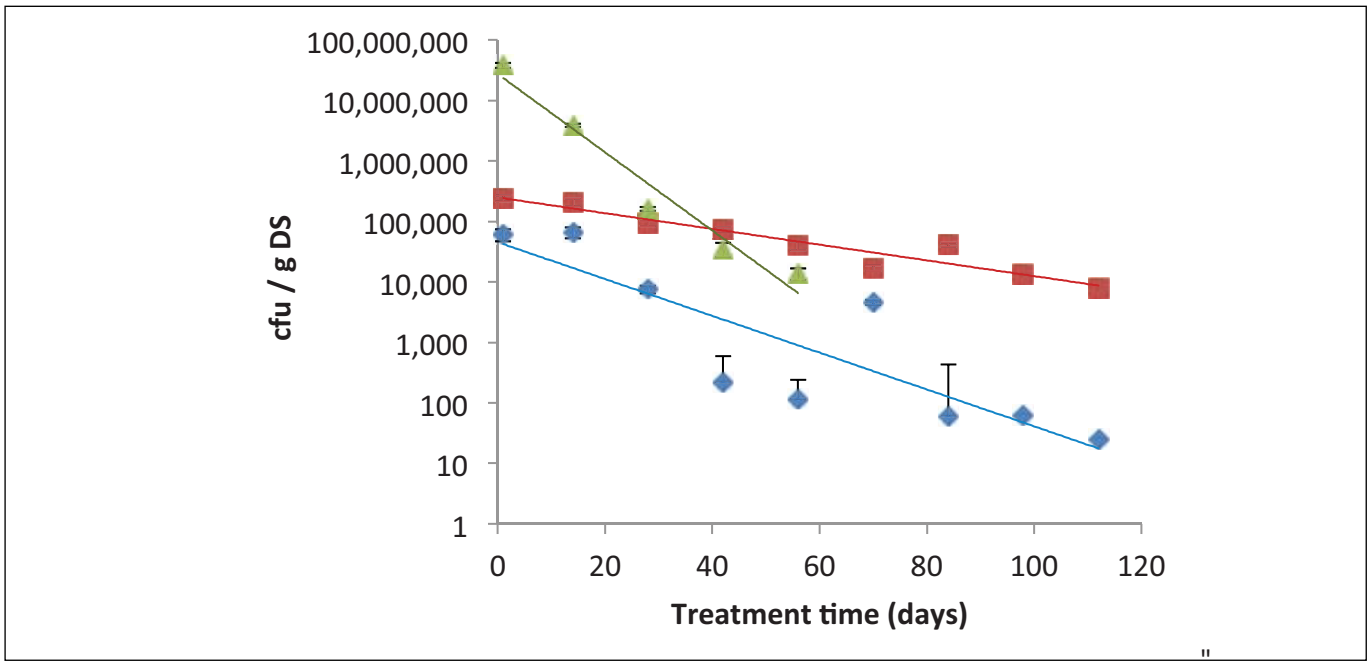

Figure 2. Decay of bacteria in drying-pan simulation 3. Symbols: ◆, *E. coli;* ■, *Enterococcus* spp.; ▲, *Salmonella* Typhimurium. Error bars show 1 sd (most too small to be visible).

Where N_t is the number of organisms at time t (cfu or pfu /g DS); N_0 is the number of organisms at time zero (cfu or pfu /g DS), e.g. at the start of pan filling; DC is the organism-specific decay coefficient (determined from regression analysis); t is time t (days).

For example, the decay of bacterial indicators and pathogens in a drying-pan simulation are shown in Figure 2. This indicates that *Salmonella* Typhimurium decays at a higher rate compared to both *E. coli* and *Enterococcus* spp., with decay coefficients of -0.149, -007 and -0.03, respectively.

Forecast of treatment times in pan-drying to reach treatment grades T1, T2 and T3

The decay coefficients of pathogens and indicators in both field treatment and laboratory simulations were used to calculate the times required for their decay according to current regulations. Both average and worst-case data was used to forecast treatment times for verification to provide T1 grade biosolids.

Both for average and worst-case data the forecast treatment time for verification to provide T1 grade biosolids in pan-drying is about 59 weeks. Therefore, treatment times could be reduced to about one year, with no requirement for storage, compared to the current regulatory requirement for three years' storage.

Risk analysis

Although most potential pathogens are either absent or present in low numbers in raw sludge in developed countries, it is still important to model the microbial pathogen risks associated with the application of treated sludge to land. We therefore developed a model to follow the decay of nine pathogens in sewage sludge treatment from estimated levels in the human the infected human population through to annual exposure from ingestion of uncooked root crops grown in biosolids amended soil[4].

Under typical conditions, the risk of infection from pathogens in conventionally treated biosolids was below the 10^{-4} pppy USEPA limit for drinking water[5].

References

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Science meets Parliament 2012

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An annual event of growing importance and popularity for both the scientific community and the federal government is Science meets Parliament (SmP). SmP is promoted and presented by Science and Technology Australia (www.scienceandtechnologyaustralia.org.au), a scientific advocacy group of which ASM is a member, bringing together scientists of all disciplines from across Australia for a unique opportunity of interactions with our federal parliamentarians in Canberra. This year, at the 13th annual SmP event, the ASM was represented by Assoc. Prof. Damian Purcell (University of Melbourne) and Dr Nick West (University of Queensland). On the first day of the two-day event, delegates participate in a series of workshops aimed at informing and equipping them to interact more effectively with members of parliament. A strong theme of these workshops is about the value of science communication, budgetary processes, formulation of policy and how to influence it. Changes in the media have resulted in the culling of several dedicated science journalists and delegates were encouraged to embrace social media, such as Twitter, to keep science in the national conversation and to guide important policy discussions. There