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Title	**Fate of faecal pathogens and indicator bacteria in urea treatment**
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Fate of faecal pathogens and indicator bacteria in urea treatment

Introduction
New resource efficient, environmentally friendly, simple and robust sanitation methods are needed for the faecal material collected in dry Ecosan toilets. The methods available today are mainly storage longer than one year and composting. However, both these treatment alternative have been shown insufficient to guarantee removal of pathogens. While proper reduction of bacterial pathogens and indicators can be measured during storage, often the more resilient organism (some viruses and parasites) still remain after one year. To ensure good sanitation in composting the temperature should be above 50ºC during 1-2 weeks and during this time the compost should be turned several times. However, data so far from composting of the faecal mixture, which also contains ash, lime and/or soil, show that it is very rare that the temperature even comes close to 50ºC.

Objectives
The objective of this study was to evaluate addition of urea as a chemical sanitation treatment of faecal matter.

Method
This chemical treatment works by adding the nitrogen fertiliser urea to the material to be treated. Faeces naturally contain the enzyme urease, which degrades the urea to ammonia and carbon dioxide, while rising the pH to somewhat above 9. The investigated microorganisms were *Salmonella* spp, *Enterocuccus* spp and *E. coli* (some of the tests were done with *E.Coli* O157:H7).

Sanitation experiments were carried out for faecal sludge, blackwater and manure. The amount of urea added differed between the different substrates and so did the temperature. To the faecal sludge (mixture of faeces and water holding 10% total solids, TS) approximately 6% by wet weight of urea was added and this experiment was done at 20ºC. To just the blackwater (mixture of faeces, toilet paper and water with TS=0.2%) 0.1% of urea was added and the temperature was 15ºC. To the cattle manure (TS=12%) 2% by wet weight of urea was added ant the temperature was 4ºC.

Result and discussion
Treatment of the faecal sludge with 6% urea (3% ammonia nitrogen) at 20ºC resulted in a rapid reduction of the investigated microorganisms. Compared to the control, with no addition, the decimal reduction time (Dr) was reduced by more than 90% for *Salmonella* spp

and *E. coli* and more than 94% for *Enterococcus* spp (Table 1). When the urea addition was just 0.1% of by wet weight to blackwater the effect on reduction was less pronounced. the Dr was reduced by more than 50% for *Enterococcus* spp, by 87% for *Salmonella* spp and 85% for *E.coli* O157:H7.

Table 1. Dr (decimal reduction time) in days for the different treatments of faecal sludge, blackwater and manure

Method of treatment	*Salmonella* spp	*Enterococcus* spp	*E.coli*
Faecal sludge 20°C, no addition	>9	51	8
Faecal sludge 20°C, urea 6%	<0.7	<3	<0.7
Blackwater 15°C, no addition	24	22	20*
Black water 15°C, urea 0.1%	3	10	3*
Manure 4ºC, urea 1%	1.2	-	-

**E.coli* O157:H7

The use of urea for sanitation of faecal matter has its origins in the ammonia addition. Advantages with urea are that it is easy to handle (granules) and that it is globally available as it is one of the most common fertilisers in the world. In addition, the treatment does not require skilled personnel, in comparison to composting and anaerobic digestion. Upon addition of urea, the enzyme urease degrades the urea to ammonia and carbon dioxide. This enzyme is generally present in faeces. Therefore, within a few hours after application to the faeces, depending on temperature, the urea is degraded to ammonia, which increases the pH. The free ammonia combined with increased pH sanitises the material (Table 1) even though the pH only reaches 9-9.5. The urea treatment gives a rapid reduction of microorganisms. From other tests we know that this also is true for viruses and parasites.

Using urea for sanitation of faeces increases the fertiliser value of the material, as no ammonia is consumed or lost during the treatment provided it is performed in a closed container. Furthermore, as long as the ammonia remains in the material, there is no risk for bacterial re-growth in the treated material and the sanitation effect remains. Both the economic and environmental costs of the treatment are low, as the fertiliser value of the urea remains and can be utilised when the material is recycled.

The urea treatment does not require any extra stabilisation as the treatment itself stabilises the material. Investigations on human urine storage show that the ammonia losses can easily be kept below 1%, even if the material is stored for 6 months or more. If the storage is not properly done and ammonia is lost, then also the protection against regrowth can be lost.