

# Producing a risk-free fertilizer: hygiene and pharmaceuticals

Loïc Decrey

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Vuna Symposium

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# Take-home messages

## A contaminated material...

- Source-separated urine contains infectious agents and pharmaceuticals.

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- If marketed at large scale, seek treatment by distillation (complete removal of infectious agents) and additional activated carbon treatment step to maximise pharmaceuticals removal.

# Take-home messages

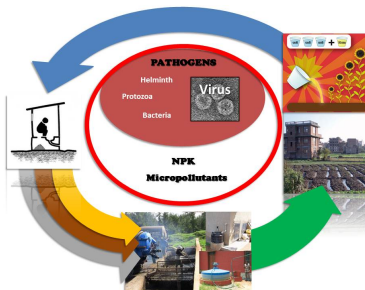
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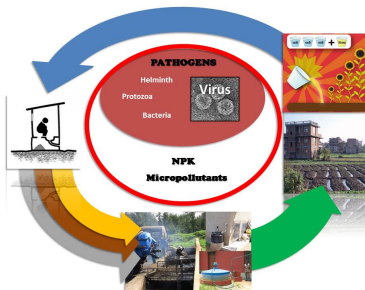
## ...that can be treated to recover valuable nutrients

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- If marketed at large scale, seek treatment by distillation (complete removal of infectious agents) and additional activated carbon treatment step to maximise pharmaceuticals removal.
- If distillation cannot be implemented, a careful examination of the risks and an optimization of the storage/treatment duration are needed.

# Bugs and drugs



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- Source-separated urine contains bacteria, virus, protozoa and parasitic worms, especially originated from fecal/menstruation cross-contamination.

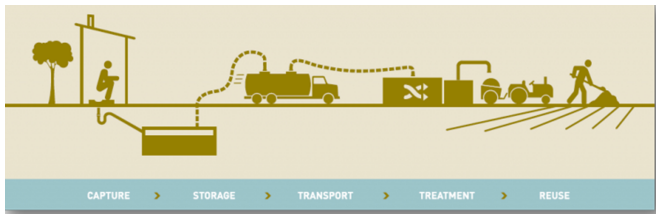


# Bugs and drugs

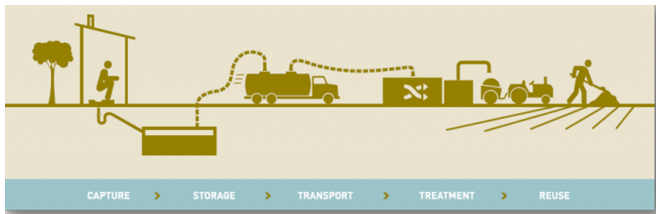


- Source-separated urine contains bacteria, virus, protozoa and parasitic worms, especially originated from fecal/menstruation cross-contamination.
- Source-separated urine contains pharmaceuticals which are mainly excreted through urine by the human body.

# Bugs and drugs



# Bugs and drugs



- Pharmaceuticals only affect the quality of the end-product, whereas infectious agents contaminate people throughout the collection/treatment chain in addition to their impact on the end product quality.



# Pharmaceuticals in urine

Urine



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Urine

**Human urine** *Present study (Bischel et al., 2015)*  
<1mg/kg, exception SMX up to 6.4 mg/kg



# Pharmaceuticals in urine

## Urine

**Human urine** *Present study (Bischel et al., 2015)*  
<1mg/kg, exception SMX up to 6.4 mg/kg

**Animal manure** *Review (Song et al., 2014)*  
from 10 ug/kg up to 100 mg/kg



# Pharmaceuticals removal through processing



	Removal	Concentration effect
<b>Storage</b>	-	-



# Pharmaceuticals removal through processing



	Removal	Concentration effect
Storage	-	-
Nitrification	partial*	-

\* only some compounds





# Pharmaceuticals removal through processing



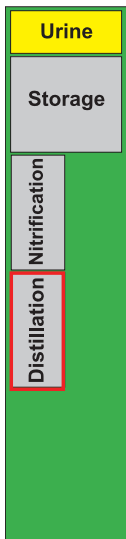
	Removal	Concentration effect
Storage	-	-
Nitrification	partial*	-
Nitrification + AC	✓**	-

\* only some compounds

\*\* >90% removal with 200 mgAC/L for ALL



# Pharmaceuticals removal through processing



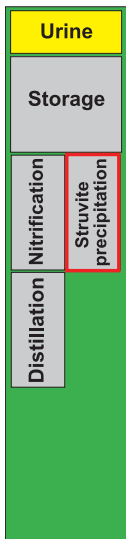
	Removal	Concentration effect
<b>Storage</b>	-	-
<b>Nitrification</b>	partial*	-
<b>Nitrification + AC</b>	✓**	-
<b>Distillation</b>	-	✓

\* only some compounds

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# Pharmaceuticals removal through processing



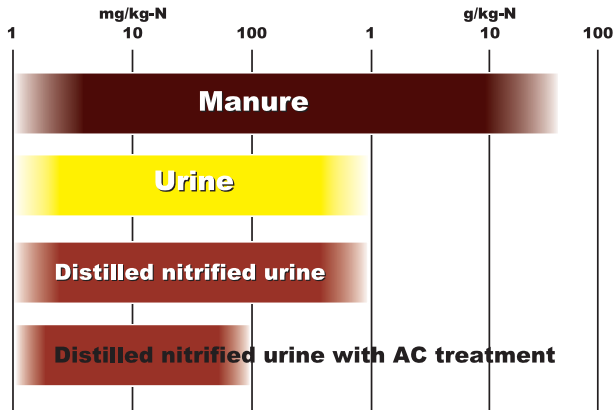
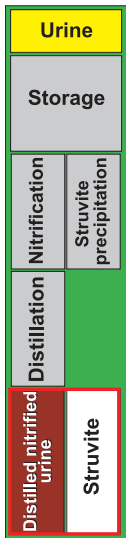
	Removal	Concentration effect
Storage	-	-
Nitrification	partial*	-
Nitrification + AC	✓**	-
Distillation	-	✓
Struvite	-	-

\* only some compounds

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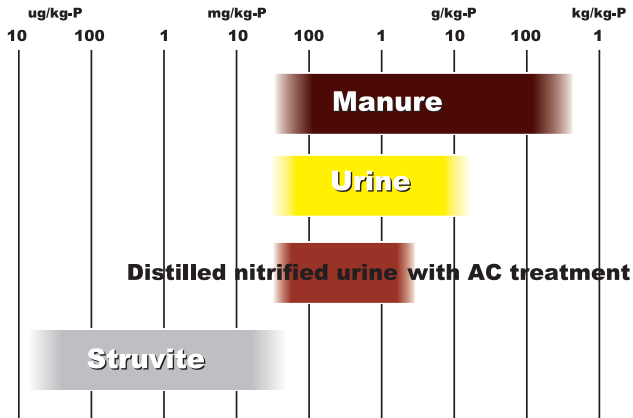
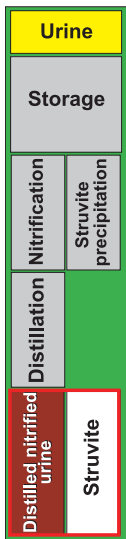


# Pharmaceutical in the end product



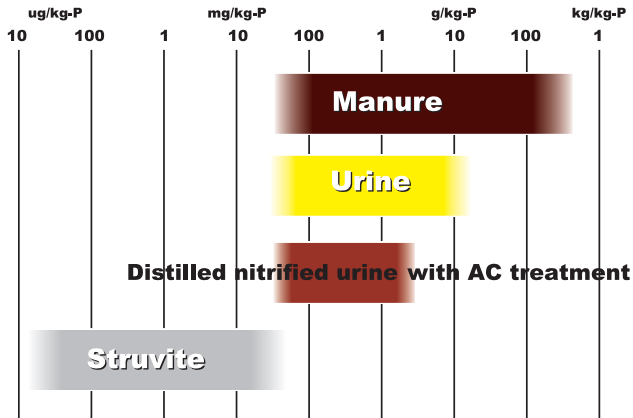
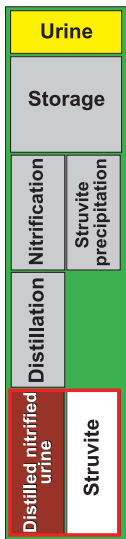


# Pharmaceutical in the end product





# Pharmaceutical in the end product



**!Struvite effluent is not treated!**



# Infectious agents in urine

A vertical diagram of a container. The top portion is a yellow rectangle with a red border, containing the word "Urine". The bottom portion is a larger green rectangle, representing the rest of the container.

Urine

**!Source-separated urine is not sterile!**



# Infectious agents in urine

## Urine

**!Source-separated urine is not sterile!**



It contains bacteria, virus, protozoa and parasitic worms originated from cross-contamination by feces or by blood from menstruation.





# Infectious agents inactivation through processing



	Bacteria	Virus	Parasites
Storage	partial	partial	partial

-: no

✓: complete



# Infectious agents inactivation through processing



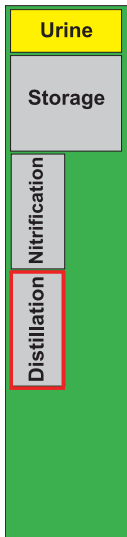
	Bacteria	Virus	Parasites
Storage	partial	partial	partial
Nitrification	partial	-	-

-: no

✓: complete



# Infectious agents inactivation through processing



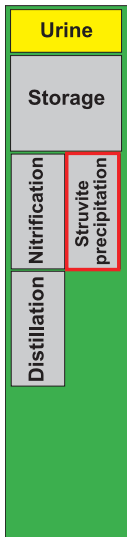
	Bacteria	Virus	Parasites
Storage	partial	partial	partial
Nitrification	partial	-	-
Distillation	✓	✓	✓

-: no

✓: complete



# Infectious agents inactivation through processing



	Bacteria	Virus	Parasites
Storage	partial	partial	partial
Nitrification	partial	-	-
Distillation	✓	✓	✓
Struvite	partial	partial	partial

-: no

✓: complete

# Infectious agents in the end product

## **BACTERIA**

*M. Tuberculosis*

## **VIRUS**

*Rotavirus*

*HIV*

## **PAR. WORM**

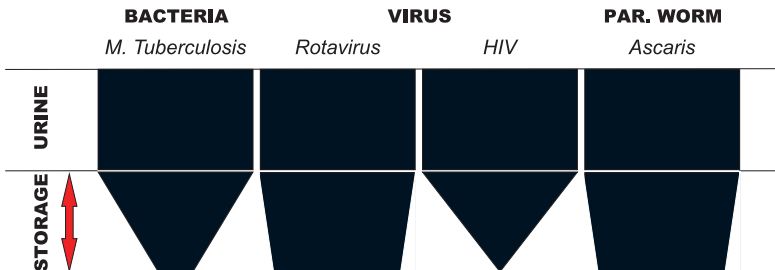
*Ascaris*

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**Distilled nitrified urine**

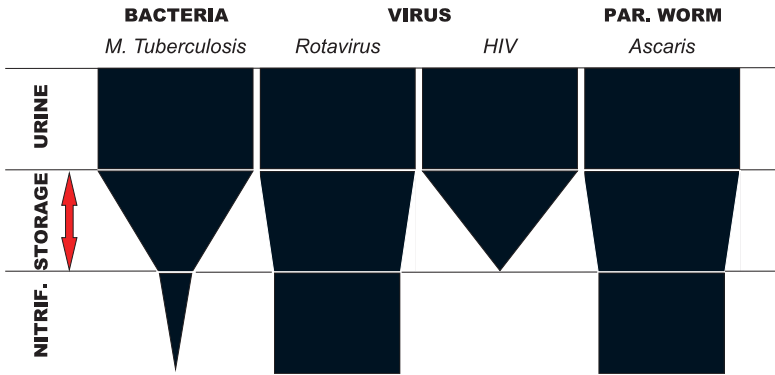


# Infectious agents in the end product



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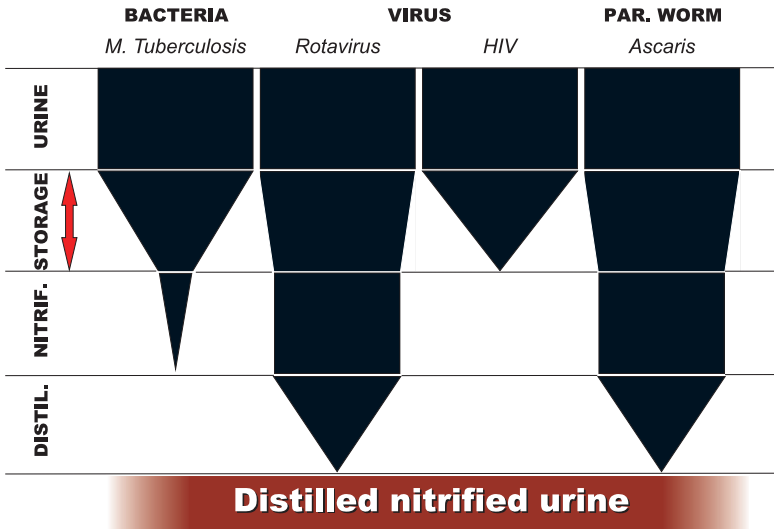
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**Distilled nitrified urine**



# Infectious agents in the end product



# Infectious agents in the end product

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*Ascaris*

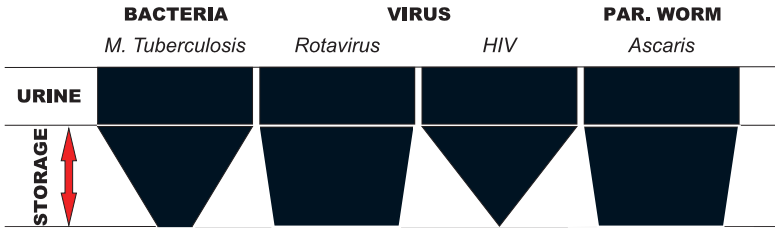
**Struvite**

# 🦠 Infectious agents in the end product

	<b>BACTERIA</b>	<b>VIRUS</b>		<b>PAR. WORM</b>
	<i>M. Tuberculosis</i>	<i>Rotavirus</i>	<i>HIV</i>	<i>Ascaris</i>
<b>URINE</b>				

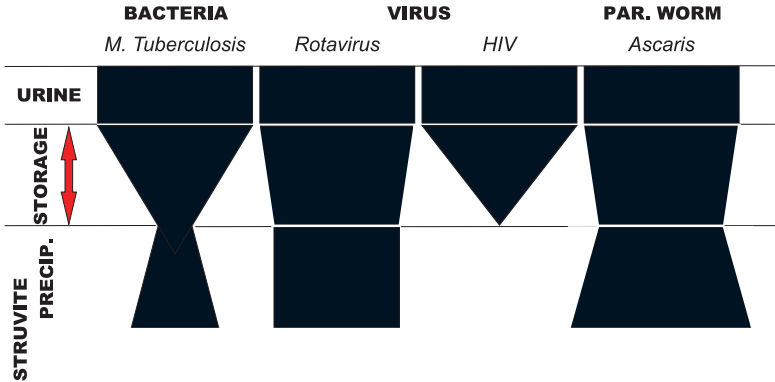
**Struvite**

# Infectious agents in the end product



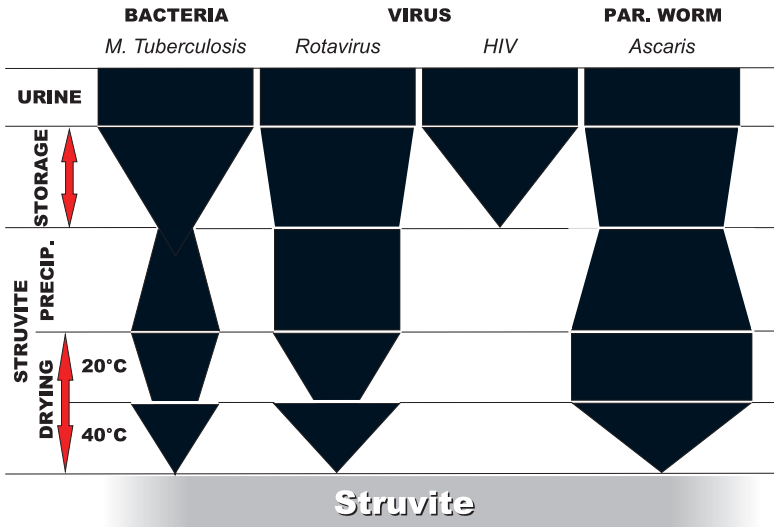
**Struvite**

# Infectious agents in the end product

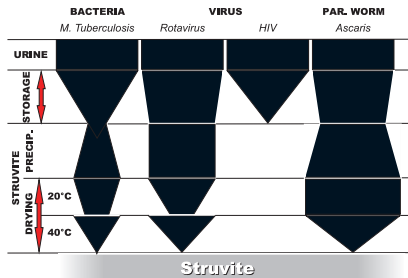


**Struvite**

# Infectious agents in the end product



# Infectious agents in the end product



## But!

- Struvite might partially decompose at  $>40\text{C}$ .
- Struvite effluent is not treated and contains infectious agents.



# Workers exposure during collection and treatment

**!Collection of source-separated urine is likely to be less harmful to urine collectors than emptying pit latrines is to pit emptiers!**



*Take precautions when working with human excreta, for example:*

- Wear gloves and masks.
- Hand-face contacts are likely, but try to avoid it.
- Disinfect and clean equipments and contaminated surfaces.
- Immunocompromised individuals may be more susceptible to infection.



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## THANKS FOR YOUR ATTENTION!

I could show you these results today, thanks to:

### Drugs:

B. D. Özel Duygan  
L. Strande  
K.M. Udert  
C. McArdell

### Bugs:

H.N. Bischel  
A. Schertenleib  
M. Schoger  
S. Schindelholz  
S. Oppenheimer  
A. Remmele  
A. Fumasoli  
K.M. Udert  
T. Kohn