Potential to close the nutrient gap through the use of source separated human urine.

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[Image: John.E.Robertson, flickr.com.]

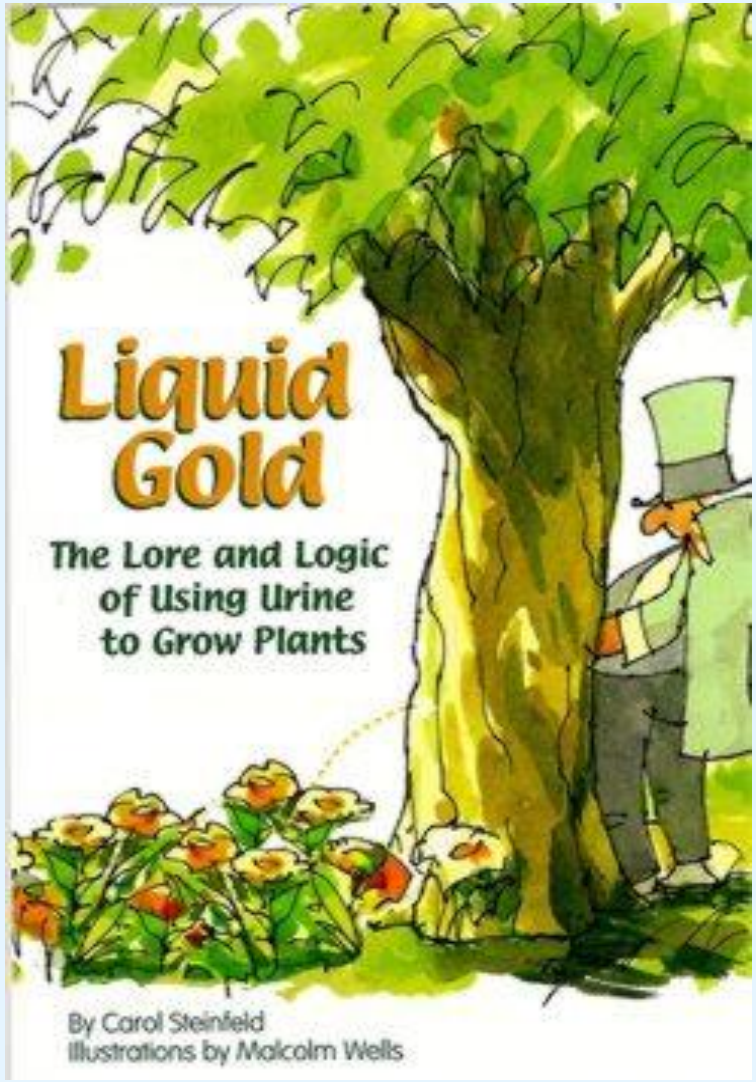
Crop nutrient input costs

- Crop fertility inputs can be expensive
  - Particularly for conventional farms
    - N & P currently very high
    - Linked to energy use in manufacture / transport
  - Not just conventional farms though
    - Organic farms aim to close the nutrient cycle
      - Not always easy
      - Some imported fertility can be useful at times
  - Recycling is a key philosophy associated with organic farming
    - Opportunity to reduce costs

What role might source separated human urine play in closing the nutrient gap?

- Boundaries need to be adjusted beyond the farm gate
  - Recycling nutrients from communities onto farm
  - Reduction in potable water use
    - Toilet flushing (~70% less water)
  - Potential to reduce volume / energy associated with grey water treatment
    - Reduced volume / N & P loading

Is urine as a fertiliser a new idea?



- No
  - Been around for many centuries
- Still frequently used in developing countries
- Lost its appeal in developed countries
  - Advent of cheap fertilisers
  - Social acceptability

Nutrient value / volume

- Domestic wastewater contains dirty water from kitchen and shower waste as well as sewage from toilets
- Urine is the fraction containing most of the key plant nutrients entering the system
  - 80% of the N
  - 55% of the P
  - 60% of the K
- Urine approx 1% of wastewater volume

Nutrient content of urine (g / L)

Refs	Tot-N	NH4-N + NH3-N	P	K	S
Carlsson (1995)	**2.6**	**1.7**	**0.19**	**0.45**	
Carlsson (1995)	**1.8**	**1.6**	**0.11**	**0.36**	
Jönsson et al (1998)	**3.5**	**3.4**	**0.31**	**0.94**	**0.33**
Kvarmo (1998)	**3.7**	**3.3**	**0.27**	**1.22**	**0.33**
Lundström & Lindén (2001)	**2.5**	**2.1**	**0.25**	**0.70**	
Olsson (1995)	**2.4**	**2.2**	**0.24**	**0.65**	**0.20**
Pettersson (1994)	**2.2**	**2.1**	**0.21**	**1.00**	**0.20**
Vinnerås (1998)	**2.3**	**2.1**	**0.14**	**0.48**	**0.17**

Various studies in Sweden (diet not hugely different to UK)

Current important EU legislation – source separated urine use

- Water Framework Directive (2000/60/EC)
- Nitrates Directive (91/676/EEC
- Wastewater Directive (91/271/EEC)
- Sewage Sludge Directive (86/278/EEC)
  - No definition of source separated human urine in this directive
- Organic (Council Regulation EEC No 2092/91)
  - List of recognised fertilisers allowed on organics (source separated human urine not on it)

- Need to comply with all of these (and other relevant legislation) / guidance
  - E.g. planning, GAP, WHO, etc

Legislation & source separated human urine use

- Use of sanitised excreta for use in agriculture often falls outside existing regulatory framework
  - With the exception of EU organic regulation
  - Interdisciplinary nature may not help
- Public health and environmental protection are major drivers
- Also need a focus on agricultural legislation
  - As this is its primary intended use

Production / storage / treatment

- Each person produces around 0.8 -1.5L urine / day
- Need to keep urine free of faeces
  - Fresh uncontaminated urine contains few enteric micro-organisms
  - Faeces contain high levels
    - Including pathogens and opportunistic pathogens
      - Even if person infected shows no symptoms
  - Evidence that suitable storage can provide safe levels of
    - Pathogens, pharmacological & hormone residues (Stinzing, 2007)

Storage guidelines – human urine

Table 1: Recommended guideline storage times for urine[a] based on estimated pathogen content[b] and recommended crop for larger systems[c] (WHO, 2006).

Storage temperature	Storage time	Possible pathogens in the urine mixture after storage	Recommended crops
4 °C	≥1 month	Viruses, protozoa	Food and fodder crops that are to be processed
4 °C	≥6 months	Viruses	Food crops that are to be processed, fodder crops[d]
20 °C	≥1 month	Viruses	Food crops that are to be processed, fodder crops[d]
20 °C	≥6 months	Probably none	All crops[e]

WHO. 2006. Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume IV – Ecxreta and Greywater Use in Agriculture.
http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html

Some Issues

- Specialist collection systems
  - Different infrastructure from current flush / centralised system
- Hygiene
- Storage volume / time
- Pipes
  - Corrosion / ammonium
    - Use plastic
  - Precipitation (struvite)
- Transport
  - Bulky / cost / distance from collection point
- Application
  - Same as livestock slurries, etc


Roediger NoMix toilet. Roediger Vacuum (www.roevac.com)


Photo by Mats Johansson


Photo by Anna Richert Stintzing


Photo by Mats Johansson

Use in agriculture

- Composition in relation to heavy metals, organic pollutants, pathogens, pharmaceuticals and nutrients need to be guaranteed
  - Level of Cd in human urine often lower than Cd-free fertilisers
  - Risk of pharmaceuticals needs care

Crop growth

- 1 ha grain typically requires 100 kg N
  - 25 people needed to supply this urine
- Smaller scale use

Energy / LCA (e.g. Tidåker, 2003)

- Sustainability in the future likely to rely more on recycling than present
- N & P emissions to water can be lowered
- Recycling of nutrients to plants can be increased
- Minor decrease in GWP-gases
  - Avoidance of mineral fertilisers
  - Larger if electricity based on fossil fuels
    - Economic costs linked to this also

- Construction phase of specialist system may contribute significantly to energy use, at least in initial stages
  - Effect on existing wastewater treatment also important
- In Tidåker's study, urine transport of more than 40km one-way would NOT exceed total primary energy of the conventional scenario

Public acceptance as a fertiliser

- Drawback / barriers
  - Generally high acceptance
  - Some concerns with respect to pathogens and micropollutants
- Improvements / recommendations
  - Storage / processing to remove pathogens
  - Clear communication strategy / positive attitude
    - Project managers / communities / authorities

Lienert & Larsen (2009) High acceptance of urine source separation in seven European countries: A review. Environ. Sci. Technol. 44, 556-566

Farmer acceptance

- KVL (Denmark)
  - Source separated human urine regularly used in trials
    - Delivered from diverting toilets in eco-villages
  - Initially strong resistance / debate about its use
    - Many meetings / authority input / safety concerns
  - A few years down the line and there is no animosity
    - Workers take a pride in its use
    - Favour its use over sewage sludge

Summary

- Technically possible to design effective integrated waste management systems
  - Close to cost level of current conventional sanitation systems
- Drivers for change to current centralised sewage systems
  - Government policy (sustainability drive)
  - Grass roots motivation
  - Economic incentives uncertain / small

Future use of human urine in organic agriculture

- Currently not allowed
- Open for debate
  - How closely does it link with general organic philosophy of recycling?
  - What are the major draw backs in principle?
  - What are the major drawbacks on a practical level?
  - Other?

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