Methods for stabilising and concentrating human urine for use as a fertilizer

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Introduction

- Agriculture in Brazil (and worldwide)
  - Still growing (population and biofuels!)
  - Growing dependency on mineral raw materials

- Wastewater Treatment
  - Brazil: mainly UASB reactors
  - World: often still insufficient nutrient removal
Intro: nutrients for agriculture

Annual fertilizer sales in Brazil (MT)

Year:
- 1998
- 2000
- 2002
- 2004
- 2006
- 2008
- 2010
- 2012
- 2014

Imports (%)
- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%

Consumo annual

Importação
Intro: nutrients for agriculture

- China: 37.0%
- United States: 14.9%
- Morocco and Western Sahara: 14.8%
- Russia: 5.7%
- Tunisia: 4.3%
- Jordan: 3.4%
- Brazil: 3.1%
- Egypt: 2.8%
- Other Countries: 14.0%

Graph showing the percentage of nutrients for agriculture from different countries over a period from 1960 to 2020.

Graph: minério de fosfato ($/ton)
Introduction: potential of urine

- Quantity available much smaller than demand
- Higher demand in more densely populated areas
Main problem: instability of urea

- **Urea hidrolysis:**
  \[ \text{H}_2\text{N-CO-NH}_2 + \text{H}_2\text{O} \rightarrow 2 \text{NH}_3 + \text{CO}_2 \]
  \[ \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^- \]

- **Enzymatic process**
  - Faster at pH ≈ 7

- **Problems:**
  - Loss of Nitrogen
  - Smell
  - Increase of pH

![Graph showing v max,hydrolysis (mmol.L⁻¹.min⁻¹) vs pH]
Objectives

• stabilizing human urine for use as a fertilizer
  • Conservation of nutrients contained
    • impeding mainly urea hydrolysis
  • Volume reduction
    • Reduction of transportation costs
Materials and Methods

• Fresh urine collection + characterization
  • pH, TN, NH₃, P, K, TS, VS, FS
• Addition of stabilizing compounds
  • acids, NaOH, limestone, ashes or a mixture
• Determination of initial weight
• Storage in temperature controlled room or greenhouse – with and without forced ventilation (→ determination of evaporation)
• Parameters followed:
  • Weight, TN, NH₃, P, K, TS
Results: evaporation

- Slightly slower when compared to water
- Influenced mainly by the TS contents
Results: hydrolysis

pH development during the experiments

1 - Urina  
2 - H2SO4  
3 - HCl    
4 - HAc   
5 - NaOH
Results: acid preservation

acids: 0.065 ... 0.27 M
Results: nutrient recovery

Nutrient recovery:

- Nitrogen – compatible to the capacity of the maintenance of a high or low pH
- K mostly 100%
- Results for P are comparable to N
Conclusions

- It is possible to preserve the nutrients in the urine by using acids or bases.
- Better results obtained with acids (lower loss of nitrogen) and easier to implement (e.g. use of vinegar).
- For the case of bases, better results were obtained by using limestone.
  + can be used to improve quality of soil
  - Significant increase of the weight of produced fertilizer
Thanks for the attention!

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Acknowledgments
CNPq – project number 475650/2009-3