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Title	**Integrating farming and wastewater management – an environmental systems analysis of barley production using human urine**
Keywords	
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Integrating farming and wastewater management – an environmental systems analysis of barley production using human urine

Introduction

Source-separation of human urine is a promising technique for improving wastewater systems. By closing the nutrient cycle, nitrogen and phosphorus can be used as resources in agriculture, while at the same time the eutrophication from treated wastewater is reduced. When using an organic fertiliser such as human urine, the farmer needs to take different considerations into account besides its plant nutrient value, e.g. when and how to spread the urine. Decisions made by the farmer might thus influence the environmental outcome for the whole system, something that emphasizes the need for in-depth studies from an agricultural perspective.

The main objective of this study was to evaluate the environmental consequences when human urine replaced mineral fertilisers in barley production. Life Cycle Assessment methodology was used to compare two scenarios: conventional barley production using only mineral fertilisers and production using a combination of source-separated human urine and mineral fertilisers. The functional unit was 1 kg of barley harvested.

Systems description

In the *reference scenario*, conventional barley production in accordance with present practice in the region surrounding lake Mälaren was assessed. In the *urine-spreading scenario*, the greater part of the mineral fertiliser was replaced by human urine. Both the immediate effects from soil compaction and its future effects were accounted for in the yield obtained in the urine-spreading scenario as a reduction of the yield in the year under study.

The urine was assumed to be collected from detached single households with individual concrete storage tanks. The urine separation system was further assumed to be a supplementary function added to an already existing conventional system with a wastewater treatment plant operating regardless of the urine separation system, treating the other wastewater fractions from the households. The reduced need for treatment, distribution and pumping of drinking water and wastewater was accounted for, as well as the reduced amount of precipitation chemicals required.

A change-orientated perspective was used, focusing on changes occurring when the urine-spreading scenario was introduced compared to the reference scenario. All main changes in the urine-spreading scenario compared to the reference scenario were considered, including production of the capital goods differing between the two scenarios.

Results

The use of fossil fuel was similar in the two scenarios, while the use of electricity differed. The electricity saved in the urine-spreading scenario emerged from a smaller quantity of drinking water produced, as well as a reduced need for pumping and treating wastewater. The emissions of greenhouse gases from the two scenarios were of the same magnitude, although slightly higher from the reference scenario. Production of mineral fertilisers contributed most to global warming in the reference scenario. The potential contribution to eutrophication was considerably higher for the reference scenario than for the urine-spreading scenario. The difference between the scenarios was explained by the reduced emissions of nitrogen from the wastewater treatment plant when urine was separated. However, the urine-spreading scenario contributed most to acidification, expressed as a maximum scenario, through its higher emissions of NO_X and NH_3. The emissions of NH_3 in particular differed between the scenarios, due to losses during storage and spreading of urine.

The potential effects of a large-scale regional change from conventional wheat production according to the reference scenario to the urine-spreading scenario were examined. In a normalisation, these changes were compared to figures on the total impact for Sweden. Urine from approximately one million users of separating toilets was assumed to be spread on arable land. The most noticeable change appeared in a lower discharge of nitrogen (-0.9%) and phosphorus (-0.4%) to water and substitution of nitrogen and phosphorus fertilisers (-1% and –3% respectively). The change in the discharge to water was relatively small compared with the total nutrient load, even in a regional context, mainly because urine-separation was compared to conventional wastewater treatment with efficient removal of nitrogen and phosphorus. The increase of NH_3 emitted in the urine-spreading scenario was 0.3% above the present emission figure for Sweden.

Discussion

An optimal fertiliser strategy regarding e.g. substitution of mineral fertiliser, spreading time and application technique was demonstrated as being important for many environmental aspects. As the handling of urine at farm level is critical for many environmental aspects, a good strategy for using human urine in practical farming needs to be an integrated part in the design of urine-separating systems.

Whether a urine-separating system, where urine is used as fertiliser, is more energy-efficient than a conventional system depends to a large extent on the design of the system. By using a change-orientated perspective in this study, major changes in the construction of capital goods were taken into account, without considering the construction phase as a whole. Production of capital goods contributed noticeably to the primary energy used in the urine-spreading scenario. The calculated lifetime for the capital goods and choice of material is therefore important. The long distance sometimes required for transporting the urine has been pointed out as a weakness for source-separating systems without further concentration of the urine mixture. The assumptions used in this study allowed transportation 42.5 km (one way) in the urine-spreading scenario, before the primary energy use in the urine-spreading scenario exceeded that in the reference scenario. Concentration of urine as an additional process in order to reduce the energy use required for transportation should therefore be compared to the construction of capital goods required for this concentration.

References

Tidåker, P. *Life Cycle Assessment of Grain Production Using Source-Separated Human Urine and Mineral Fertiliser*. Department of Agricultural Engineering, Report 251, Swedish University of Agricultural Sciences, Uppsala, 2003.