Urine Re-use with Drip Irrigation

Environmental Impact and Equipment Sustainability

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Scientific context

The Mediterranean region has scarce water resources and is particularly sensitive to climate change (Giorgi, 2007). Thus, precise irrigation systems such as drip-irrigation, which allow for optimal use of water supplies, may be particularly beneficial and when combined with organic fertilizers could mitigate N_2O emissions in Mediterranean climates (Aguilera, 2013). Fertigation (a combination of drip-irrigation with fertilization) is currently gaining popularity in southern France, including in vineyards and for perennial crops.

Many studies have shown the value of urine as fertilizer in agriculture (Jönsson, 2004). Urine separation reduces the energy requirement for water treatment and allows for the production of a safe and easy-to-use fertilizer. The use of urine as a fertilizer may offer an alternative to the continued large-scale exploitation of nitrogen (energy intensive) and phosphorus (non-renewable) for fertilizers which is considered unsustainable and may be untenable within a few decades (Cordell, 2010). However, to make this possible, research is needed to reduce constraints to the development of urine drip-fertigation, particularly linked to the properties of urine and improving irrigation equipment, which is currently sensitive to blocking.

A previous bibliographic study on the technical (Marijn, 2012), (Gutierrez, 2015) and agronomic (Schönning & Stenström, 2004) aspects of urine-irrigation underlined the lack of information on the impact of these practices on soil (salinity) and aquifers (transfers).

Goals

This research program aims to address several barriers to the use of urine as a large-scale fertilizer. An initial technical study will simultaneously analyze several drip-irrigation systems, looking into the physical clogging and degradation of the irrigation system when distributing diluted urine. The project will ensure the safety of urine-irrigation by monitoring soil salinity and potential pollution from leached nutrients. In addition, a complete analysis of the effluent and the leachate will check for possible micropollutants and pathogens.

Materials and methods

A first experiment will be conducted at the *Plateforme de Recherche et d'Expérimentation pour l'Irrigation* (PReSTI) at IRSTEA to test several drip-irrigation systems (pressure compensating PC and non-pressure compensating NPC) in controlled conditions similar to real working conditions. The closed-loop system will include four polyethylene lines of 5m long with 16 mm diameter each (Figure 1). Each line will contain 20 drippers (NPC2, NPC4 and PC) and the system, pressured for eight hours per day with pure urine, will accelerate the blocking process. For three months, weekly monitoring of dripper flow will allow us to investigate emitter clogging.

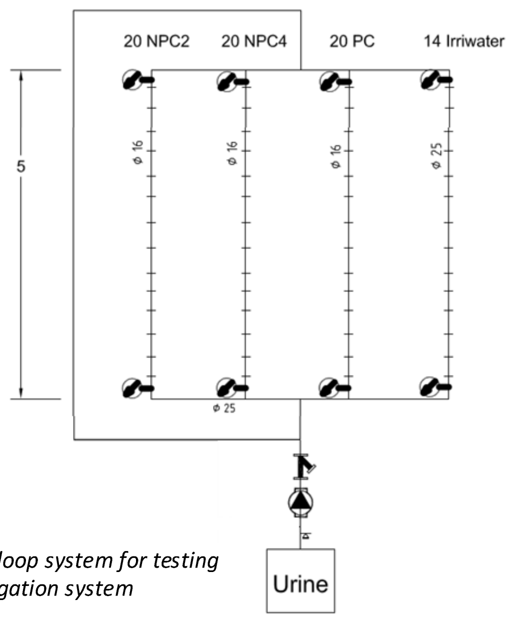
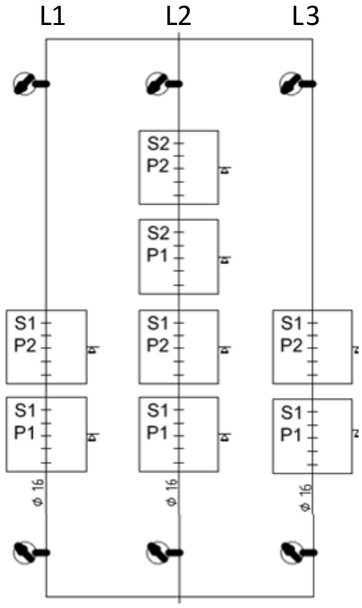


Figure 1: Closed-loop system for testing drip-irrigation system



Simultaneously, eight 1m^3 containers will allow off-ground crop cultivation. This innovative system provides the recovery of all leachates. Plants P1 and P2 (Figure 2) will be fast-growing plants; P1 a fodder plant (rye grass, *Lolium perrene spp.*), and P2 an edible plant (spinach, *Spinacia oleracea*). Two types of soils will be used to obtain two different hydraulic conductivities (S1 and S2, of 5 and 20 mm/h respectively).

Two irrigation lines will be fertilized with urine (L1 and L2) and one (L3) fertilized with a common horticultural fertilizer, Triabon. The amount of urine on line L2 will set at double the limit stipulated in the Nitrate Directive (170 kg N/ha). Line 1 and 3 will be fertilized at the limit of 170 unit per hectare. During this voluntarily excessive application on nutrients, leachate will be collected and essential nutrients (NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}) quantified weekly with a Hach DR900 spectrophotometer.

Figure 1: Off-ground culture system

The system used for the recovery of urine is a urine-diverting dry toilet such as the Ecodomeo sanitary system (Figure 3). It is possible that the urine collected from this type of system can be contaminated by pathogens such as viruses or fecal microorganisms. In order to ensure the safety of this urine and to detect the potential presence and persistence of pathogenic molecules, analysis will be carried out before and after the off-ground system. Chemicals to be analyzed will include drug residue indicators (carbamazepine, 10,11 epoxide-carbamazepine and diclofenac) and indicators bacteria of faecal contamination (Escherichia coli and enterococci).

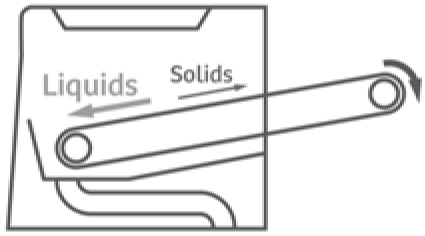


Figure 2 : A urine-diverting dry toilet system type ECODOMEO

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Project led by: ecosec irstea

Supported by: transferts LR Agence Régionale de l'Innovation du Languedoc-Roussillon; Occitanie La Région Pyrénées Méditerranée; bpifrance