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Advanced sensor system dedicated to real-time soil monitoring

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Summary:

The EU project FAMOSOS (Farm monitoring via real-time soil sensing) aims to develop a real-time monitoring system for soil data, including nitrogen (ammonium, nitrate, nitrite), moisture, pH, and dissolved oxygen with increased sensitivity, reduced response times and sample volumes. This IoT system will be composed of a wireless underground sensor network, composed of porous ceramic probe, combined with a micro pump, a sensor, and an antenna for wireless data transmission. The system will be tested in Germany, Portugal, and Finland, with data used in the biophysical Agricultural Production Systems Simulator (APSIM) model to identify sustainable, climate-resilient agricultural practices.

Keywords: soil monitoring, real-time, modelling, nano-electrodes, wireless underground IoT nodes

Famosos Objective

In 2015 alone, pollution led to an estimated 9 million premature deaths worldwide (16% of all deaths), 15 times more than from all wars and other forms of violence [1]. The zero-pollution vision for 2050 is *for air, water and soil pollution to be reduced to levels no longer considered harmful to health and natural ecosystems…. thereby creating a toxic-free environment*.

The EU is developing a more effective action plan [2] based on a 'zero pollution hierarchy' using the precautionary principle. Specifically, this plan calls out that where prevention at source is not (yet) possible, smart production and digital solutions for pollution tracking and reduction should be promoted. However, even if sensing platform for environmental monitoring already exist [3], a key challenge is the lack of effective digital monitoring tools [4] that provide real-time decision-making capacity and agency to end-users and stakeholders; including consumers, inspection services, industry operators, and environmental emergency responders.

FAMOSOS aims to enable more sustainable agricultural practices through real-time monitoring of N concentrations in the soil solution and the environmental conditions that drive them. This will be achieved through a novel sensor system [5], combined with laboratory and field experiments and modelling.

FAMOSOS will address these challenges:

1. Develop and test a tool for real-time in situ measurements of soil solution characteristics, including N concentrations (NH4, NO3) and oxidation status.
2. Estimate N losses (gaseous and leaching) from soil solution data and environmental drivers.
3. Improve our understanding of hot moments in N cycling after fertilization and rainfall/irrigation.
4. Develop smart fertilization practices depending on soil N concentrations.

In addition to detecting soil nutrient concentration, and predicting fertilisation requirements, soil and water detection can also allow for the early detection of contaminants.

Famosos System

FAMOSOS consists of three components that will be advanced in parallel: (i) sensor development, (ii) lab-field testing/measurements and (iii) Modelling & development for guiding N fertilisation.
The figure 1 described the concept.

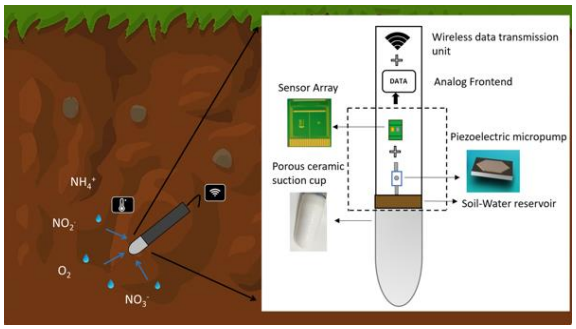

Fig. 1. FAMOSOS IoT system concept

The micro-pump and sensors already developed in Germany and Ireland will be evaluated, integrated with off-the-shelf suction cups, and need for adjustments or extensions of the sensors to operate under real conditions, as well as the sensor's requirements for proper operation (distance, reliability, ...) will be evaluated.
Concurrently, we will start with measurements and analysis of the data from the new probes, to i.e. relate soil N concentrations to fertiliser treatments. The experiments will start under controlled lab conditions, followed by in-situ measurements in the field.
The proposed cost-effective sensor system allows to measure continuous in-situ soil water N concentrations, using automated data acquisition and wireless data transmission through soil.

Results

By developing a tool which provides farmers with real-time information on the soil N status, FAMOSOS will make an important contribution to improving our understanding of soils for better management (optimized N fertilization strategies), which will further enable a more sustainable agricultural production (more efficient N use) and a healthier environment (decreased N leaching, N_2O emissions).

FAMOSOS illustrates the maturation of technologies towards broad adoption. The expected impact focuses on the benefits of the new sensor technologies to better understand N cycling in soils. This will increase the real-time decision-making capability of fertilizer management. Additionally, the project will create a new product, which can be marketed throughout Europe and worldwide.

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