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How to Close Nutrient Cycles in Agriculture? Innovative Solutions & Environmental Benefits

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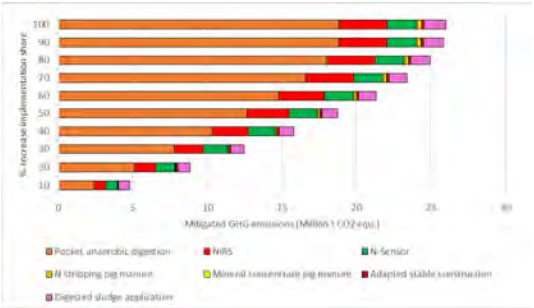
Sustainable agricultural intensification is needed to tackle food insecurity in Europe, but it is also associated with various environmental challenges, such as GHG emissions, acidification and eutrophication. Inadequate manure management and excessive nitrogen and phosphorous fertilizer application lead to eutrophication, contamination of ground and surface water with nitrates. The development of innovative technologies and new farming management practices in agriculture can help bridge the current nutrient gap, reducing environmental pressure. In the Horizon 2020 Nutri2Cycle project, existing CNP flows and innovative farm management systems and technologies are proposed, tested, and analysed.

Investigated technologies include: **(1)** Small/Farm-scale anaerobic digestion of pig manure ("**Pocket anaerobic digestion**"), **(2)** stable construction for separated collection of solid manure and urine ("**Adapted stable construction**"), **(3)** Using digestate, precision agriculture and no-tillage ("**Digested sludge application**"), **(4)** Near-infrared sensor technology in the nutrient application of liquid manure ("**NIRS**"), **(5)** Sensor technology to assess crop N status ("**N-Sensor**"), **(6)** Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming ("**N stripping pig manure**"), **(7)** Pig manure processing and replacing mineral fertilizers ("**Mineral concentrate pig manure**").

We investigate the (potential) mitigation of environmental emissions from implementation of each technology in Europe in 2030 using the CAPRI and MITERRA-Europe model. The mitigation effect is quantified for a range of implementation shares, ranging from the assumed initial implementation share to the maximum estimated implementation share.

Results show that among all modelled technologies "Pocket anaerobic digestion" emerges as a solution, offering the most significant benefits at the EU level with regard to agricultural GHG emissions (see Figure 1). The maximum application of pocket anaerobic digestion leads to the mitigation of 18.8 million tonnes CO2 eq., which reduces the agricultural GHG emissions in the EU-27 by 4.8%. The highest reductions occur in livestock-intensive countries like Germany, Spain, Italy, France and Denmark.

Figure 17. Mitigated GHG emissions in the EU for technologies scenarios compared to the reference.



In terms of the nutrient-related environmental impacts of the modelled technologies, we analyse their influence on mineral fertilizer utilization, manure application, nitrogen (N) surplus, and N leaching. Compared to other technologies, the N-Sensor shows the highest potential for reducing N-surplus, achieving a 2.6% reduction in the EU at maximum implementation share, followed by NIRS with a potential reduction of 2.1% compared to the reference in 2030.

Overall, our findings highlight the potential of innovative agricultural technologies to contribute to sustainability goals in the EU.