Dairy manure variability and treatment potential across different management systems

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Motivation

In 2023, 75 billion kg of manure was produced in the Netherlands, with 84% originating from the 3.85 million cows in the country. The total phosphorus (P) content in this manure amounted to 73.4 million kg (Fig.1). Due to nutrient surpluses, 30 million kg of phosphorus was exported to other countries[1].

At Wetsus, phosphorus removal as calcium phosphate (CaP) from animal manure through anaerobic digestion is already a well-established process[2]. However, until now, experimental setups have relied on manure from a single farm, despite chemical and physical analyses indicating variation in manure composition across different farms.

Technological challenge

Beyond the apparent uniformity of dairy manure, its chemical complexity varies depending on the type and proportion of organic inputs, directly influencing the potential for phosphorus (P) recovery. One key parameter is bicarbonate, a major buffering component in manure. It inhibits manure acidification, which in turn reduces ion solubilization and their availability during recovery processes. Bicarbonate also competes with phosphorus (P) for calcium (Ca), affecting calcium phosphate (CaP) precipitation during anaerobic digestion. Initially, a lower pH favors the release of phosphorus from bound into soluble forms. As digestion progresses, microbial activity raises the pH again, stimulating P precipitation as struvite or calcium phosphate. Additionally, manure's ionic strength – determined by ions like K^+, NH_4^+, Na^+, and Cl^- varies between manure samples and impacts the formation and stability of mineral phases, including those that regulate inorganic phosphorus (Pi) solubility[3].

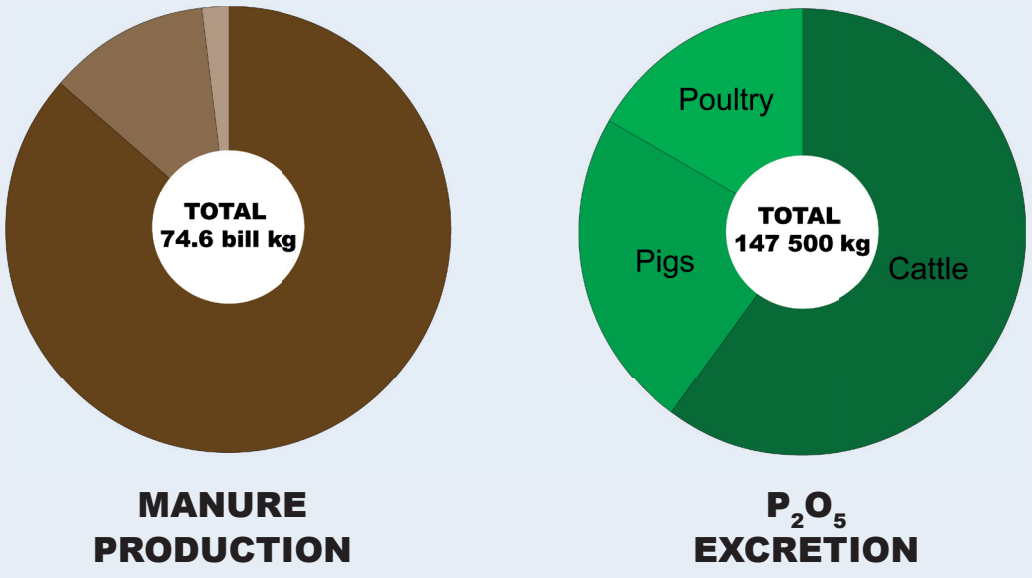

Fig 1. Manure production and P_2O_5 excretion in the Netherlands [1]

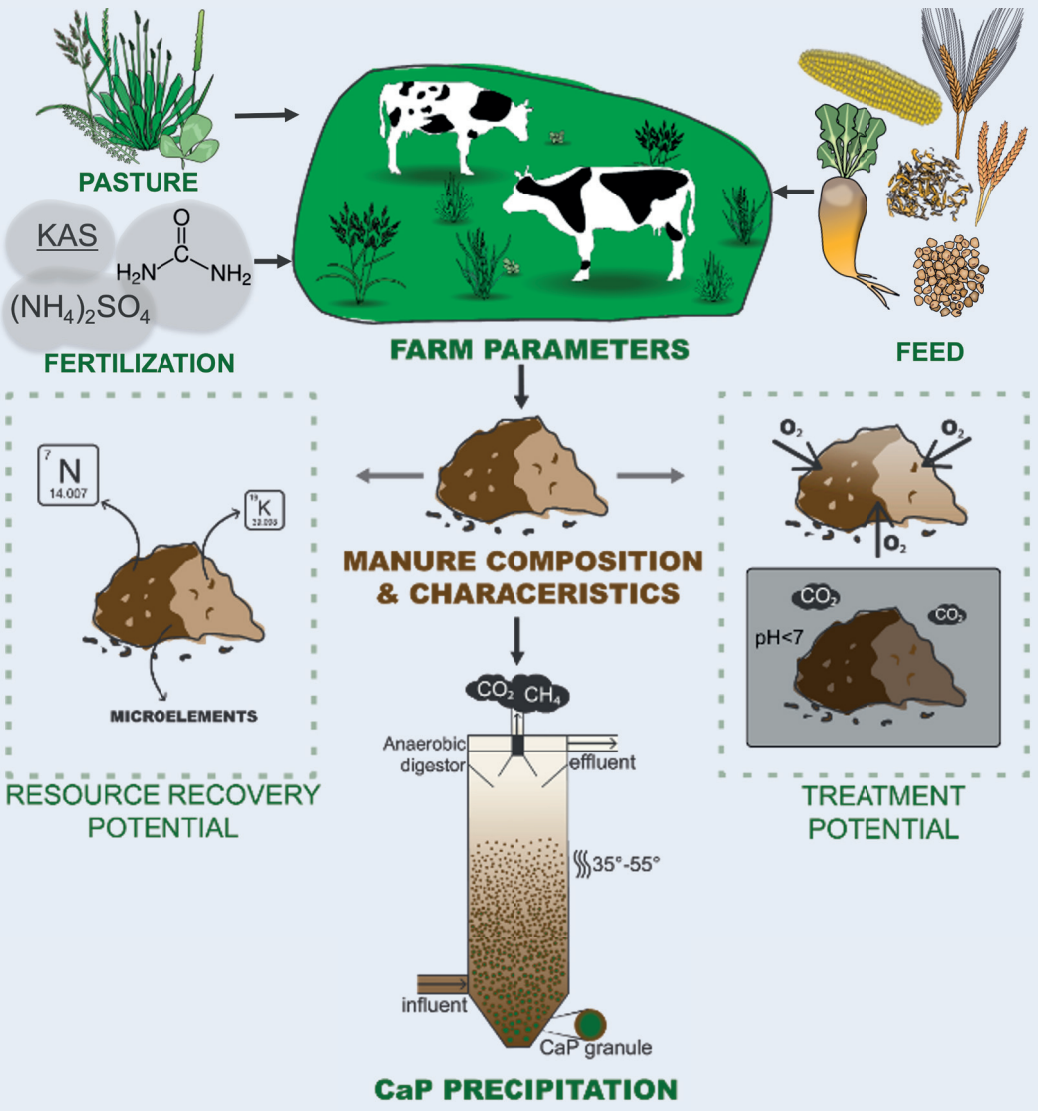

Fig 2. Project overview and schematic approach

Research goals

- Determine which farm upstream parameters enhance the availability of phosphorus for calcium phosphate (CaP) precipitation during anaerobic digestion.
- Identify farm-level upstream parameters that contribute most to the buffer capacity of manure.
- Characterize manure composition and characteristics to identify potential treatment methods and other resource recovery opportunities.
- Define manure recovery potentials based on farm management systems.

References

[1] CBS, StatLine, Animal manure (2024)
[2] C. Schott, Recovery of phosphorus from animal manure (2023)
[3] P. H. Pagliari, Applied Manure and Nutrient Chemistry for Sustainable Agriculture and Environment (2014) 141-161

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