Cradle to Cattle farming

Acronym: CtoC farming

Coordinator:
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- **Maatschap Nijkamp-Marsman (NL)**
- **New Chemical Syntheses Institute (PL)**
- **Warsaw University of Life Sciences (PL)**
- **Centre for Ecology and Hydrology (UK)**

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Introduction

The decrease in number of farmers and the increase in farm sizes will continue. The milk quota in the EU will be abolished and this will give a further increase in the size of herds of milking cows. In the Netherlands the stables for milking cows have been enlarged. Even in the period of recession in the building sector, companies building stables were very busy in the Netherlands. The next bottle necks for farmers will be to get rid of the manure. This is already a problem for pig farmers in the Netherlands, who pays up to € 20,- euro a ton. The norm for putting the nitrogen part has also decreased in the last week to 230 kg a hectare for grassland (derogation). For phosphate the Dutch government has introduced legislation to limit the amount of phosphate for the Dutch agriculture. Farmers could get additional revenues when export it. The solution of the problem of phosphate surplus could be the decrease of phosphate import. The second problem is the feeding of the cows. Protein rich feed is needed to get the a highly productive milking cow. Soya is important for this. It would be good to replace this by locally produced feed. This means less import of Soya beans for feeding the cows and pigs and less imported phosphate for using fertilizer. To a lesser extent, but concentration processes in the farming sector takes place also in Poland and the UK. This proposal gives a solution to these problems on farm scale.

Results

Over the past 3-4 years a manure treatment system based on an anaerobic digester, phosphate removal system, nitrogen removal system and duckweed production system has been developed and tested. Based on the test results a commercially viable installation has been built on a dairy farm close to Deventer.

A mono manure digester takes in the fresh manure and produces biogas from it. In the process organic material is degraded and chemically bound nitrogen and phosphates are released in their mineral form to the digestate solution. In a manure refinery system consisting of a nitrogen stripper and phosphate crystallizer these mineral nutrients are isolated from the digestate and converted into mineral fertilizer (nitrogen in the form of ammonium sulphate) and concentrated organic fertilizer (phosphate in the form of struvite). Subsequently the remaining digestate is used in a duckweed pond where the duckweed grows on the remaining nutrients. The produced duckweed is a high protein biomass that can be used as soybean replacement in the animal feed mixture.
Before the digestate enters the manure refinery installation, dubbed Bio-NP, it is separated by a screw press separator into a liquid fraction and a solid fraction. Only the liquid fraction is processed as it contains the soluble minerals.

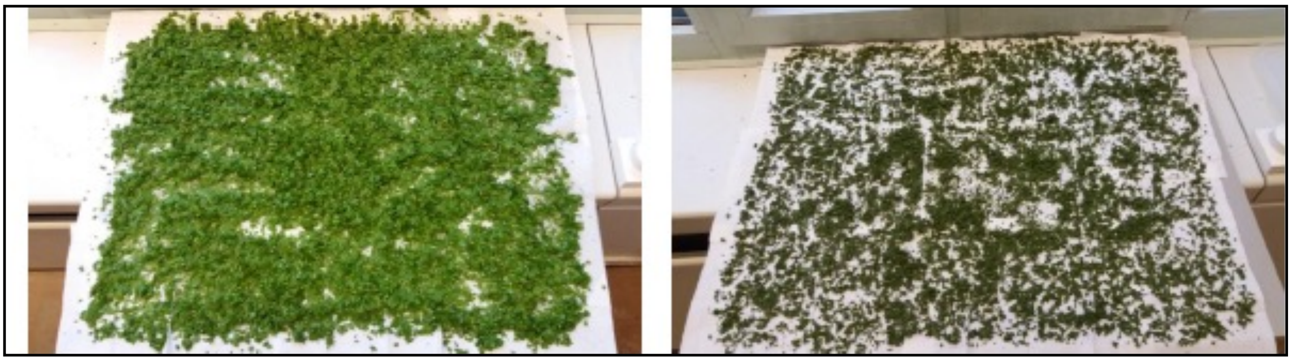
After separation the liquid fraction is heated before it enters a packed column where it is brought into close contact with circulating air. The pH is raised to release ammonium to the air. The ammonia containing air is subsequently washed in a second packed column where an acidic solution is sprayed over the column bed. Ammonia in the air thus reacts with the solution to form an ammonium-salt solution that can be regarded as a mineral fertilizer.

picture 1: Greenhouse testing Lemna Minuta

In the struvite reactor, a conical crystallizer, magnesium and sodium hydroxide are added to form struvite crystals that consist of magnesium, ammonium and phosphate. Originally the struvite crystals were supposed to sink into a fluidized bed in the crystallizer. Tests have shown that this is not, or very limited, the case. Hence, a second separator was added behind the crystallizer to collect the fine crystals that formed. This product is a phosphate rich fertilizer.
The product (mineral) fertilizers with phosphate and nitrogen have been analyzed and tested for their fertilizing behavior. In pot experiments grass and corn were tested with different regular fertilizers and the fertilizer products of the Bio-NP. The results were equivalent and in some cases advantageous for the Bio-NP products.

As a final treatment and manure processing step, a duckweed pond was designed and build to produce protein rich biomass from the remaining nutrients in the effluent of the manure refinery. Herein Lemna minuta/Lemna minor is cultivated. Several tests have been done in order to optimize the growth conditions, optimize the pond layout, harvesting system etc.
The different steps in the process have been carefully integrated and the complete installation has been evaluated in an extensive mass and energy balance. From these calculations and the test results, a detailed business case has been developed on the basis of which the first commercial farm near Deventer decided to start operation.

picture 2: Drying Lemna Minuta



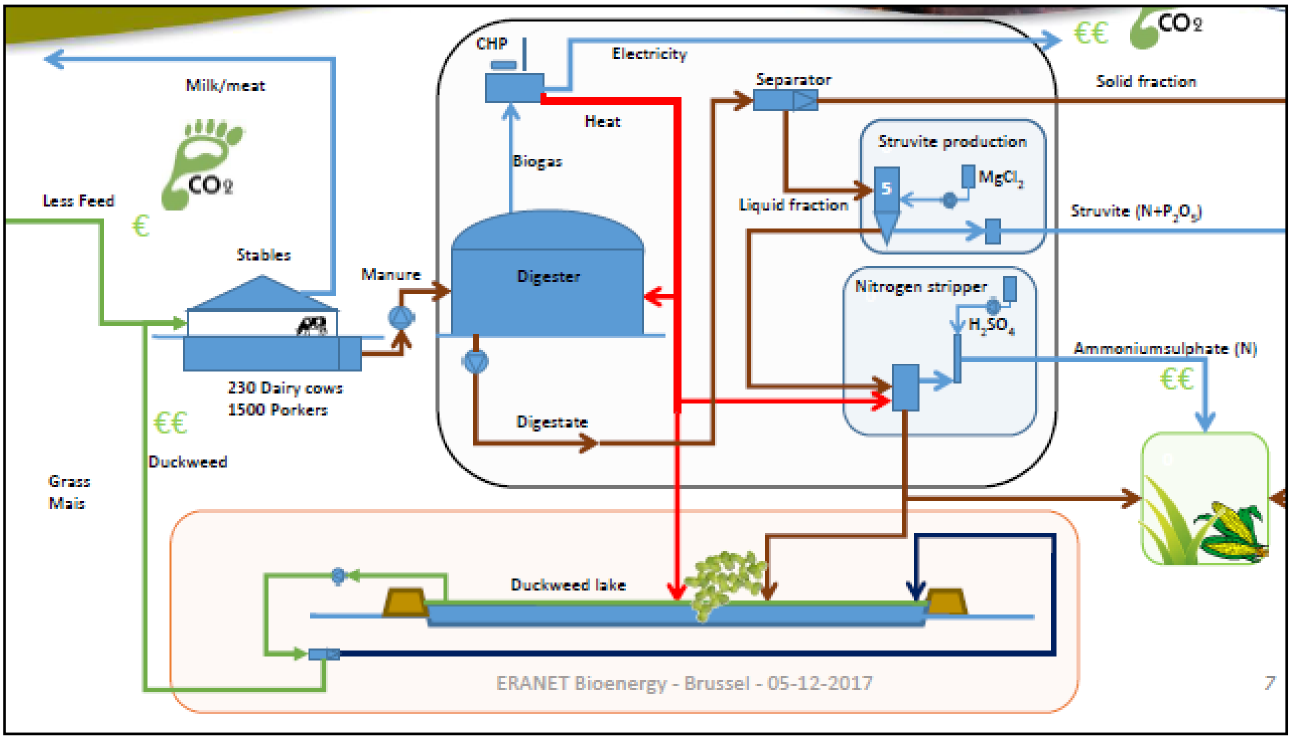


Figure 1 Schematic representation of the CtoC process on the farm

Conclusions

A manure/digestate refinery system has been build and tested at De Marke, showing the potential for phosphate and nitrogen removal from manure. Based on the findings, updates and improvements have been made to the system before it was commercially deployed at a farm in the Deventer environment. Improvements made are changes to the struvite separation system in order to separate more phosphate from the liquid manure. Furthermore modifications were made to the nitrogen stripper system so it relies to a lesser extend on the addition of sodium hydroxide, making it obsolete in the end.

In the CtoC project the products of manure refinery have been analyzed and tested for applicability as mineral fertilizer. It was shown in several pot tests that the produced struvite and ammonium sulphate can be a suitable replacement of commercially available mineral fertilizers with similar or better results.

On the effluent of the biorefinery duckweed was grown in several test series. As maximum duckweed production is crucial, both to nutrient recovery rates and to feed production rates, it was found that the effluent of the biorefinery is sub-optimal and it is better to use untreated digestate. A fully equipped test pond has been developed and build at the same site as the biorefinery system and will commence production in 2019.

Acknowledgment

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The ERA-NET Bioenergy is a network of national ministries and agencies. It contributes to further development of the European research area in bioenergy and strengthening of national research programmes through enhancing international cooperation and coordination.

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