Managing phosphorus cycling in agriculture

Phosphate recovery from animal manure

Introduction

The total amount of animal manure, expressed in terms of phosphate, was 160-180 million kg P_2O_5 in the Netherlands, during the period 2005-2009. About 50-60% of this amount could be applied to the land of livestock farms where the manure was produced. The complement (40-50%) had to be transported to other farms (mainly arable farms), was exported to other countries, or was treated (e.g. incineration of dried poultry manure). For the implementation of 'balanced fertilization' by 2015, the use of phosphate fertilizer has to be restricted and manure production has to decrease by about 60 million kg phosphate or this amount will have to be processed and exported. The limited space for manure disposal has serious economic consequences for intensive livestock production.

At the request of the Ministry of Agriculture, Nature and Food Quality, series of explorative studies have been carried out to optimize the phosphate cycling and balance in agriculture. Some of these studies focus on the possibilities and consequences of lowering the phosphate content in animal feed through altering its composition and by means of biorefinery. Others focus on manure separation and precision fertilization with separated manure fractions. In this factsheet we summarize the results of an explorative study of ways to recover phosphate from animal manure into chemical fertilizer or biochar. The aim of the study was to identify cost-effectives ways for large-scale recovery of phosphate from manure, i.e., some 40-60 million kg phosphate per year.

Methods and results

On the basis of a desk study, which combined literature review, stakeholder interviews, expert meetings, assessment of international studies and economic costs assessments, a framework was developed for manure processing and discussed with stakeholders (waste processing industries, phosphate fertilizer industries) who could use these types of resources for further processing. Together with these stakeholders, the conditions and composition of the phosphate resources from manure were discussed. Finally, a tentative cost analysis was made in relation to the observed potential options of P recovery. The phosphate fertilizer industry show great interest in phosphate recovery from animal manure. They are keen on using certain wastes as feed stock for the manufactory of phosphate containing products and fertilizers, because they are aware of the future shortages of rock phosphates. However, they set constraints to the composition of the feed stock (i.e., manure). In order to obtain the right conditions and compositions of the phosphate containing manure resources for these industries a scheme was developed to show in which way these phosphate containing manure resources can be processed from pig slurry (Figure 1). This requires a sequence of steps, as discussed below.

Manure separation

Via manure separation a solid wet cake with a relatively high phosphate and organic matter content is created and a voluminous liquid fraction with relatively high nitrogen and potassium contents. In many cases, the liquid fraction can be used on nearby agricultural land, and only the solid fraction has to be exported from the farm. The transport costs are relative low because the water content is relatively low (see also factsheet Slurry separation justifies differentiation of manure application thresholds). The solid fraction is considered as the most valuable manure fraction for energy production and phosphate recovery.

Purification

In case the liquid fraction cannot be applied to nearby agricultural land, it has to be treated before it can be discharged to surface water. However, the purification of the liquid fraction can be performed in such way that also some products are produced which could be supplied to the industry (e.g. phosphate precipitates, potassium precipitates and nitrogen compounds, and natural mixtures of these components like ammonium and potassium struvite).

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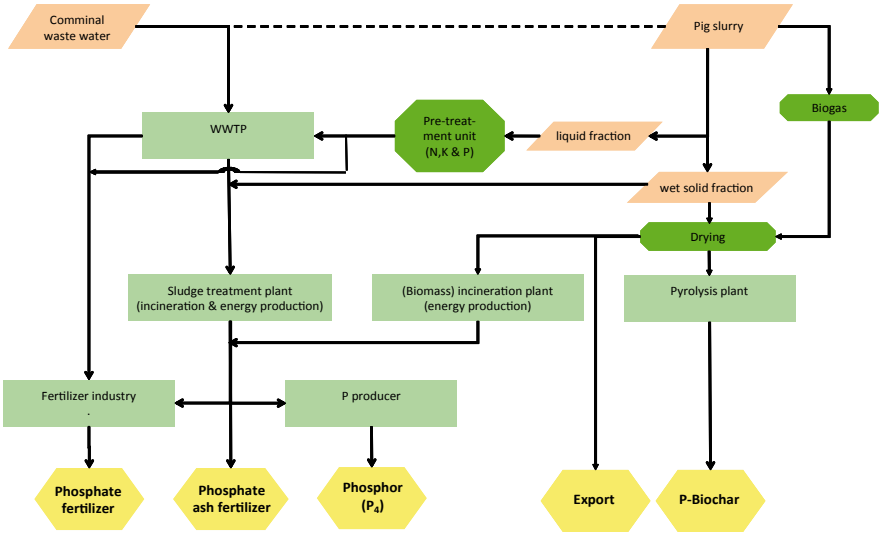
Drying

Depending on the following processing steps drying of the wet manure cake is sometimes needed in order to increase the dry matter content. An option is to dry the wet manure cake centrally in the region at large scale, and not at each individual farm, to make use of the possibilities to combine drying of manure with the residual heat of power plants.



Figuur 1. Scheme of the treatment of animal manure to valuable P resources for important P industries.

Pyrolysis

Dried manure cake can be pyrolized and a soil ameliorated product is produced (biochar) with a high P content (see also factsheet 27). Soil ameliorated products have a relatively high market value compared to chemical fertilizers. However, the market for these products is limited compared to the fertilizer market, although the interests of farmers to use biochars is increasing (especially in the USA).

Incineration

The dry matter content of wet manure cake is comparable to the dry matter content of sewage sludge and can be incinerated at a sewage sludge plant. A phosphate rich ash will be formed. During the incineration a part of the energetic value of manure will be recovered More efficient and even profitable recovery from the energetic value of the dried cake can be achieved by using furnaces which are specially designed to generate electricity ,e.g. at biomass incineration plants.

P ash treatment

The P-rich ash of incineration plants can be used as a resource to produce elementary phosphorus. Elementary phosphorus is used as a resource for several markets, including food as well as non-food markets. The fertilizer industry would be able to process the P-rich ash by mixing it with chemical fertilizers. For both ends, final processing steps and some additional practical experiments are needed, before the industries will implement the material into there processing system.

Conclusions

There are various technical options to recover phosphate from animal manure. Especially, the solid fraction of manure is useful, because of the relatively high phosphate and organic matter contents. Energy recovery may facilitate the phosphate recovery.
The phosphate industries are interested in using phosphate-rich animal manure fractions as feed stock, but they demand further real-scale practical experiments. Furthermore, producers and consumers of the animal manure P-resources have to come to agreements regarding the delivery (quantity and guaranteed quality). Ultimately, the net costs to produce these P animal manure resources should be acceptable for all parties involved.

Factsheets Wageningen innovation studies on manure processing:

No. 23 Tentative results from innovation studies in a nutshell
No. 24 Phosphate recovery from animal manures
No. 25 Reduction of Dutch agricultural phosphorous load through bio-refinery
No. 26 Pretreatment of manure
No. 27 Biochars from digested fattening pig slurry
No. 28 Market survey into reduction of phosphorous in pig feed
No. 29 Feeding management to reduce phosphate in animal husbandry
No. 30 Slurry separation justifies differentiation of manure application thresholds

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