Animal manure has always been used as a nutrient in crop production. As livestock farming became increasingly industrialized, farms became so big that there was not enough land available for dispersing the manure they produced. Manure contains large quantities of the nutrients phosphorus and nitrogen. Without proper management, the nitrogen is released into the air where it contributes to climate change. The phosphorus enters watercourses and contributes to eutrophication in lakes and seas. The natural cycle is disrupted.

In 2010 BalticSea2020 started a long-term, large-scale project in close cooperation with an industrial pig farm in Poland. The project aimed to see if it is possible to carry out a modern meat production without extensive loss of nutrients.

It is a cold morning in March when we arrive at the pig farm in Przybkowo, about 150 km from the coast in northwest Poland. As the car door opens, we are assailed by a smell that leaves us in no doubt that the farm produces a great deal of manure. The farm raises about 60,000 pigs annually. Together they produce 55,000 m³ of manure. This is equivalent to what a town of about 200,000 people produces per year. We are on a large farm, but Poland and Europe have many farms like this – or even larger.

Pigs, like humans, have a relatively inefficient digestive system. A pig utilizes about 25% of the phosphorus and 35% of the nitrogen in its diet. The rest is simply passed out in the dung. Both nitrogen and phosphorus are important plant nutrients and are therefore used in crop production. When managed correctly, manure is a valuable agricultural resource.

The aim of the project at the pig farm in Przybkowo is to try to retain as much as possible of the nutrients in the manure. This is to enable the farm to become virtually self-sufficient and to avoid having to buy in mineral phosphorus or nitrogen. In other words, to create a nutrient cycle.

The old way
Before the farm joined the project, the manure from pig production was managed in accordance with current practice. The raw manure was collected and stored in large lagoons before being spread on fields, either early in the spring or before the autumn sowing. The manure was collected from the lagoons in large barrels pulled by tractors, and then spread on fields in the vicinity. The tractor would then return to the lagoon with the empty barrels to be refilled. Pig manure contains a lot of water (about 95%), so it is heavy and expensive to transport over longer distances. The repeated trips to refill the barrels damage the soil through compaction. The process is also labour-intensive and consumes a lot of fuel. But above all, the manure
nutrients are not utilized efficiently. The main part of the nitrogen is lost to the atmosphere as ammonia. Phosphorus is not managed at all, which makes it easy to over-fertilize the fields. The amount of nitrogen that may be added to arable land is subject to legislation, maximum 170 kg per hectare. However, all forms of phosphorus management are currently completely voluntary in most EU countries. In Sweden and Finland, a level of phosphorus that may be applied to fields has been decided under the auspices of HELCOM (a rule of thumb is that it should not be more than 22 kg per hectare).

The start of the project
In 2010, BalticSea2020 started Circular Nutrient Management at Industrial farms (CNMI), a long-term research and action program aiming to identify technologies and methods for minimizing the risk of nutrients leaching from manure. To enable it to be implemented, the project needed a large-scale livestock farm whose management and staff were willing to invest both time and commitment. That farm was in Przybkowo in Poland, managed by Marian Kaplon.

Marian has spent most of his working life in the industry, and knows everything worth knowing about running a pig farm. He and his employees also share a drive that was a good fit for the project: a strong desire to improve processes and management, which has been indispensable throughout the project.

“From the outset we had an idea about building a biogas plant for the manure and maize we produced. The majority of the construction would be financed through government loans. When we were looking for a company to help us build the plant, we came into contact with a Swedish company. This led to a meeting with BalticSea2020. Following that meeting, we realized quite quickly that the best thing for the Baltic Sea and our business was not energy production. It was converting the farm’s surplus nitrogen and phosphorus for food production, and using technology and methods to reduce the leaching of nutrients into watercourses and ultimately the Baltic Sea,” says Marian.

At the start of the project, the farm’s nutrient balance was studied in depth. This was to enable the testing of a series of measures to facilitate the monitoring and control of phosphorus and nitrogen in the manure. The farm has 900 hectares of arable land, but produces so much manure that it would need just over 3000 hectares to disperse the excess nutrients. The nutrients are intended to be used in agriculture, so it is important that they are plant-available. The solution was therefore to separate the phosphorus and nitrogen as a wet (nitrogen-rich) fraction and a dry and light (phosphorus-rich) fraction. The dry fraction can be transported to neighbouring arable farms, thereby increasing the area over which the manure is spread. Achieving nutrient circularity required investments in some new technology and new manure storage. The construction project began in 2014 and was completed in autumn 2017. Today, three years later, almost 165 m3 of manure is treated every day of the year.

Safe management of manure and effective spreading
In the new management system, all raw manure from the livestock housing is pumped to buffer tanks. These ensure a constant flow of manure through the separation line. From the buffer tanks, the manure is then first pumped to a screw compressor (fig. 1) where large particles are separated to create wet and dry fractions. The dry fraction is fed to a container, while the wet fraction is pumped on to the next stage, centrifugal separation. In the centrifuge (fig. 2), very small particles are separated out, leaving a nitrogen-rich, brown-coloured liquid (liquid manure). The dry, phosphorus-rich fraction is separated in the screw compressor and the finer ones using a centrifuge. The dry fraction is transported daily by truck to farms in the vicinity and a biogas plant. After the manure has been separated into two stages, the wet fraction is pumped to an acidification plant where sulphuric acid is added (Fig. 3). The sulphuric acid lowers pH in the liquid manure which makes the nitrogen less volatile and reduces odour when the manure is spread.

Project brief

Fig. 1. The screw press separates the fine particles in the phosphorus-rich dry fraction. The material that passes through the screw press is collected in a container below. The container is connected to a truck that removes the dry fraction daily.

Fig. 2. The centrifuge that separates small particles. Photo: BalticSea2020
Finally, the wet fraction is pumped to four sealed lagoons of 13,000 m³ each (Fig. 4). The large storage capacity means that the farm can store manure for up to 12 months, or until growing or weather conditions are optimal for spreading.

To minimize the loss of nutrients when the manure is spread, and to increase the efficiency of the work (by reducing material, personnel and fuel costs), the project has established a closed system for transporting and spreading liquid manure. The liquid manure is pumped from the storage lagoons through soft transport hoses right up to the edge of the field (up to 6 km). At the edge of the field there is a hose reel where the soft transport hose is connected to a hard trailer hose (Figs. 5 and 6). The hose is changed from soft to hard because it is much easier for the tractor to drag the hard hose over the field and it does not damage growing crops.

Finally, the manure is applied to the roots of the crops using a 24-meter-wide dribble bar (Figs. 6 and 7), which adjusts the amount of manure applied on the field to suit the crop.
Results
The results of the project indicate that nutrient utilization is now much more efficient. Today 65% of the nitrogen is stopped from escaping to the air as ammonia, and just over 70% of all phosphorus is separated out. The phosphorus that is not used as fertilizer on the arable land locally is sent daily to farms in the vicinity. Any dry fraction remaining is sold to a local biogas plant.

Phosphorus management in particular has proved very cost-effective compared with other manure phosphorus management measures. And perhaps most important of all is that the farm now applies the exact amount of the nutrient that the crops need. Phosphorus does not therefore leach into watercourses, lakes and ultimately the Baltic Sea.

Conrad Stralka, Executive Director at BalticSea2020, has been working on the project since it started in 2010. “The big advantage of the process is that the technology used is based on mechanical processes, no chemicals are used. The technology is also known to farmers who run larger farms or animal farms. Acidification is a well-known technique in Denmark and fertilizer separation is done today mainly to produce bedding material for animals.”

And Marian agrees: “The biggest advantage, in my opinion, is that the line is straightforward and efficient, and can be implemented on any livestock farm.

Spreading knowledge
In parallel with the practical work, the project has run a scientific monitoring program in collaboration with the Swedish University of Agricultural Sciences (SLU) to measure and evaluate the effect of the measures taken.

To disseminate experiences from the project, a White Paper is being produced describing the project’s objectives, how and why it was carried out, and its results and costs. The White Paper will be available from the beginning of 2020. It will also contain recommendations applicable to livestock farms and agriculture in the region.

Read more about the project at www.balticsea2020.org

Text: Madeleine Kullenbo, BalticSea2020