Recyclable liquid manure – how the environment and businesses benefit from mobile liquid manure processing

Liquid manure is initially a waste product. Within the framework of a closed nutrient cycle, it can also become a valuable raw material. When liquid manure is used in large quantities as a fertilizer in regions with intensive cultivation, it increasingly pollutes the environment and groundwater. This results in stricter regulatory requirements, which in turn make it more difficult to economically store, transport and spread liquid manure. Innovative concepts and technologies for the processing of liquid manure are needed to ensure that the nutrient cycle does not ultimately become a „vicious circle“ for farms. Liquid manure should continue to be understood as a recyclable material and not just as a disposal problem. To achieve this, new treatment processes must be both environmentally friendly and economical. Ideally, the liquid manure should be processed directly on site and used regionally.

This whitepaper deals with the question of how liquid manure processing can be carried out simply and efficiently. The focus is on the mobile liquid manure separation system MoRoPlant20. The paper is aimed at small and large livestock breeders, agricultural consortia and suppliers of large agricultural enterprises, as well as specialist media and the interested public.

1. Liquid manure poses a challenge to agriculture

Liquid manure is often primarily perceived as a problematic substance. This is mainly due to overfertilization practices in regions with intensive processing. Plants are usually only able to absorb part of the nutrients supplied. In the case of phosphate, an absorption of less than 30 percent may be the case during the vegetation period. The supply of nitrogen via liquid manure and via other fertilizers also exceeds the absorption capacity of many locations. Excess nutrients seep away with the rain and can get into groundwater or inland waters. There they disturb the ecological balance and, in the worst case, threaten health. To reduce risk, the EU has set limits such as 50 milligrams of nitrate per liter in groundwater. However, measuring points repeatedly prove that the limiting values are exceeded.

One reaction in Germany in 2017 was the amendment of the German Fertilizer Ordinance (DüV) combined with the further restriction of the spreading of liquid manure on fields or grassland. This regulation is intended to relieve soil and groundwater pollution during periods of high precipitation. However, many farmers face challenges in meeting deadlines. They must either create significantly larger storage capacities or transport their liquid manure to other regions. The shipment must be declared as hazardous goods, although it is predominantly water. This “manure tourism” is associated with further costs and additional emissions. In other words: in the long term, neither the transport nor the storage of liquid manure is a sensible solution for farmers.

In the context of liquid manure, this situation shows that a different approach to nutrient management is required. The central solution lies in the processing of liquid manure by separation.

2. Liquid manure must be defined as a valuable recyclable material – and then separated

In order to find an environmentally friendly and economical solution for the liquid manure "disposal problem", a different way of thinking must be adopted: away from dealing with a problem and towards recycling materials. After all, elements such as phosphate and nitrogen are ideal plant fertilizers when they are professionally filtered and processed. Cattle and pig breeders therefore have the opportunity to contribute to a closed nutrient cycle with their alleged waste product and to create added value for their business.

Various separation processes are available for the processing of liquid manure on demand. What the techniques have in common is that they tend to separate the liquid manure into solid matter (dry solids) and process water (centrate). Thus, on one hand, farms receive natural fertilizer, and on the other hand they have water which they can sprinkle over a region. The following five mechanical processes can be considered for the separation of liquid manure:

1. Screw press
Procedure: The liquid manure is pressed by a screw against a surrounding sieve.
Advantage: moderate energy requirement
Disadvantage: lower separation efficiency than with centrifugation

2. Centrifuge
Procedure: The liquid and solid phases are separated by a fast rotary motion.
Advantage: higher separation efficiency than with press screws
Disadvantage: slightly higher energy requirement than with press screws

3. Multi-stage separator
Procedure: Several centrifuges are used one after the other.
Advantage: particularly high separation efficiency
Disadvantage: high investment and operating costs

4. Sedimentation
Procedure: During storage of the liquid manure, the solids gradually settle downwards.
Advantage: cost-effective
Disadvantage: lower separation efficiencies, high storage and safety costs

5. Complete system
Procedure: The liquid manure is processed in several steps using additives which are mostly chemical.
Advantage: particularly high separation efficiency
Disadvantage: high investment and operating costs

Among the processes mentioned, to date, press screws and centrifuges have the best cost-benefit ratios. In both cases, however, the available technologies do not yet bind enough nutrients in the dry solids, so that the concentration in the remaining liquid manure (the centrate), is still too high. In addition, stationary separation plants are usually not profitable for smaller companies due to high investment and operating costs. For these reasons, developers in agricultural mechanical engineering have embarked on a search for a more efficient, mobile separation technology. One promising result of these efforts is the MoRoPlant20 separation system, which is described in more detail below.

Outside view in DLG field test

3. Functionality of mobile manure separation with MoRoPlant20

The system offers an equally efficient and environmentally friendly solution for the mobile separation of liquid manure. The basis for this is on the one hand a new flocculant and on the other hand Flottweg's proven centrifugal technology. The result is a particularly high separation efficiency for phosphate and nitrogen. As a container system, it can be used on more than one farm and is therefore also ideal for smaller farms, machinery cooperatives and agricultural equipment suppliers. It will also make it possible to process manure lakes, which already represent a major environmental problem in some regions of the world.

The compact system is located in a swap body container and is scalable in size:

Technical data of the Flottweg MoRoPlant*

Type	MoRoPlant20	MoRoPlant20+	MoRoPlant40	Individual
Materials	All product-wetted parts are made of corrosion-resistant stainless steel.			
Dimensions (l x w x h)	6058 x 2438 x 2591 mm	7820 x 2438 x 2591 mm	12192 x 2438 x 2591 mm	individual
Gross weight	approx. 9000 kg	approx. 13000 kg	approx. 20000 kg	individual
Required power	63 A	125 A	250 A	individual
Mobile	yes	yes	yes	no
	Capacities			
Pig slurry	up to 5 m³/h	up to 10 m³/h	up to 20 m³/h	up to 200 m³/h
Cattle slurry	up to 2 m³/h	up to 5 m³/h	up to 10 m³/h	up to 100 m³/h
Fermentation residues/slop	Due to different raw materials, the capacity for biogas may vary considerably. Please contact us for individual information.			
Possible operating hours	24/7			

* The listed figures are merely guidelines. Actual capacity depends on the individual characteristics of the product. Subject to technical changes.

Preliminary stage: Addition of bentonite and starch

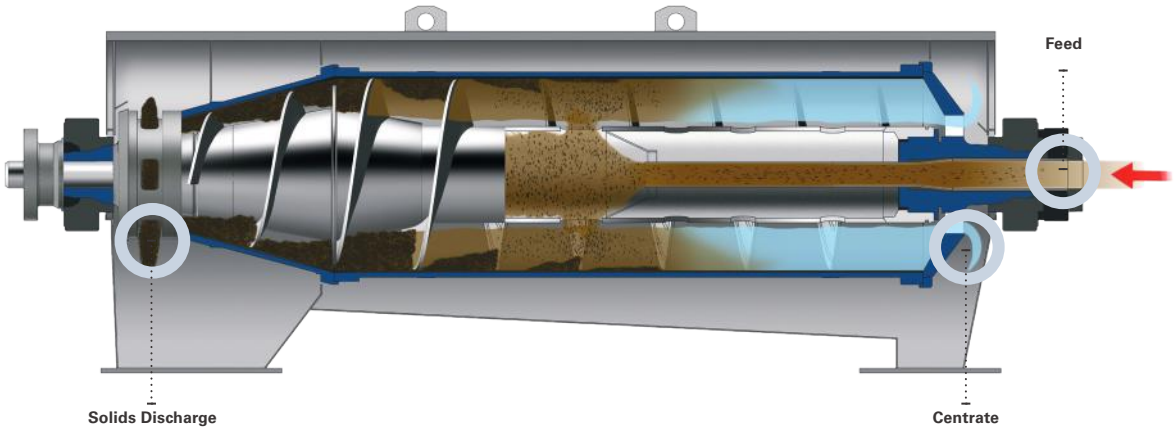
A special flocculant consisting of bentonite and starch is added to the liquid manure before the separation process. The clay mineral mixture, bentonite, acts as a natural separating agent. Due to its adhesive-similar properties, the plant starch binds the solid components of the liquid manure with the bentonite to form a water-insoluble flock. This facilitates mechanical separation and increases selectivity. The mixing and administration of the two additives is fully automatic. The components enter the liquid manure via a hose system before it is fed into the decanter.

Centrifugation: Separation of solids and process water

The separation takes place in a Z-series modular high-performance decanter from Flottweg. The decanter centrifuge bowl has a cylindrical-conical shape and rotates at a high speed (approx. 2500-5000 rpm). Its geometry is precisely matched to the slurry additive mixture. The mixture reaches full circumferential speed within the bowl and then settles on the bowl's surface as a cylindrical sleeve. Solids settle on the inner wall of the bowl when subjected to centrifugal force. Under centrifugal force, solids settle on the inner wall of the bowl. The differential speed determines the residence time of the solids in the bowl. Among other things, this residence time is decisive for a high dry solids content after separation.

The separated solids are finally centrifuged through outlet openings at the conical end of the bowl into the solids housing and discharged downwards. The clarified process water flows to the cylindrical end of the drum and is then collected in a centrate chamber and discharged by gravity.

Schematic view of manure separation in the Flottweg decanter centrifuge:



4. Separation efficiencies determined in DLG test

In order to determine the performance of the MoRoPlant20 liquid manure separation system in a reproducible manner, an extensive test with cattle and pig manure was carried out in 2018 on behalf of the German Agricultural Society (DLG e.V.). Based on the measurements, the DLG confirmed a high degree of selectivity by awarding the “DLG recognized” test seal in gold.

The most important facts about the measurements and results are summarized below. The complete DLG test report is available free of charge at: www.DLG-Test.de

Method of measurement

The measurements took place on a pig fattening farm in Bavaria. Trials were carried out with liquid manure from three fattening pig herds and three dairy cattle herds, from six separate operations. To this end, two tankers of liquid manure were delivered from each farm. A tanker truck equipped with a pumping system for homogenizing the slurry was used to feed the separation system via a shearing wheel pump. The contents of the second tank truck was intermittently transferred via a mobile pumping station to the other tank truck, so that there was always enough homogenized liquid manure from a single origin during the measuring period. The inspectors recorded all material flows and took samples hourly at each inlet and outlet point.

Calculation of separation efficiencies
From the samples, laboratory technicians determined the dry solids (DS) content and the total content of ammonium nitrate, phosphate and potassium, copper and zinc, as well as the pH value and the carbon/nitrogen ratio. Based on these results, the separation efficiencies for liquid manure from fattening pig and dairy cattle could finally be calculated.

This formula was used to calculate the separation efficiencies:

$$y = \frac{c_{Feed} \cdot m_{Feed} - c_{Centrate} \cdot m_{Centrate}}{c_{Feed} \cdot m_{Feed}}$$

y = separation efficiency in %
c = concentration of the component in kg/t
m = mass of the nutrient

Results
The test has confirmed that MoRoPlant20 achieves remarkable separation efficiencies: Through the combination of flocculant and high-performance decanter, the separation system achieves a dry solids content of over 80 percent. A special feature is the highly efficient separation of phosphate: up to 99 percent phosphate is bound in the solids. For nitrogen, the separation rates are over 60 percent (dairy cattle manure) and over 40 percent (fattening pig manure) respectively. The degree of separation of potassium from the liquid manure of fattening pigs was average, however in contrast, a high degree of separation of more than 40 percent was achieved from the dairy cattle liquid manure.

The following table provides an overview of the results:

Test result/separation efficiency	Manure from fattening pigs		Manure from dairy cattle	
	Test result	Evaluation*	Test result	Evaluation*
Fresh weight	13%	n. e.	29%	n. e.
Dry substance	83%	++	89%	++
Total amount of nitrogen	41%	++	67%	++
Phosphor	96%	++	92%	++
Potassium	23%	o	43%	++

* Valuation area: ++ / + / | / o / -- (o = standard, n. e. = no evaluation)

According to the DLG (German Agricultural Society), the centrate may qualify for an exemption from the restriction period due to its low dry solids content of less than 2 percent (according to § 6, Section 10 of the Fertilizer Ordinance – subject to the competent state authority).

5. Possible use of solids and process water

The test results indicate that a wide range of uses are possible for the separated products. The following options make it possible to economically produce a closed nutrient cycle using the extracted solids and the process water.

Dry substance for biological fertilizer

The separated solids are odorless and can be stored safely. They can be pelletized and sold to horticultural businesses and garden centers as garden or spreading fertilizer.

Overview of the advantages of the recovered dry substance:

- **safe and simple storage (no safety data sheet required)**
- **no odor pollution**
- **suitable for sale as garden or spreading fertilizer**

Process water for irrigation

the process water is much less aggressive and less toxic than liquid manure. This significantly reduces the risks involved in storage and the corresponding licensing requirements. It lessens the amount of odor pollution and particulate emissions and operating costs. Transport costs are also reduced because the classification as hazardous goods no longer applies. The water is ideal for irrigating hops and asparagus by means of sprinkling. It is also suitable for irrigating leguminous crops (five-field farming), thus contributing to sustainable soil improvement. The new process can significantly reduce nutrient input to e.g. nitrogen-contaminated soils, particularly in areas that are intensively farmed. The separation system thus contributes to environmentally friendly livestock husbandry and improves the protection of groundwater.

Advantages of process water at a glance:

- **safe and inexpensive storage because less aggressive/toxic**
- **drastic reduction of the risk of accidents during storage (suffocation, drowning)**
- **no odor pollution or particulate emissions**
- **no contamination of feed (grass)**
- **no transport of hazardous goods, thus reducing transportation costs**
- **simple application through sprinkling**
- **used for irrigation of hops and asparagus as well as legumes, etc.**
- **simple hygienization by heating possible (option)**

6. Further factors for efficient liquid manure processing

As shown, the use of the mobile manure separation system can pay off economically and ecologically in several respects. For the optimal design of the separation technology, specific questions must be answered in advance, among them: At which location or at which changing locations is the liquid manure separation to take place? Which quantities and types of liquid manure are to be processed? What is to happen to the dry solids and the process water afterwards? In order to answer these questions adequately, an individual consultation is always recommended.

Potential users should also have the opportunity to install a test system and determine their separation efficiency in advance. Furthermore, an analysis of operational factors should be carried out in order to calculate whether a rental or purchased facility is the most economical long-term solution. In addition, qualified service technicians should be available for the necessary installation and commissioning as well as for predictive maintenance and repairs. With MoRoPlant20 all these factors are done justice and ensure successful operation.

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