Sustainable Manure and Digestate Treatment through Innovative Filtration Technologies

Case Study

Manure and digestate are valuable by-products of agricultural livestock farming and biogas production. They contain large amounts of nutrients that can be reused in fields as fertilizers. However, farmers face the challenge of processing these raw materials efficiently and in an environmentally friendly way. Excessive quantities, high transport costs, and potential environmental impacts, such as nitrate leaching into groundwater or the emission of methane and ammonia, make advanced treatment necessary.
With the help of modern filtration technologies, it is now possible to fractionate manure and digestate into clean water and highly concentrated fertilizers through multi-stage processes. The fractionation is particularly efficient with the use of Dynamic Crossflow Filtration (DCFF) using ceramic filter discs from KERAFOL in one of these steps.

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The Treatment Process

The process of digestate treatment takes place in several steps that are coordinated to separate valuable components and minimize environmental impact. An example of a possible process sequence is described below:

1. **Separation of Solids**
   - Initially, the raw material is separated by a separator. Coarse solids and liquid components are separated to relieve the subsequent filtration processes.
2. **Pre-treatment: Dynamic Crossflow Filtration (DCFF)**
   - In the next step, the liquid phase from the separator is pre-treated using Dynamic Crossflow Filtration (DCFF). This technology uses rotating ceramic membranes to efficiently separate solids and liquids. The rotation effectively prevents membrane clogging and reduces energy consumption.
   - **Result:** The sludge concentrate, rich in organic solids with a high C/N ratio, is returned to the fermenter to generate energy (biogas) again. The permeate, from which solids and microorganisms have been removed and which is rich in nitrogen (N) and potassium (K), is used for further treatment steps.
3. **Forward Osmosis (FO)**
   - In the next step, Forward Osmosis is used, where water is removed from the permeate of the previous stage by an osmotic pressure gradient.
   - **Result:** Another concentrate rich in nutrients (N and K) is produced. The permeate is transferred to the next step. Organic components were also removed from this by forward osmosis, protecting the subsequent reverse osmosis from fouling.
4. **Reverse Osmosis (RO)**
   - The Reverse Osmosis system removes dissolved salts and impurities from the permeate of the previous stage by pressing it through a semipermeable membrane under high pressure.
   - **Result:** Traces of ammonia and carbon dioxide are removed. The permeate moves on to the final treatment step.
5. **Ion Exchange (IE)**
   - In the final step, ion exchange is used to remove the last traces of nitrogen (ammonium) and other ions from the water.
   - **Result:** Nearly clean water is produced that meets environmental standards and can either be used for irrigation or returned to the water cycle.

Fractionation of Manure and Digestate

The above-described process leads to precise fractionation of manure and digestate into several usable components:

- **Clean Water:** Thanks to the combination of rotation filtration, forward osmosis, reverse osmosis, and ion exchange, a large portion of the water can be recovered from manure and digestate. This water is free of impurities and can be reused for irrigation or as process water.
- **Concentrated Nutrient Solutions:** By separating the water, the volume of material to be stored and transported is significantly reduced. The remaining concentrate, which only accounts for about 30% of the original volume, is rich in nutrients such as nitrogen and potassium. It can be applied directly to the fields as an efficient, highly concentrated fertilizer. Depending on the process control, the fractions can also have varying contents of nitrogen (N), phosphorus (P), and potassium (K), allowing them to be targeted for different crops and soils.

Benefits of Modern Manure / Digestate Treatment

The application of these advanced technologies brings numerous benefits, both for the environment and for agricultural operations:

- **Volume Reduction:** The concentrate obtained from the manure / digestate represents only 30% of the original volume, significantly reducing storage and transport costs.
- **Improved C/N Ratio:** The returned sludge concentrate has an improved carbon-nitrogen ratio, increasing the efficiency of biogas production.
- **Resource Conservation:** By recovering water and reusing organic substances, the nutrient cycle is closed, promoting sustainable agriculture.
- **Cost Efficiency:** Reducing the volume to be transported, as well as the ability to use the produced water on-site, saves significant costs in manure spreading and associated transports.
- **Environmental Protection:** Thanks to the clean water fraction, potential environmental impacts from nitrogen entering groundwater or the release of greenhouse gases such as methane and ammonia are minimized.

Conclusion

The treatment of manure and digestate through innovative filtration technologies, particularly using Dynamic Crossflow Filtration, opens new possibilities for sustainable and efficient utilization of these raw materials. Fractionation into clean water and concentrated nutrient solutions contributes to both resource conservation and the economic optimization of agricultural practices. Thanks to these technologies, farmers can not only increase their yields but also significantly reduce their ecological footprint.

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