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MANURE TREATMENT ACCORDING TO THE TREVI CONCEPT

In Flanders great amounts of livestock, especially pigs, lead to a surplus of manure that can not be spread on farmland because of the prevailing fertilising restrictions. Aside that, Flemish government obliges farmers with a surplus of 7500 kg total P_2O_5 production to treat this excess of manure partially or totally. Trevi nv developed a manure treating system that starts with the separation of the raw manure in a solid fraction and a liquid fraction. The solid fraction can be exported after drying and hygienisation in the condensation drier, which is characterised by the absence of off-gases. The liquid fraction is treated in a biological plant and contains only 10 to 15% of the original amount of nutrients. As a result of this, the biological effluent can be spread on farmland at a bigger quantity (100-150 ton/ha) in comparison with raw manure. This biological effluent needs further polishing to obtain an effluent that can be discharged into surface waters. This was realised in co-ordination with Danis nv at the Discover plant in Izegem. In this plant, an evaporator treats the biological effluent and produces a dischargable condensate.

► Introduction

Formerly, livestock excreta were a desired product. At present, Flanders and other regions suffer from a strong discrepancy between the amount of nutrients produced in animal husbandry and the quantities that can be used as a fertilizer on farmers land. Especially pig manure is a problem, since pigs are permanently housed and several industrialised farmers in Flanders have no or only small amounts of farmland to spread the manure. Pig manure contains approximately 7 000 mg N/l and 4500 mg P_2O_5/l.

Manure processing in Flanders aims at the neutralisation of nutrients in manure or at making it suitable for export to other countries requiring organic fertilisers. Manure regulation in Flanders imposes the farmer to treat 30% (> 7500 kg total P_2O_5 production) or 100% (> 10000 kg total P_2O_5 production) of its excess manure production. This means that the government allows some farmers to perform a partial purification and to spread nutrient-poor liquid manure on the fields. Other farmers need a complete purification of the manure to allow direct discharge into surface waters (see Table 1 for discharge limits).

Table 1. Discharge limits for effluents from manure treatment in Flanders

Parameter	Discharge limit (mg/l)
COD	125
BOD	25
Total nitrogen	15
Total phosphor	2
Suspended solids	35

This contribution is focussing on the different aspects of the Trevi technology for manure treatment. In Figure 1, an overview of the Trevi technologies for manure treatment is given.

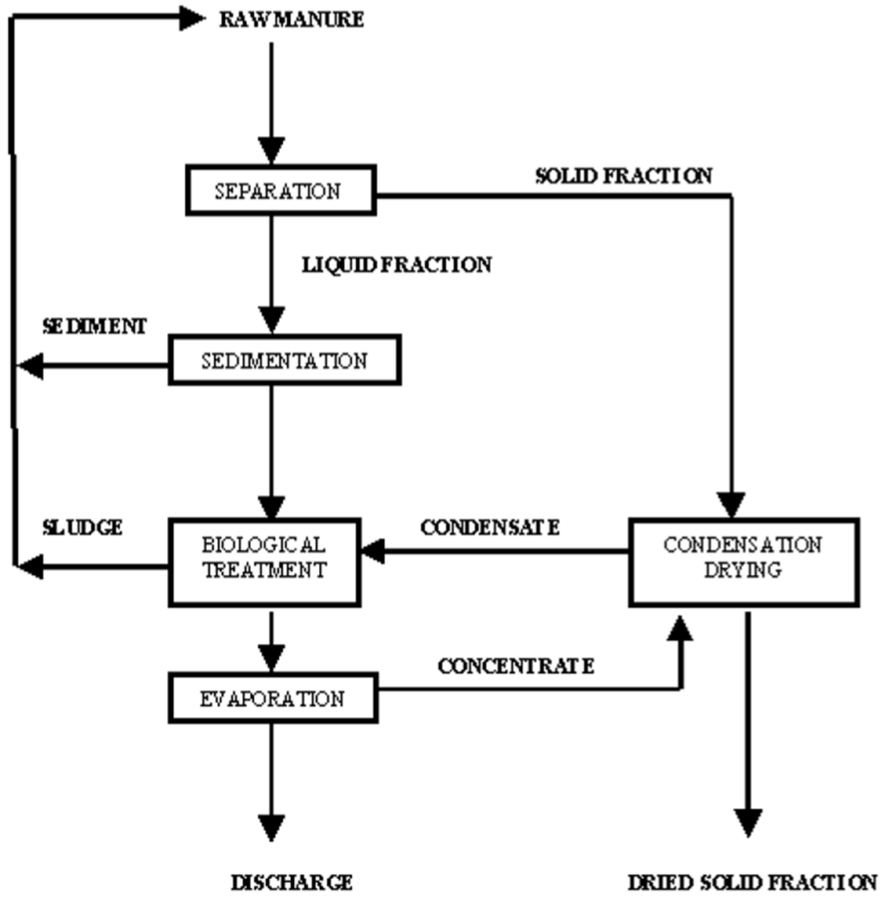

Figure 1. Flowchart of the Trevi manure treatment concept

By the summer of 2003, about 300.000 ton/year manure treatment capacity was realised according to this Treviconcept, being about 12.5% of the total capacity to be built in Flanders (2.390.000 ton in 2003). Part of this was realised on the farm (spreading of the biological effluent), while another part was realised at the Discover plant in Izegem with discharge of the liquid fraction (Table 2).

Table 2. Trevi-technology for manure treatment: realisation (summer 2003)

Project	Capacity	Year	Liquid fraction		Solid fraction
	tonnes/year		biology	biology + evaporation	condensation drying
Tolpe, Eernegem	3 200	2000	x		
Tolpe, Eernegem	10 000	2001	x		
Varfome, Lendelede	3 000	2002	x		x
Danis, Izegem	35 000	2002		x	
Jaltho, Merksplas	13 000	2002	x		
D'Hoore, Ardooie	10 000	2002	x		
Van Wonterghem, Aalter	4 000	2003	x		
Vermeiren, Hoogstraten	4 000	2003	x		
Snels, Hoogstraten	7 500	2003	x		
Van Thillo, Hoogstraten	10 000	2003	x		
Leenaerts, Hoogstraten	10 000	2003	x		
Schrauwen, Hoogstraten	5 000	2003	x		
Tolpe, Zedelgem	10 000	2003	x		
Danis, Izegem	200 000	2003		x	

► Separation of the raw manure

The separation of the manure in a solid and a liquid fraction can be performed using a centrifuge or a screw separator. Scope of the separation is the concentration of nutrients (mainly phosphorous) in the solid fraction. In Table 3, it can be seen that the centrifuge is much more successful in separating the phosphorous. Results for both techniques can be optimised by the addition of polymers. As a result of this however, considerable amounts of COD can be removed from the liquid fraction, increasing the chemical costs for the biological denitrification. When using a screw separator, the liquid fraction is treated in a sedimentation tank in combination with a sieve bow, in order to avoid solid particles to enter in the biological purification and realise an extra phosphorous removal from the liquid fraction. The sediment collected at the bottom of the sedimentation tank should be returned and mixed with the raw manure for further separation (e.g. discontinuous centrifugation).

Table 3. Separation results of screw separator and centrifuge (without polymers) (Feyaerts et al., 2002)

Separation technique	% solid fraction	DM-content solid fraction (%)	Nutrients in solid fraction (%)	
			N	P_2O_5
Screw separator	10-30	25-35	20-40	20-50
centrifuge	17-20	30-35	33-34	70-80

► Biological purification of the liquid fraction

The liquid fraction contains most of the nitrogen and is treated in a biological way according to a semi-batch nitrification-denitrification process. Typical COD- and N_{tot}-concentrations in the untreated liquid fraction are 30.000 and 6.000 ppm, respectively (Table 4).

Aeration panels (Picture 1) with a high oxygen transfer efficiency (3-6 kg O_2/kWh in pure water) are used in the nitrification tank, yielding a total energy consumption for the biology (aeration and pumps,...) of ± 15 kWh/m^3. Due to the performant aeration panels, sludge concentrations up to 20 g/l can be maintained in the biological plant. This allows the operation of the biology at a loading rate of ± 0.125 kg N/$m^3_{reactor}$.d. The excess sludge can be removed by sedimentation or can be spread onto the fields.

Table 4. Average composition of the liquid fraction before and after biological purification

Parameter	Influent biology	Effluent biology
pH	7.7-8.5	6.5-8.0
EC (mS/cm)	10-60	2-12
COD (mg/l)	4000-80000	1000-5000
P_2O_5 (mg/l)	100-1500	100-1100
N_{tot} (mg/l)	2000-11000	300-1500
NH_4-N (mg/l)	1200-8000	0-20
NO_2-N (mg/l)	0	0-600
NO_3-N (mg/l)	0	0-1400

Depending on the composition of the liquid manure and the nitrogen removal efficiency to be obtained, a chemical carbon source (acetic acid, methanol, other...) has to be added in order to obtain a nearly complete denitrification. Typical COD- and N_{tot}-concentrations in the liquid fraction after biological purification are 3.000 and 500 ppm. As a result of the separation and biological purification, higher dosing volumes of this effluent can be spread onto the fields (typical 100-150 ton effluent/ha) in comparison with the raw manure.

Picture 1. Nitrification tank before (left) and after (right) start-up

Due to the optimal nitrification conditions in the reactor, typical ammonium concentrations in the biological effluent are 0-15 ppm (Figure 2). As a result of this low ammonium concentrations, no ammonia emission is expected when spreading the effluent onto the fields. Moreover, no odour pollution is to be expected when spreading this liquid on the fields.

Odour emission and emission of ammonia (NH_3) and nitrous oxide (N_2O) from both the nitrification and denitrification tank at a manure treatment plant were measured using a Lindvall box (Picture 2). In both tanks the emission of odour, ammonia and nitrous oxide was very low (Table 5). The total nitrogen loss (except N_2) corresponded to only 0,5% of the amount of nitrogen input in the reactor. These low emission data can be explained by the very performant and homogeneous aeration in the nitrification tank. Next to this, the operation of nitrification and denitrification in separate tanks minimises the appearance of microaerobic conditions and thus considerable N_2O-emission, as is the case in intermittent aerated tanks, is absent.

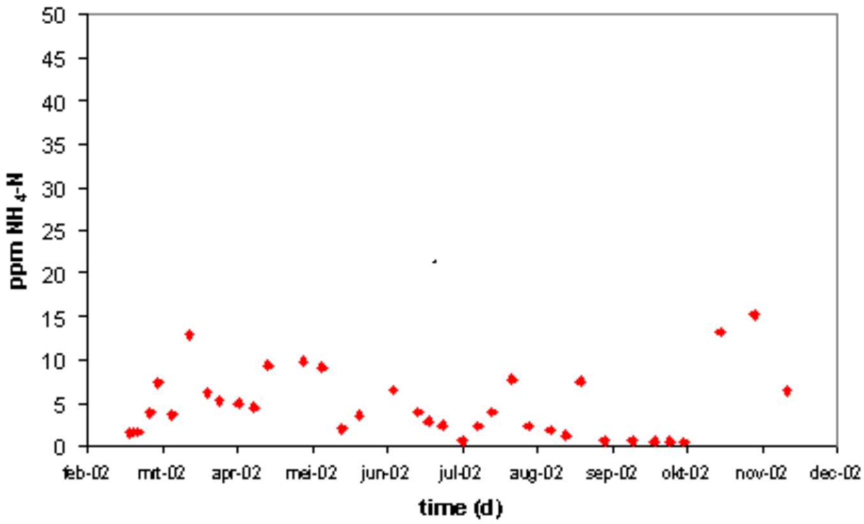

Figure 2. Ammonium concentrations in the effluent of a biological manure treatment plant

Table 5. Emission of odour and volatiles at the surface of a biological manure treatment plant

	nitrification	denitrification
Odour emission (ouE/m^2.h)	3705	13140
NH_3 emission (g/m^2.h)	nd	0.051
N_2O-emission (g/m^2.h)	0.046	0.056

nd: not detectable

Picture 2. Lindvall box at the surface of a denitrification tank

► Polishing of the biologically treated liquid fraction

After the biological treatment, the liquid manure fraction contains minor amounts of ammonia (< 15 mg/l). However, considerable amounts of organic and nitrous nitrogen are present. Since the latter compounds are not volatile, evaporation and condensation can be used to separate them from the liquid fraction and to obtain a dischargable liquid. Since the biological purification removes most of the volatile organic compounds as e.g. fatty acids, also the COD discharge limit of 125 mg/l can be obtained using evaporation and condensation. Since the condensate is free of all other compounds (Table 6), it can be discharged in the river without being subjected to any other posttreatment. The evaporation is operated at low temperatures using mechanical vapour recompression, yielding a favourable energy efficiency. This concept was realised in co-ordination with Danis N.V. at the Discover plant in Izegem.

Table 6. Average composition of the biological effluent before and after evaporation

Parameter	Effluent biology	Effluent evaporator	Discharge limits
pH	6.5-8.0		
EC (mS/cm)	2-12		
COD (mg/l)	1000-5000	40-80	125
P_2O_5 (mg/l)	100-1100	0-1	2
N_{tot} (mg/l)	300-1500	0-10	15
NH_4-N (mg/l)	0-20	0-10	
NO_2-N (mg/l)	0-600		
NO_3-N (mg/l)	0-1400		

► Condensation drying of the solid fraction

The solid fraction of the manure can be treated in a multibelt condensation drier, allowing drying and hygienisation in a single unit (Picture 3). The drier is working with a low energy consumption and without the need to treat off-gases. In a condensation unit, air is heated up to 70-80°C and blown through the solid fraction in the multibelt drier. When leaving the drier, the humidified air is cooled down to below its dew point, producing a NH_3-rich condensate. This condensate has to be treated in the biological plant for the liquid fraction. After condensation, the cold air is reheated up to 70-80°C in the condensation unit and reused in the multibelt drier. In this way, the air is continuously recycled. The multibelt condensation drier allows a continuous drying capacity, with high drying performance in a small space. The solid fraction can be dried up to a DM-content of 90-95%. The closed system prevents ammonia and odour emission.

Picture 3. Condensation drier with drying unit in front and heat-exchanging unit on top

The solid fraction is conveyed into the upper belt of the drier. The product is slowly transported through the first, second and third belt, while heated air from the condensation unit flows through the material. Predrying and drying occurs within the first and second belt. The finishing (hygienisation at 70°C for more than one hour) occurs within the third belt. The retention time in the drying zone can be adjusted by the frequency-controlled drives. Thus, the drying plant can be adapted extremely well to the most different requirements (through-put, contents of dry matter, drying temperature, need of hygienisation, ...). Next to this, also the product depth on the different belt sections can be variated. Continuous temperature and air relative humidity monitoring is provided in the drier. In this way, it is possible to control and to match the requirements of the drying process.

► References

Feyaerts T, Huybrechts, D (2002). Beste Beschikbare Technieken voor mestverwerking. Tweede uitgave. Academia Press Gent.

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