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A Review of Liquid Manure Treatment Systems in Germany

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Introduction

About 10 million cattle and 15 million pigs in Germany are held on slatted floors. This implies a total slurry output of almost 175 million m³ in a year. Bad odours, epidemical risks and pollution of the soil and the groundwater represent a range of slurry problems. Especially pollution of soil and groundwater with nitrogen and phosphate became important. For that reason the federal states Nordrhein - Westfalen, Lower Saxony, Bremen and Schleswig - Holstein enacted liquid manure regulations in order to control manure spread on the soil.

Especially in some regions of Nordrhein - Westfalen and Lower Saxony available land for spreading manure on is very limited. Therefore the Federal Minister of Research and Technology (BMFT) supports 26 liquid manure treatment projects with 40 million DM. An investment of at least more than 67 million DM will be necessary for the construction of the liquid manure treatment plants, their running demonstration and a compound project, in which the products of the single treatment systems will be evaluated.

Additionally the federal states of Nordrhein - Westfalen and Lower Saxony invest more than 10 million DM in liquid manure treatment systems and the federal states of Bremen and Schleswig - Holstein have invested more than 2 million DM into projects, which have been finished in the meantime.

The slurry treatment systems of the BMFT are divided up into demonstration projects, development and pilot projects. The manure treatment systems of Lower Saxony are pilot plants and in Nordrhein - Westfalen there is a demonstration plant for the bounding of ammonia as a magnesium ammonium phosphate salt (MAP).

In this paper the demonstration plants of the BMFT and two pilot plants in Lower Saxony supported by the State Minister of Food, Agriculture and Forestry (MELF - LS) are represented.

Project aims

Dependent on the density of breeded animals in an area part purification systems or complete purification systems are promoted by the governments. Especially in two districts of Lower Saxony and in one district of Nordrhein - Westfalen almost 2 to more than 3.5 dung units are held on one hectar. A dung unit for example is corresponding with one cattle which is older than 2 years or with 7 fattening pigs. In these districts most of the purification systems and among these also the most complete purification systems are seated.

All the systems take aim at two objects. The first objective is the abstraction of the slurry nutrients as a concentrate and second: nutrients are uneven distributed in the liquid manure. So if it is spread into the fields its fertilizer value can hardly be calculated. Therefore it is also the aim of all the systems to transfer the slurry nutrients in a form for better handling.

Processing treatments

Producers, the supporting institutions and the degree of purification are listed in table 1. In table 2 the slurry throughput and the single process steps of each system are enumerated. The numerals in the table specify the sequence of the process steps.

In all projects the slurry is separated with decanter centrifuges or with a sieve facility into a liquid and a solid phase. The solid phase is always composted and sold as a natural fertilizer.

Furthermore liquid manure is treated in a biogas reactor. The biogas is burned in a combined heat and power (CHP) scheme. The biomethanation of the part purification systems yields enough heat for keeping the biogas reactor on temperature and enough electricity to run the other process steps. Great plants like the facilities of Schwarting GmbH produce an electricity surplus. It is introduced into the national grid.

By reason of biomethanation the BOD is reduced by 95 %. Furthermore organic bound nitrogen is mineralized into ammonia. It is usually desorbed from the putrefied slurry with a stripper.

Liquid manure treatment with a decanter centrifuge, a biogas reactor and a NH_3 - stripper reduce the nitrogen and phosphate content of the slurry for more than

80%. Part purification plants, which are built in this way, are usually energy self sufficient.

If the treated liquid manure shall directly be discharged into a river or into a lake, in Germany a purification degree of at least 99.9 % is necessary. The technical efficiency of a good operating purification process gets up to 90 %, so that in theory three serial process units are necessary to reach this aim. The connection is explained in table 3. Because the single purification steps do not always strip anionic pollutants as well as cationic pollutants as shown in table 2 complete purification systems need up to 8 process steps to meet this requirement.

Usually the slurry nutrients are disintegrated with an anaerobic or aerobic digestion facility. Chemicals are dosed into it so that the solved or coagulated nutrients precipitate. Because of their chemical attributes an acid or a lye must be used. The fallout is separated with a filter or another mechnical separation installation. These treatments are repeated until the quality standards are reached at which the technical expenditure increases.

In these plants the biogas output is not sufficient for the energie demand of the running process. Combined heat and power scheme supplies only 30 % of the needed electricity. So additional energy must be bought.

The constructions of the systems A,D,F enumerated in table 1 have been finished. Significant results exist only from system F which was finished in 1990. It is a complete slurry purification system. The handicaps and the obtained results of the power of purification are given in table 4. The system has failed at the NH_4 - N and COD precipitation degree as shown in table 4. In the manin non degradable organic compounds have induced the four times exceed of the given quality standard. The results have confirmed the experts opinions that treated liquid manure can not comply with the effluent standards.

The constructions of the systems C,E,G will be finished at the end of this year. It is uncertain whether system B will ever be built.

Process description of the systems D and F

The process of system F is demonstrated in figure 1. Following the thick arrows firstly liquid manure is pumped into a decanter centrifuge, which separates the slurry into a solid and into a liquid phase. The solids are composted and after this procedure spread into the fields as an organic fertilizer. The liquid phase, the so called centrate reaches a biogas plant. The yielded biogas is cleaned in a desulphurization facility, because the hydrogen sulphide (H_2S) would damage the combined heat and power scheme within a short time.

After the centrate has passed the biogas reactor phosphate which is adsorbed at the organic substance is dissolved because the BOD is degraded by biomethanation roundabout 95 %.Calciumhydroxyde ($Ca(OH)_2$) and a flocculant are dosed into the separarted and putrefied slurry. Phosphate is falling out as Hydroxyapatite ($Ca_5(PO_4)_3OH$). It is separated with a membrane filter press. The filter cake is grinded and spread into the fields as a Ca/P - fertilizer.

Because calciumhydroxyd is dosed in a surplus into the effluent its pH - value increases. Additional the effluent is heated so that nearly all ammonia evaporates when air is blown through in the NH_3 - stripper. It is absorbed in a sulphuric acid washer. The yielded ammoniumsulphate is a nitrogen fertilizer.

The residual liquid is neutralized with carbondioxyd (CO_2) from the exhaust gases of the CHP. It is lead into an aerobic digestion facility. Because of the separation facilities and the biodegradation in the biogas plant the BOD is less than 40 mg/l so that there is not enough available carbon for the reduction of the NH_4 - N in the residual liquid. This is the main reason why the NH_4 - N standard could not be held.

The process of system D is demonstrated in figure 2. Following the thick arrows first the slurry is pumped into a biogas plant. It is divided up into a two stage process. Firstly the process of acidification is carried out in a mesophile working reactor and afterwards the process of methanation is carried out in a thermophile working reactor. The advantages of this procedure are a higher biogas output and a shorter time for putrefaction corresponding with a smaller biogas reactor.

The time for putrefaction shall be less than 15 days instead of roundabout 30 days in usual biogas reactors. The putrefied slurry is separated with a decanter centrifuge and subsequently the liquid phase is treated in a steam stripping facility at 2 bars. Ammonia is desorbed. The steam and the ammonia condensate. Nitric acid is dosed into the condensate so that ammoniumnitrate is built. It is used as a nitrogen fertilizer. The residual slurry is poor in nutrients. It is used for irrigation.

More than 80 % of the nitrogen and the phosphate shall be withdrawn from the slurry. The degree of phosphate purification is doubtful because it is adsorbed at the organic substance. Biomethanation reduces the organic substance by 50 %, so that phosphate is dissolved. It can only be separated with a precipitant in a precipitation facility but not with a decanter centrifuge.

Process costs

In table 5 the investments of the BMFT demonstration projects are specified. There are no published results concerning the specific costs per cubic meter up to now. The costs per year usually amount to at least 25 % of the investment. So if this estimated amounts are divided through the slurry throughput of the corresponding systems the specific costs per m^3 come up to 165.00 DM. Part purification systems with a purification degree of more than 80 % cost more than 30.00 DM/m^3 while total purification is not available for less than 50.00 DM/m^3.

In Germany farmers gain less than 30,-- DM per pig. A pig produces in its life round about 0.8 m^3 slurry so that the costs for slurry treatment would consume more than the obtained profit.

Conclusion

In Germany at least more than 80 million DM will be invested in slurry treatment systems in the next years. In this paper it is demonstrated that the specific costs per m^3 slurry will reach more than 30.00 DM for part purification systems and more than 50.00 DM for complete purification systems. So slurry purification will only be successful if it is supported by the government. Part purification may be carried on with a justifiable expenditure but complete purification of the slurry will be priceless and the result of the procedure will be uncertain.

References

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