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Comparing the Drying Characteristics of Biogas Effluent, Cattle Slurry and Sewage Sludge

The number of biogas plants is steadily increasing due to legislative support for renewable energies. The by-product of biogas production, biogas effluent, is a valuable organic fertilizer, which currently is used in crop production. The increasing accumulation of fermentation residues will require interregional solutions in the future. High water content in the biogas effluent would cause transport costs to be very high. Drying the biogas effluent is one possibility for increasing its value for transportation. Differences between the drying characteristics of biogas effluent, cattle slurry and sewage sludge make it necessary to modify drying processes for biogas effluent.

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The world's growing energy consumption and the associated greenhouse gas emissions lead to a change in the world's climate. In order to avoid the evident climate change, it is necessary to develop new alternatives to cover the primary energy demands. In Europe was decided to reduce the greenhouse gases emissions and increase the energy efficiency for renewable energies. The renewable energy consumption in Europe should increase up to a share of 20% in 2020. In 2005 the EU the total renewable energy consumption was approximately 6.6%. In Germany the total energy consumption from renewable materials was about 10.2%, of which approximately 20% was produced from biomass. Due to the new legislations the number of biogas plants has been increased. After the fermentation process the effluents remain as by-products. They are organic fertilizers and its nutrient content depends on the substrates used in the fermentation. With the increasing number of biogas plants and the associated accumulation of effluents, the treatment of them becomes ecologically and economically meaningful. In addition, the use of fertilizers the plant production is restricted by new regulations. In a lot of regions in Germany there are nutrient surpluses compared to agricultural land. In the practice the biogas effluents are currently used in liquid form as fertilizer. The transport of the liquid effluent over long distances is very expensive. The water content of the residues is approximately 93% (renewable-energy-crops residues). For this reason, the use of effluents is restricted and they cannot easily be transported to other agricultural regions. In order to have lower transport costs, the reduction of water content is an important prerequisite. One possibility to reduce the water content of the biogas effluents is drying.

Drying of biomass

The technical complexity of the drying of biomass depends on the economic value of the dried product. For the drying of waste materials such as sewage sludge, the primary drying process is solar drying. The requirements for the dried sludge in this case are low, that is why the construction, operation and maintenance of the system are relatively inexpensive. The use of waste heat to increase the drying capacity is usually possible without major technical efforts. The principal objective of drying is to reduce the water content, but in the case of the effluents, a preservation of the contents in the material should be carried out, too. Another advantage of drying is the reduction of volume and weight of the material. The nutrients will be concentrated in the dried product. It is possible to face problems related to the emissions coming from the surface of the material and the intensive odours, caused by substance like ammonia. Dust emissions represent another environmental problem. One promising possibility for the drying of biogas effluents could be the solar-supported drying in greenhouses. In order to reach an optimum process control during the drying, basic tests and investigations in the area of drying of biogas effluents are essential. For this reason the initial drying experiments of the effluents were done at a laboratory scale. Here the drying behaviour of biogas effluents, cattle slurry and sewage sludge was compared.

Experimental design

The effluents used for the experiments are from a biogas plant in which cattle slurry, pig slurry, juice residues, salad and vegetable wastes, malt coffee draff and broken grain and rape seed were fermented. The cattle slurry comes from a herd of dairy cattle herd with followers. The animals are fed with silage the whole year. The sewage sludge was sampled in a wastewater treatment plant after the fermentation stage. In order to ensure a uniform blending of the ingredients the selected products were intensively mixed before filling the containers. For the drying experiments, three samples of each material were taken. The standard containers have a diameter of 80 cm and a height of 2.5 cm. The heights of the samples were approximately 0.7 cm, which corresponds to a weight of about 20 g. The drying experiments were

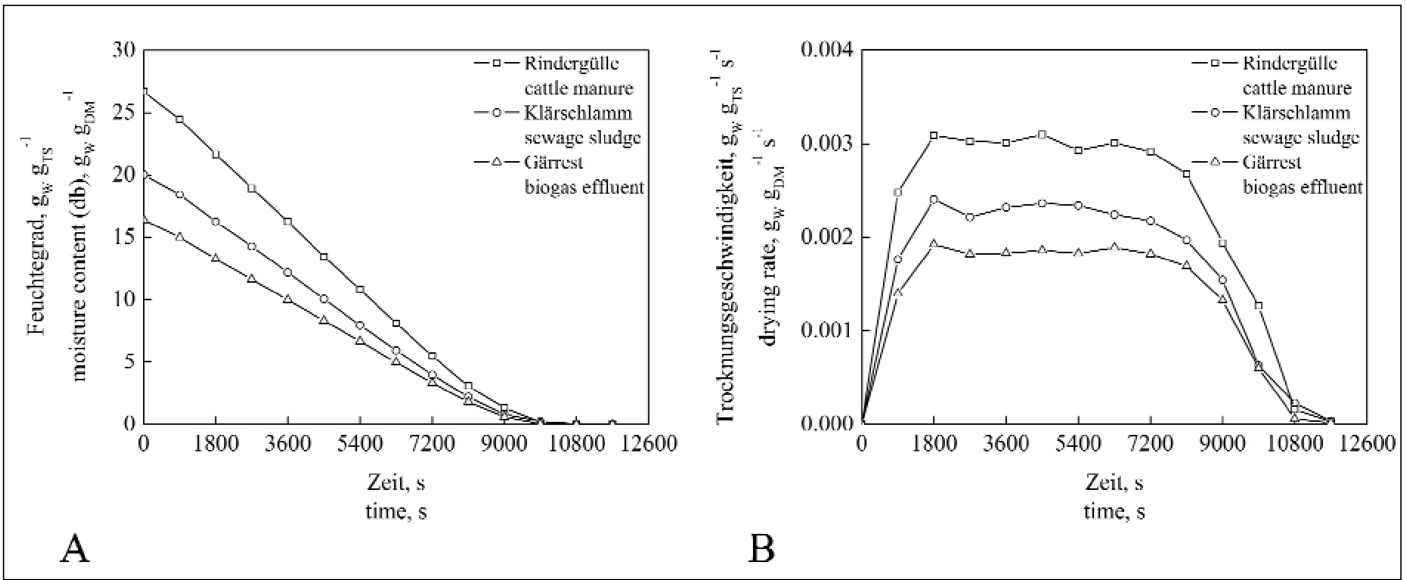

Fig. 1: Development of moisture content (A) and drying rate (B) of cattle slurry, sewage sludge and biogas effluent

carried out in a drying oven Memmert UL 30. The samples were dried in the pre-heated oven at a temperature of 70 °C. The relative humidity in the drying oven was not regulated during the the experiments. After 900 seconds, the weight of each container was measured and the experiments were finished when a constant weight was reached. The determination of dried matter content was made according to the standard method (105 °C, 24 hrs). For the analysis and presentation of the results, the moisture content and drying rate were calculated. The moisture content can be calculated with the next equation:

$$X(t) = \frac{m(t) - m_{TS}(t)}{m_{TS}(t)} \qquad (1)$$

The drying rate can be calculated according the next formula:

$$g(t) = \frac{X(t) - X(t + \Delta t)}{\Delta t} \qquad (2)$$

Results

The behaviour of the moisture content during the drying process of cattle slurry, sewage sludge and biogas effluent is presented in *Figure 1* (A). The initial moisture content of the three residues is different, due to the dry matter contents of the residue examined. The cattle slurry has the lowest DM value with 3.6 % and the biogas effluent has the highest DM content with 5.8 %. The sewage sludge is in a middle range with 4.8 %. DM.

The initial moisture content is highest with cattle manure with values of 26.7 $g_W\ g_{TS}^{-1}$ and lowest for the biogas effluent with 16.4 $g_W\ g_{TS}^{-1}$, the sewage sludge stays is in between with 20.0 $g_W\ g_{TS}^{-1}$. The drying curves of the three residues appear different. They drying rates are shown in *Figure 1* (B). During the warm-up phase, the drying rates of all products increase. Then after the first drying period, the drying speed remained constant. The second drying period was characterized by the fact that the drying decreases to 0 and the material was finally dry. Here the cattle slurry showed the highest value 0.0030 $g_W\ g_{TS}^{-1}$. The sludge has a value of 0.0018 $g_W\ g_{TS}^{-1}$ and it dries itself in about half as fast as the cattle slurry.

Conclusion

The drying of biogas effluents provides an interesting alternative for the utilisation of this kind of residues. By means of the drying, new recycling opportunities can arise. It will also help to improve the handling of the effluents. The dried fermentation residue could be used not only as organic fertilizer, but also in horticulture and in landscaping. The drying of biogas effluents shows different behaviour in comparison to cattle slurry manure or sewage sludge. It can also be concluded that depending on the DM content of the residue, the drying rates will vary. For an optimal control of the drying process, further studies on the drying behaviour of the biogas effluents are required.

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