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Dewatering of Thermally Disintegrated Sewage Sludge

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The contribution describes investigations in the attainable dry matter content of thermally disintegrated sewage sludge. The purpose is to find the effects of thermal disintegration on sewage sludge. Additionally, to identify disintegration conditions especially temperature level for energy efficient equipment design. Measurements showed that thermal disintegration of sewage sludge results in a higher amount of undissolved matter in the supernatant water. The improve in dry matter content depends highly on the temperature level and was identified to be significant from 120°C onwards. Based on the results, investigations in thermal disintegration will be intensified in the region of relevant temperatures.

1. Introduction

In recent years, it has been found that sewage sludge is a suitable and widely applicable alternative energy source, which falls into the category of renewables. Several options for « sludge-to-energy » utilization in sludge treatment sections of waste water treatment plants (WWTP) can be considered. Among key factors, influencing the choice of sludge treatment technology is sludge heating value, its composition and specifically, the fraction of organic compounds. A crucial parameter in evaluation of mass and energy fluxes is the level of attainable dewatering, which, beside the type of sludge, also depends on the treatment technology.

Water contained in sludge can be categorized in four types of water according to a simple model shown in Figure 1:

- Interspace water (can be removed by dint of gravity thickening),
- Capillar water (can be removed by dint of pressure filter or centrifuge),
- Adsorption and inner water (can only be removed by dint of thermal energy).

Thus, interspace water and capillar water can be removed by simple and cheap dewatering. The maximum degree of dewatering, however, depends on the amount of adsorption and inner water as these types of water can only be removed by drying.

In literature, one treatment technology influencing the dewaterability is referred to as disintegration. The three most important methods of disintegration are mechanical, chemical and thermal disintegration. During disintegration the sludge flakes become disrupted and water contained in the flakes becomes available for gravitational means of dewatering.

The contribution describes investigations in the attainable dry matter content of thermal disintegrated sewage sludge.

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Emphasis is on the identification of disintegration conditions especially temperature level for an energy efficient equipment design.

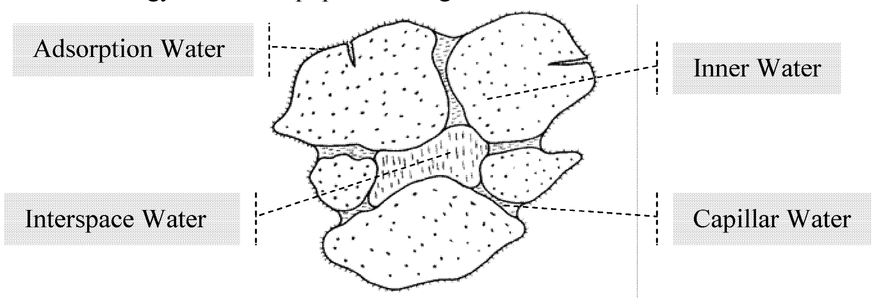

Figure 1 Water distribution in bulk material; [Batel (1961)]

For evaluation purposes, it is important to select a method of dewatering that both, complies with the model and provides reliable results in bench-scale measurements. Convenient dewatering was found using a centrifuge. Centrifugation is applicable for solid – liquid blends where the solids show a higher density than the liquid. After separation, the solids become compressed. This method represents the maximum of attainable dry matter content. The described dewatering procedure doesn‘t allow conclusions to be drawn with respect to the temporal course of water release.

2. Methods and Materials

For measurement purposes thickened sewage sludge samples were taken from the waste water treatment (WWTP) plant in Tetcice. The WWTP is designed for a maximum load of 15000 population equivalents (PE). The sludge treatment section is rated to serve 18000 PE since sludge from small scale WWTPs is treated additionally. On the WWTP the digestion operates under aerobic thermophilic conditions using pure oxygen. The samples were taken from the inlet of the digester and had an dry matter content of 3.9% on average. The samples were collected the same day into canisters of 5l and stored at 5°C until they were used for measurement purposes.
The bench-scale measurements were performed at four temperature levels (60, 90, 120, 150)°C. Each temperature level was measured separately on one day. For each measurement on thermally treated sludge, the same measurement was carried out using untreated sludge synchronously. By this reference-based approach, a higher comparability was achieved.
The disintegration unit is built as double jacket vessel designed to operate under pressure or atmospheric conditions and can hold up to 2.7 liters of sludge. The admissible pressure is 1 MPa at an operating temperature of 180°C. For heating purposes the double jacket is insulated with 30 mm insulation material. It can be heated by means of an external heat source and liquid heat transfer medium. During heat treatment of sludge, measurement instruments on top of the vessel monitored pressure and temperature in the vessel. For heat treatment of sludge the supply temperatures of the vessel were selected (60, 90, 120, 150) °C. The experimental set up is shown in Figure 2.

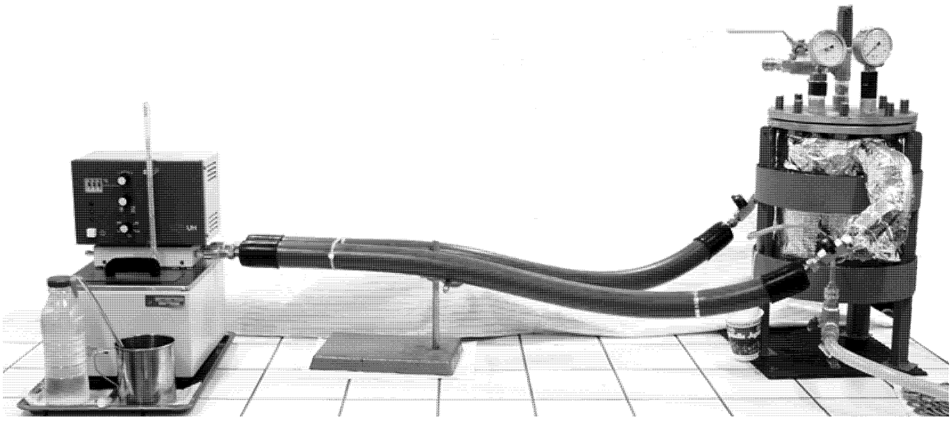

Figure 2 Experimental set up of sludge heat treatment

In order to prevent sludge from partial boiling a pressure of 0.8 MPa was applied on the vessel. After the sludge temperature has reached a value that was 20°C lower than the selected supply temperature the heat treatment was maintained for another 60 minutes.

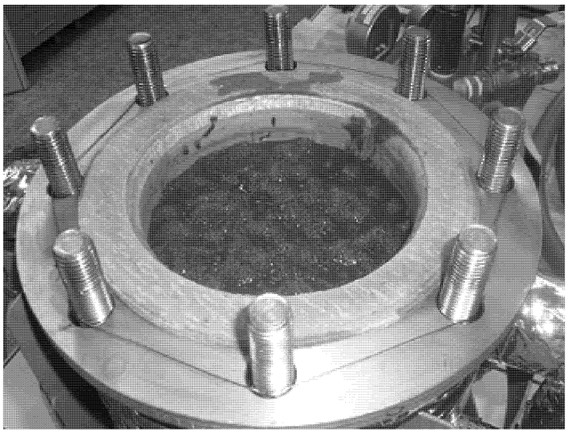

Figure 3 Disintegration unit filled with sludge

After the heat treatment was finished a sample of treated and untreated sludge were prepared and centrifuged under equal conditions. For the experimental dewatering test a laboratory centrifuge was used. It featured up to four centrifuge tubes containing up to 100ml each.
The operational rotational speed was selected 1500 1/min and maintained for 10 minutes. This method of treatment generates the maximum of attainable dry matter content. However, doesn‘t allow conclusions to be drawn with respect to the temporal course of water release.
For measurement of dry matter content first, the supernatant water was poured off and collected for further analysis. Then, the cake was spread on a tray and dried at 105°C.

3. Results

After the heat treatment was finished, the samples' surfaces were almost transparent. Occasionally the samples smelled strongly like vinegar.

After centrifugation, the treated sample showed more turbid supernatant water (see Figure 4). This was observed for all temperature levels and can be traced back to the fact, that sludge flakes become disrupted and generate small solids that have not been separated. Comparing the treated and untreated (reference) sample it is obvious that the amount of suspended solids has increased due to thermal disintegration. Using suction filtration measuring the suspend solids contained in supernatant water of treated sludge caused frothing in the flask. Frothing tended to become more intense for higher treatment temperatures and was not detected while filtration of untreated samples was carried out.

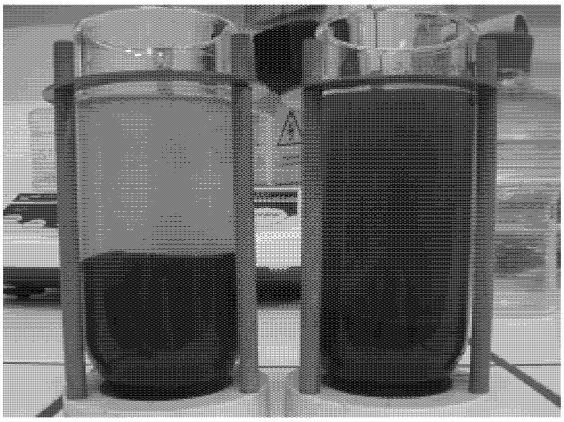

Figure 4 Untreated (left) and treated (right) sludge samples after centrifugation

Both samples showed an evident liquid - solid boundary, which indicates that the sedimentation process has been finalized during centrifugation. The volume ratio of cake and supernatant water changed within the course of experiment. Keeping the dewatering process equal, the total volume of cake decreased at higher temperatures.

The samples differed in their consistency after dewatering. Treated sludge tended to produce one slimy chunk of cake that could be simply removed from the centrifuge tube. Untreated sludge tended to produce highly viscous, shapeless cake.

Table 1 Results of dry matter content (DM) measurements

Temperature level [°C]	60	90	120	150
DM of untreated cake [%]	6.0	6.0	5.9	6.3
DM of treated cake [%]	6.2	6.0	6.5	9.0
Increase [%]	3.4	1.4	9.7	43.4

In dry matter measurements no sample of thermally treated sludge had a lower dry matter content than untreated sludge. The detailed results of dry matter (DM) measurements are shown in Figure 5 and Table 1. Values for untreated sludge ranged from (5.9-6.3) % compared to (6.0-9.0) % in treated sludge samples. This results in a dry matter increase of up to 43%.

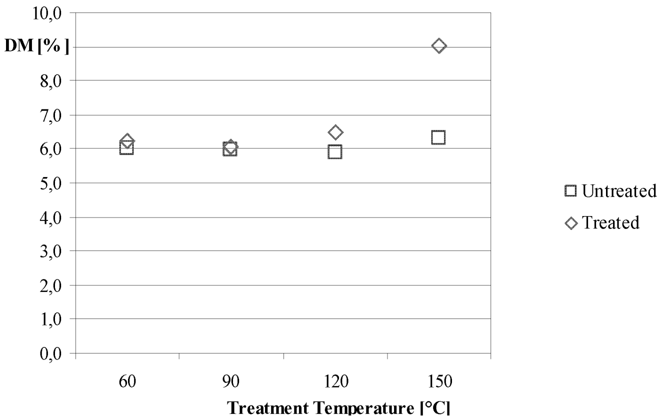

Figure 5 Dry matter content (DM) of centrifugation cakes

In Figure 6 the relative increase in dry matter content depending on the temperature level is shown. From this figure it is obvious, that no significant increase in dry matter was detected at temperature levels below 120°C. For a temperature level of 120°C the dry matter content gained 10%, which is still a low number compared to an increase of 43% corresponding to a temperature level of 150°C.

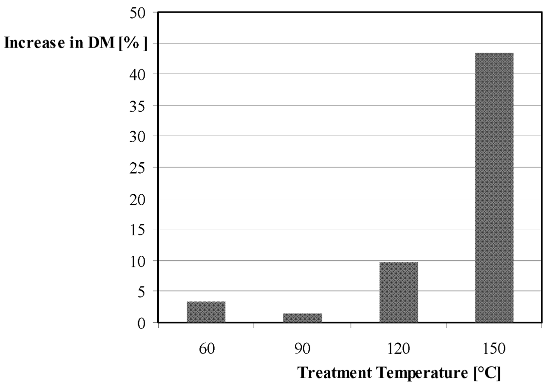

Figure 6 Increase in dry matter content of centrifugation cake

Time dependencies on the dewaterability of sludge could not be investigated using the described disintegration unit. Poor heat transfer resulted in long heat up periods. Thus, the unit did not act fast enough to investigate time dependencies. The poor heat transfer can be traced back to poor heat conductivity of sludge, the chosen design and the method of heat transfer of the bench-scale unit.

4. Conclusion

The effect of temperature treatment of sludge on its dewaterability was investigated in bench-scale. For this purpose, sludge was exposed to different temperature levels ranging from 60°C to 150°C.

Thermal disintegration of sewage sludge has an effect on sludge dewatering by means of centrifuge. The outcome is a higher amount of suspended solids in the supernatant water and a higher dry matter content in the cake. The improve in dry matter content depends highly on the temperature level and was identified to be significant from 120°C onwards. For a temperature level of 150°C a increase in 43% was determined.

After dewatering the samples of treated and untreated sludge cake differed in consistency. In contrast to untreated sludge, treated sludge produced chunky cakes by dewatering.

During vacuum filtration of supernatant water of heat treated sludge caused frothing and white, stable bubbles were produced.

For energy efficient design of a full scale unit it is required to revise the method of heat transfer.

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