Digesting Sludge and the Influence of the Temperature

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The digesting of sludge in sewage treatment plants is a standard solution for waste water treatment. Usually all waste water treatment ends with sludge. This sludge has to be disposed of in a most effective manner. And this effective manner usually is digesting. This process yields a significant reduction in the amount of sludge and produces methane gas, that is used to cenerate electricity and heat. The technology goes back to a paper by Fair & Moore, Sew. W. J. (1934). The original graph from this paper is still found in modern waste water handbooks, unchanged up to this day.

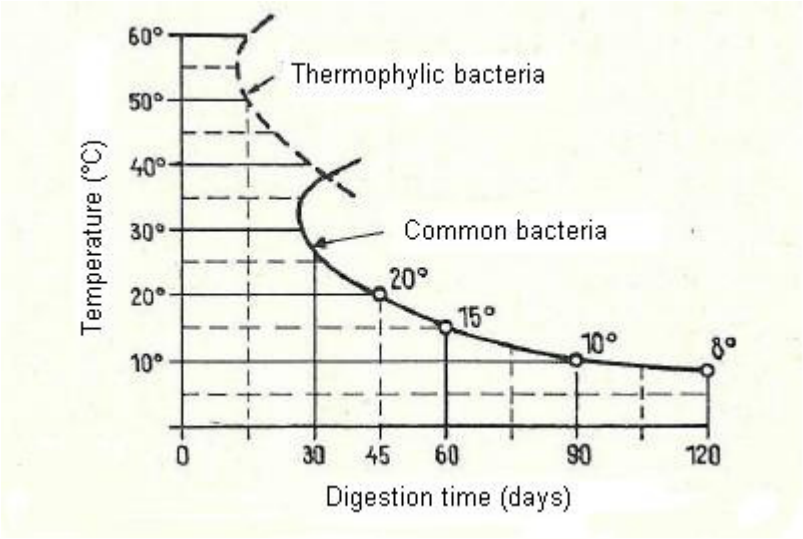

Fig 1: Fairs graph taken from Imhoff's Handbook: "Taschenbuch der Stadtentwässerung" (1990).

In the 40 years I was involved in waste water treatment, there were great improvements of this technology, especially in new aerobic biological processes like nitrification/denitrification or biological phosphorus elimination, not to mention the fixed film reactors. But digesting still remains in its infancy. E.g. it is not understood why some digested sludges thicken well and others do not. Furthermore, there has been little research on digesting at elevated temperatures.
All sewage engineers know the graph of Fair & Moore (Fig. 1). It hasn't changed since it was created in the 30s, and it is still considered to be gospel today. A further question that hasn't been investigated at all is the role of pressure.

Findings of Kuster+Hager Engineers

During the 35 years as head of the laboratory department at Kuster+Hager Engineers, we ran many tests on digesting, both lab-scale and large-scale. Mostly our subject was the digestion of industrial sludges. We had to decide how the sludge was degradable and if an adaptation of the anaerobic bacteria was possible. Some of the studies also investigated was the behavior at elevated temperatures.
At large-scale plants sometimes the temperature of the digesters ran out of control. Among the 250 or so plants we constructed in my time, there was such an incident every couple of years. That gave us further hints that something with Fair's graph was wrong. This proved to be a lucky strike.
The graph of Fair & Moore (Fig. 1) shows a peculiar minimum activity at 38 °C, considered a forbidden temperature range between mesophylic and thermophylic digestion. Fair & Moore claimed two sorts of bacteria were responsible for these two temperature ranges, hence, the minima between them.

In our experience, we didn't find a minimum at 38 degrees at all. Quite the contrary, we found a continuously rising curve with an abrupt end at 58 °C!

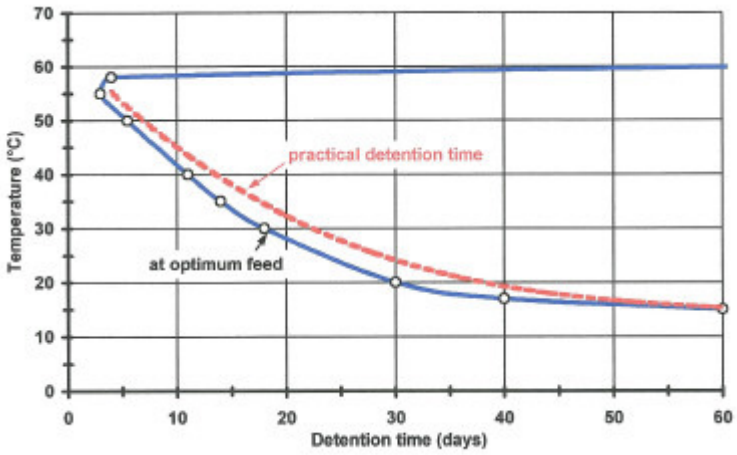

Fig. 2:
Sludge digestion:
Temperature and Detention Time

The meaning of "optimum feed" is:

- The digester is continuously fed with primary sludge of a predominantly rural sewage treatment plant,
- continuously stirred, and
- the temperature kept very constant throughout of the body of the digester

Practical detention time is:

- The digester is usually fed two to four times a day
- One total mixing cycle in about an hour
- Temperature kept in the range of plus or minus 2 degrees centigrade.

The digestion shows in fact no minimum at 38 °C. There is a continuous increase in digestion capacity in relation to temperature with an abrupt end at 58 °C.

Fig. 3:
In the foreground the new thermophylic digester with a detention time of 2½ days. In the rear the old mesophylic digesters that had a detention time of 18 days. Now they serve as sludge storage tanks.

Discussion

The speed of digesting sludge is limited solely by the speed of hydrolization of its solid matter. After hydrolization the methanization occurs within minutes.
This was proved by blowing pure hydrogen gas to the bottom of a 12 meter-deep, sludge storage tank through a 10 millimeter tube. When the bubbles arrived at the surface, they contained only traces of hydrogen. Hence, hydrogen was completely methanized within a minute.
We found an acceleration of the hydrolization of fresh sludge up to about 80 °C. Unfortunately, we found no methan bacteria that could survive this temperature.
To start up a digester at temperatures up to 35°C without properly adapted sludge is possible at low loads. Without inoculation with adapted sludge, it took more than a year to start up the first thermophilic digester at 55°C. One may explain this by the lack of these kinds of bacteria in cold Switzerland. These kind of bugs wouldn't find good, natural breeding grounds here. So, we needed patience and had to wait until one of these bugs probably was shipped in from a tropical country, maybe on the back of a banana that found its way to a Swiss sewer.

Uznach, May 2005/UB