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INVESTIGATIONS ON THE ANAEROBIC–AEROBIC TREATMENT OF A HIGH CONCENTRATION WASTEWATER

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At the Technical University of Braunschweig a research project is being performed on the treatment of a high concentration leachate of a sanitary landfill. Its concentration has decreased somewhat in winter 83/84 from 56 g/l to 31 g/l COD (17.5 g/l to 88 g/l TOC). The research project covers laboratory scale experiments and 4 pilot scale reactors of 12 m³ volume each located at the landfill of Hannover. The pilot scale anaerobic plant was completed in August 1984. This poster presents first results of the laboratory tests.

The decision for a two stage treatment scheme depends on various reasons:

1. In practice, during the aerobic treatment of the water in an oxidation pond as the only treatment step, severe problems arose due to strong surplus sludge production.

2. With the aerobic treatment, enormous energy costs occur.

The two stage treatment concept aims at an 80 percent COD-reduction in the anaerobic step and the elimination of the residual COD and nitrification/denitrification in the aerobic step.

The tests comprise the following reactors:

A) Anaerobic filters, upflow mode, T=30°C
different support materials as:
composted municipal solid waste (MSW); stones; plastic media; burned clay.

B) Anaerobic filters, upflow mode, ambient temperature
different support materials as:
composted MSW; lava slag; burned clay.

C) Anaerobic filters, downflow mode, support material composted MSW, different temperatures: 30°C, ambient temperature.

D) Upflow reactor.

One major intention of the tests was to prove whether or not the composted MSW is a well suited support material. The application of this material has several advantages expecially for the treatment of waste waters with low suspended solids content:

1) MSW is a very cheap material, unlike most of the other available support materials.
2) In former investigations we found that composted MSW produces methane immediately, if the environment turns to anaerobic conditions. This means that composted MSW containes considerable amounts of methanogenic bacteria. Therefore, an anaerobic filter with composted MSW would not need any inoculation.
3) Because of its structure, the MSW is thought to have an adsorption capacity for organic components of the waste water. Therefore an MSW filled filter must be well suited to retain slug loadings.

reactor no.	temp. [°C]	vol [l]	support material	space load [gTOC/l*d]	TOC red. [%]	gas prod. [l/gTOC degr.]
AS1 U	30	70	MSW	2.6	89	1.5
AS2 U	30	70	MSW	1.8	92	1.6
				3.7	91	1.6
AS8 U	30	70	MSW	4.2	87	1.6
AS9 U	30	27	MSW	2.0	87	1.6
AS13 D	30	38	MSW	1.3	93	
AS6 U	amb.	70	MSW	1.8	83	1.5
AS11 D	amb.	28	MSW	1.5	75	1.4
				2.8	62	1.4
AS3 U	30	70	lime stones	0.7	83	1.8
				1.9	86	1.5
				2.5	82	1.5
				4.9	67	1.5
AS4 U	30	27	plastic media	2.3	77	1.5
AS5 U	30	5	burned clay	1.3	83	1.3
				1.7	89	1.6
AS14 U	amb.	27	lava slag	2.6	68	
				3.5	57	1.5
U1 S	amb.	35	——	0.9	35	
U2 S	30	70	——	2.7	50	1.2
				4.5	45	1.3

Tab. 1: Results of lab scale anaerobic reactors
U: Upflow anaerobic filter
D: Downflow anaerobic filter
S: Upflow activated sludge blanket reactor

The tests showed that the leachate is very well degradable under anaerobic conditions. One of the reasons surely is that the liquefaction and the acidification already takes place within the landfill. Therefore 70-80% of the organic matter in the influent to the anaerobic reactors consist of volatile fatty acids. During the laboratory scale tests we also found that, despite the high BOD_5:P ratio, no P-addition was necessary. Table 1 contains data of some lab scale anaerobic reactors, indicating that the anaerobic filters containing MSW obtained slightly better removal efficiencies than that ones with inert support materials. The anaerobic filters running at ambient temperatures (18-27°C) generally showed poorer results than the reactors held at 30°C. However, the unheated reactors demonstrate that anaerobic treatment also works at low and fluctuating temperatures.

With the anaerobic MSW filter the effluent concentrations remained stable below 2000 mg/l TOC after a startup period of 40 days, independent of the space loading. Stable operation of the reactor is also characterized by a fairly constant pH of 8.0-8.3 and a methane content of 72-77 vol.% in the produced gas. In the upflow anaerobic filters, which are operated without any effluent recycling, most of the TOC-removal occurs in the lower 25% (40 cm) of the reactor. We found the sludge concentration to be highest in the lower part of the anaerobic filters, present not mainly as attached biomass but as sludge in the void spaces. That is, the low pH of the influent has no adverse effects on the methanogenic activity.

After abrupt increase of the loading, gas production rises immediately. Note that only very small increases of the effluent concentrations were measured after increasing the space loading, and they returned to the basic values within few days. This means, the anaerobic filters are well suited to receive slug loadings without failure. Moreover, a temporary shutdown and the restart of the anaerobic filters caused no problems. The experiments showed that also shut down phases of several weeks are possible without any need for special measures with the restart.

Data of the laboratory reactors presented in Table 1 show that up to 4 g TOC/l reactor volume * d can be applied without noticeable decrease of the removal efficiency. There are not yet sufficient data available to evaluate the reactor performance at higher loadings. At ambient temperatures the results vary over a wide range as a result of the temperature changes. On average, the unheated reactors definitely achieved a lower TOC removal rate than that ones operated at 30°C. However, no serious operating problems arose even at temperatures as low as 18°C. Daily temperature fluctuations clearly affect the specific gas production. Reactor failure, however, was not even observed at temperature changes of 7°C within 3 days. The fluctuations between day and night temperatures amounted up to 6°C without problems. This demonstrates the high biological stability of the anaerobic filters.

From the biological view, there were no problems in the operation of the anaerobic filters. Difficulties arose from the inorganic compounds of the leachate as Iron (700 mg/l) and Calcium (1900 mg/l). Due to the high reaction activities and the rising pH in the bottom zone especially of the upflow anaerobic MSW filters, these elements form insoluble salts and precipitate. As a consequence, the MSW reactors clogged after a certain time of operation. To solve the problem of clogging, a two stage anaerobic treatment is being tested at the present, consisting of an upflow activated sludge blanket (UASB) reactor followed by an anaerobic MSW filter. The precipitation of the inorganic components takes place in the first UASB reactor, which proved to be not so susceptible to clogging. The second step is necessary, because the UASB reactor has a rather poor removal efficiency. Up to now, no clogging occurred with this combination.

The pilot scale anaerobic plant at the Hannover landfill was completed in 1984. The reactors (2.0 m diameter, 4.5 m height) are in the startup phase at present time. To achieve an isolation effect, the reactors are located in the slope of the landfill body, enclosed from the refuse. The pilot plant includes the following reactor types:

1. Anaerobic MSW filter
2. Upflow activated sludge blanket reactor
3. Anaerobic filter (burned clay)
4. Anaerobic filter (plastic media)

Results of the aerobic post treatment will be presented elsewhere.