*Wat. Sci. Tech.* Vol.17, Amsterdam, pp.1377-1379.
Printed in Great Britain. 

0273-1223/85 $0.00 + .50


# A FIXED-BED REACTOR AND A STIRRED REACTOR COMPARED FOR ANAEROBIC WASTEWATER TREATMENT

S. Kunst and K. Mudrack

*Institut für Siedlungswasserwirtschaft und Abfalltechnik, Universität Hannover, Welfengarten 1, D 3000 Hannover 1, F.R.G.*

A fixed-bed reactor and a stirred reactor with secondary clarifier (both 12 l) were compared to investigate the anaerobic treatment of pectin wastewater. Pectin is a less easily degradable substrate than other carbohydrates, and the success of the process depends on complete acidification of the pectin, since otherwise the incompletely hydrolyzed pectin limits the space loading rate and efficiency of the treatment by forming a gelatinous pudding with the biomass. Therefore we control the fermentations in such a way, that the substances in the wastewater are completely hydrolyzed.

The fixed bed reactor was filled with 6 l expanded clay, the stirred reactor was stirred with 60 U/min. The treatment plants were started up with activated and digested sludge from a municipal treatment plant. The retention time was 3 d in the stirred reactor and 1 d in the fixed-bed reactor, the temperature between 30-35 °C.

Tables 1 and 2 show the main results of the fermentations. The space loading rate possible in the stirred process (Table 1) was much lower than the fixed-bed reactor (Table 2). In both fermenters were produced about 2.000 mg/l fatty acids, but in the stirred reactor a space loading of 2.1 g COD/l.d led to the same acid concentration as a space loading of >5 g COD/l.d in the fixed-bed reactor. This means that in the fixed-bed reactor a lot of acid molecules were degraded to methane while in the stirred one the substrate was degraded to fatty acids and $CO_2$. In the fixed-bed reactor methane was produced at all substrate concentrations, e.g. at a $B_{R-COD}$ = 6.3 g COD/l.d and a pH = 3.4 the gas contained 37% $CH_4$, although the gas production decreased.

TABLE 1 Results From Stirred Reactor

| $B_{R-COD}$ (g/l·d) | pH | pectin-η (%) | COD influent (mg/l) | COD effluent (mg/l) | COD η (%) | TOC η (%) | Products fatty acids (mg/l) | Products % acet.a. | Products % buty.a. | Gas ml/g $COD_{ell.}$ | Gas % $CO_2$ | Gas % $H_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.31 | 4.5 | 99 | 942 | 550 | 42 | 38 | 548 | 90 | 0 | 65 | 8 | 96 |
| 0.63 | 4.0 | 99 | 1884 | 1110 | 41 | 49 | 1096 | 91 | 1 | 55 | 11 | 89 |
| 1.26 | 3.8 | 99 | 3768 | 2440 | 35 | 48 | 1800 | 77 | 14 | 52 | 19 | 81 |
| 1.75 | 3.5 | 94 | 5346 | 3790 | 29 | 45 | 1800 | 45 | 41 | 78 | 22 | 78 |
| 2.10 | 3.3 | 84 | 6318 | 4750 | 25 | 33 | 1908 | 45 | 39 | 159 | 25 | 75 |
| 2.20 | 3.3 | 83 | 6804 | 5523 | 19 | 26 | 2160 | 42 | 22 | 260 | 28 | 72 |
| 2.40 | 3.3 | 69 | 7290 | 6040 | 17 | 13 | 2118 | 66 | 9 | 223 | 26 | 74 |

TABLE 2 Results From Fixed-Bed Reactor

| $B_{R-COD}$ (g/l·d) | pH | pectin-η (%) | COD influent (mg/l) | COD effluent (mg/l) | η % | Products fatty acids (mg/l) | % acet.a. | % prop.a. | % buty.a. | Gas ml/g $COD_{ell.}$ | $\%CO_2$ | $\%CH_4$ | $\%H_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1 | 6.6 | 95 | 2508 | 378 | 85 | 242 | 68 | 18 | 14 | 344 | 36 | 55 | 3 |
| 2.5 | 4.3 | 99 | 3009 | 630 | 80 | 468 | 56 | 19 | 16 | 370 | 39 | 53 | 3 |
| 2.9 | 4.3 | 95 | 3511 | 1310 | 63 | 723 | 54 | 20 | 18 | 340 | 42 | 42 | 3 |
| 3.1 | 4.3 | 90 | 3761 | 1497 | 60 | 722 | - | - | - | 282 | 48 | 49 | 2 |
| 3.3 | 4.1 | 90 | 4012 | 1599 | 60 | 761 | 54 | 18 | 19 | 362 | 38 | 49 | 5 |
| 4.2 | 4.1 | 95 | 5015 | 2269 | 55 | 843 | 54 | 19 | 21 | 248 | 46 | 42 | 5 |
| 4.6 | 3.5 | 87 | 5517 | 3396 | 38 | 1619 | 46 | 18 | 26 | 209 | 53 | 31 | 7 |
| 5.0 | 3.4 | 88 | 5767 | 3536 | 39 | 1737 | 60 | 20 | 15 | 190 | 52 | 32 | 8 |
| 5.4 | 3.4 | 92 | 6540 | 3999 | 39 | 2339 | 62 | 25 | 10 | 157 | 59 | 31 | 5 |
| 5.8 | 3.4 | 83 | 7021 | 4565 | 35 | 2096 | 58 | 28 | 13 | 127 | 46 | 38 | 5 |
| 6.3 | 3.4 | 85 | 7523 | 4946 | 34 | 2179 | 57 | 27 | 12 | 125 | 48 | 37 | 4 |
| 6.7 | 3.3 | 83 | 8024 | 5177 | 35 | 1856 | 60 | 28 | 9 | 103 | 45 | 31 | 5 |

Figure 1 shows that there are great differences between the processes in the production of fatty acids and gas. The main difference consists in the presence of methane-formation in the fixed-bed and its absence in the stirred reactor. The fixed-bed reactor must offer a much more favourable environment for methanogenic bacteria than a stirred reactor.

Figures 2 and 3 show the environmental differences between the stirred and the fixed-bed reactors. The biomass is completely blended in the stirred process. All organism groups contribute to the mixed culture in the same way, while in the fixed-bed the mixed culture is separated. Microenvironmentals are built up between the small compartments in the fixed-bed. In these small compartments the surrounding conditions (e.g. pH) seemed to be much more favourable for methanogenic organisms (also through their own microbial activity), because there is a higher concentration of methanogenic bacteria than in the water phase above the fixed-bed or within the expanded clay.

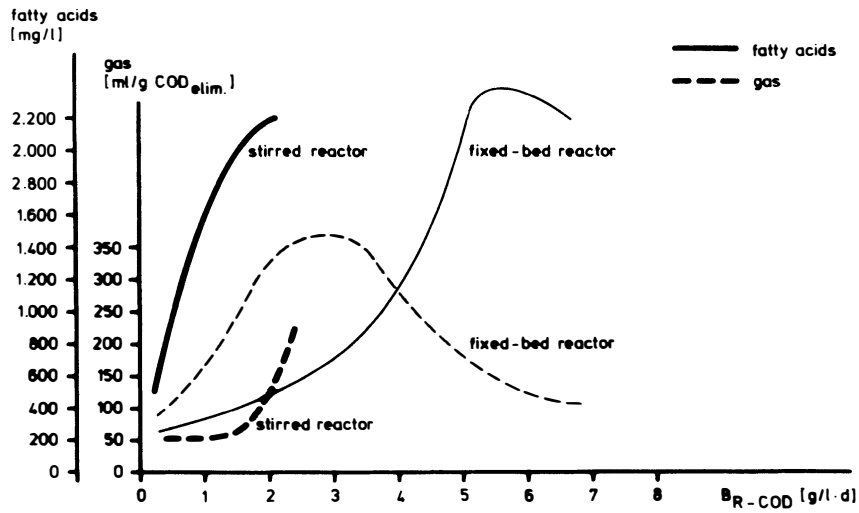


Fig. 1. Production of fatty acids and gas in both types of reactor

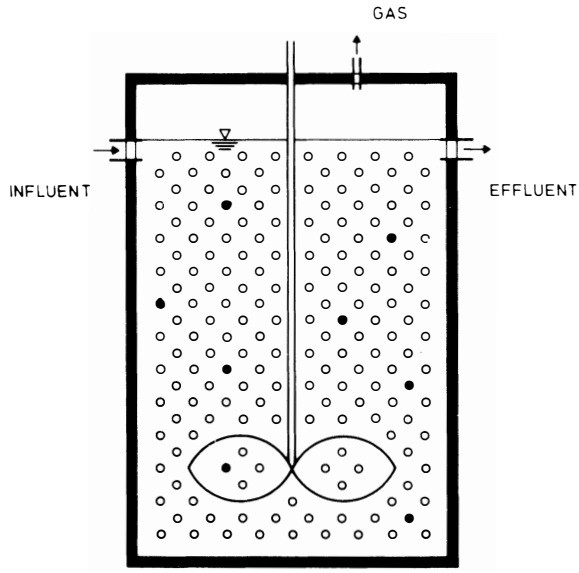


Fig. 2. Stirred Reactor

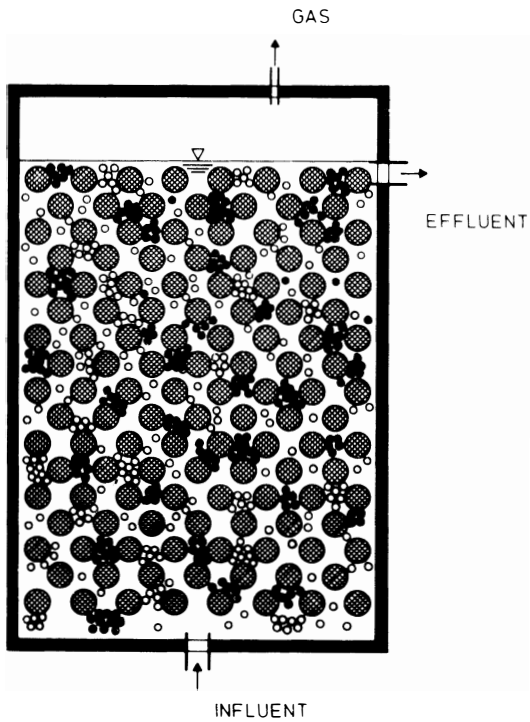


Fig. 3. Fixed-Bed Reactor