VII-1 LOW TEMPERATURE TREATMENT OF RAW SEWAGE IN AN UASB REACTOR

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1. INTRODUCTION A long term study on a 'high-rate' anaerobic process for treating sewage under temperate climate has not been reported so far. When treating the sewage, the process should also be able to operate successfully without heating during a low temperature period, otherwise the process may not be economically feasible compared to the conventional activated sludge process. Among the various anaerobic process developed so far, UASB has been found to be relatively simple and more economical because it neither requires added substratum as in anaerobic filters nor effluent recirculation as in fluidized bed reactors. In this study, an UASB reactor treating raw sewage in Japan over a long period of time (over 550 days) at the sewage temperature (in summertime at 20°C or above; and in wintertime at 10-20°C) has been investigated. The reactor was seeded with digested sewage sludge as this is available in many countries.

2. MATERIAL AND METHODS The schematic diagram of the UASB reactor is shown in Fig.1. The reactor (47.1 L), built of PVC, consisted of two parts: a cylindrical column with a conical-shaped bottom (35 L), and a gas-liquid-solid separator (12.1 L). The reactor was seeded with 0.5 kg VSS having VSS to SS ratio of 0.47. The seed sludge was obtained from a sewage sludge digester located in Nagaoka. The reactor is being continuously operated in the basement of the Hiratsuka community WTP since August 19th 1994. Sewage is fed to the reactor after passing it through 1 mm openings and it has average COD of 300 mg/l total and 100 mg/l soluble; BOD_5 of 100 mg/l total and 30 mg/l soluble. The hydraulic retention time (HRT) was decreased stepwise to 7 h. Influent and effluent analyses were determined according to the *Standard Methods* [1] and a 24 hour composite sample was used for the analysis of COD_{cr} and BOD_5.

3. RESULTS In this section, data on the effluent COD_{cr}, BOD_5 and volatile fatty acids (VFA) obtained during the HRT of 7 h under the sewage temperature in the range of 10-30°C (Fig.2a) has been described. Fig.2(a) represents the sewage temperature from August 1995 (day 374) to February 1996 (day 556). From Fig.2(b), it can be seen clearly that effluent COD_{cr} and BOD_5 increased to some extent as the sewage temperature declined below 20°C (from day 450). As shown, effluent soluble COD_{cr} and BOD_5 was stable at around 50 and 15 mg/l, respectively up to 20°C. However, as the temperature fell below 20°C these values were found to be increased (about 1.5 times). As indicated in Fig.2(b), a few times the washout of biomass occurred as evident from a sudden increase in the effluent total COD_{cr}, because the reactor was full of the sludge. As obvious, VFA increased as the temperature fell below 20°C (Fig.2c). As shown, concentration of acetate (upto 26 mg COD/l) and propionate (upto 11 mg COD/l) increased, however, propionate concentration gradually recovered although the temperature was still low. Fig.3 represents the relationship between soluble COD_{cr} and soluble BOD_5 in the effluent. The regression line could be represented by an equation (SOLUBLE COD_{cr} = 40.55+ 1.24×SOLUBLE BOD_5) having $r^2 = 0.789$. According to Yoda *et al.*[2], intercept of the line represents non-degradable COD. Fig.4 represents sludge hold-up along the height of the reactor on day 485. As shown, sludge bed occupied about 1 m height of the reactor and the sludge concentration was up to 29 g MLSS/l. The sludge volume index (SVI) at 30 cm height of the sludge bed was measured to be 40 ml/g SS. As was observed, occluded gas caused a part of the sludge bed to move occasionally upwards, however, it dropped after liberating the entrapped gas.

4. DISCUSSION In the same experiments (upto HRT 11 h) after 89 days of operation (November 16th 1994) when the temperature became lower than 20°C, effluent COD_{cr} and BOD_5 increased to a very high value (Fig.5a). The peak was observed on 3rd April 1995 (day 227), thereafter, the performance of the reactor recovered slowly by June 5th 1995 (day 290). As shown in Fig.5(b), soluble COD_{cr} in the effluent increased upto 5 times (soluble BOD_5 upto 10 times) from the original level. As shown in Fig.5(c), total VFA sum of acetate and propionate as COD increased upto 134 mg COD/l. It should be noted that the reactor was seeded with a digested sewage sludge, which had very low activity and high SVI. Therefore, the total amount of the sludge mass retained decreased by day 150 due to washout of light and poorly settling sludge, thereafter, it increased gradually (Fig.6). On day 485, the retained sludge was estimated to be 7.2 kg $MLVSS/m^3$ reactor volume and the ratio of VSS to SS in the sludge bed was in the range of 0.65-0.78. From these observations, the most likely reason of obtaining a satisfactory performance as described in the results part (during the HRT of 7 h) without having any large effect on the effluent quality during the period of low temperature appears to be due to: (1) the enrichment of methanogens and acetogens; and (2) acclimatization of biomass over a long period of operation. From COD mass balance (based on input and output values as COD) determined during the second time low temperature period (HRT 7 h), 25-30% of COD accumulated in the reactor, while about 40% of COD converted into methane. Unfortunately, we do not have data of the COD mass balance from the beginning to compare.

In general, the effluent quality of an anaerobic process, mainly in terms of N and P is not sufficient for direct discharge, some kind of post-treatment must follow this process.

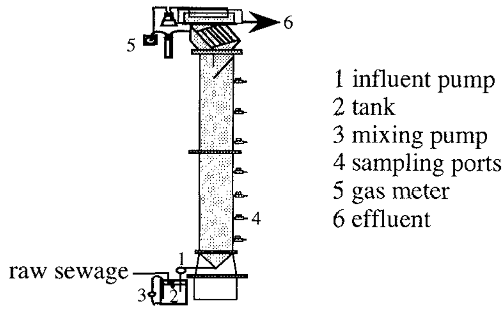

Fig.1 schematic diagram of the UASB reactor

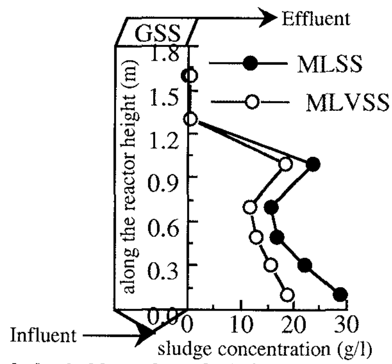

Fig.4 sludge hold-up along the height of the reactor on day 485

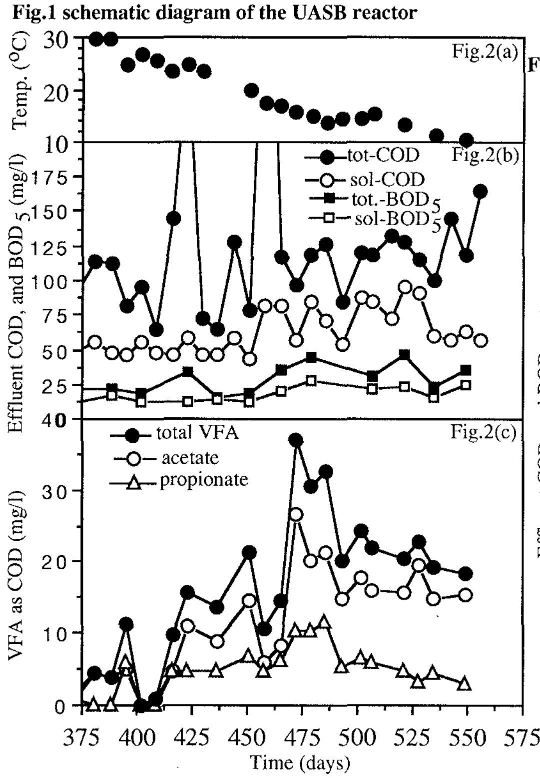

Fig.2 illustrates the following (a) the sewage temperature; (b) effluent COD and BOD $_5$; and (c) effluent VFA

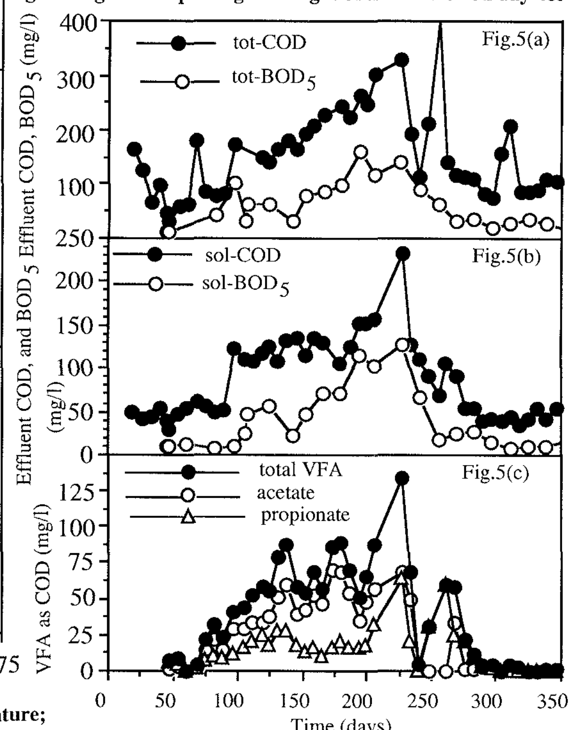

Fig.5 illustrates the following of the effluent (a) total COD and BOD $_5$; (b) soluble COD and BOD $_5$; and (c) VFA

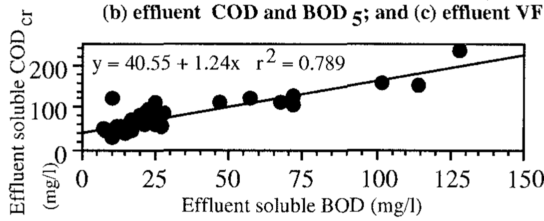

Fig.3 relationship between soluble COD $_{cr}$ and BOD $_5$ of the UASB effluent

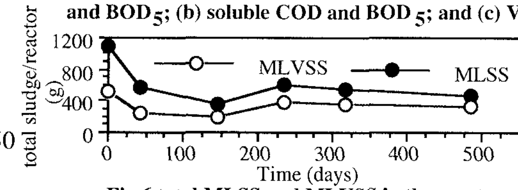

Fig.6 total MLSS and MLVSS in the reactor with the time course

5. CONCLUSIONS (1) It was possible to treat raw sewage under temperate climate using UASB reactor without having any large effect on the effluent quality during the period of low temperature.
(2) A substantial part of the effluent CODcr contained non-degradable COD.

6. REFERENCE 1) *Standard Methods for the examination of water and wastewater* . (1985). 16th Ed., American Public Health Assoc., Washington, D. C.; 2) Yoda, M., Hattori, M. and Miyaji, Y. (1985) "Treatment of municipal wastewater by anaerobic fluidized bed: behaviour of organic suspended solids in anaerobic reactor." *Proceedings of the sem./workshop: Anaerobic treatment of sewage*. Univ. of Massachusetts, Amherst, USA, 161-196.