VI ENGINEERING SIGNIFICANCE

6.1 Effect of Wastewater Concentration

The unnormal pollution load that has been reduced by better residues handling in the production line made these slaughterhouse wastewater differ from other reports (Wipitch Chaisrisongkram 1986, Lund 1971, Gutteridge et al. 1978, Sayed et al. 1984). The low concentration of COD and high suspended solids of this wastewater made it resemble domestic wastewater rather than its normal slaughterhouse counterpart.

The limiting design criteria for a certain wastes depends on its organic concentration. For concentrated waste, the limiting parameter is the applied organic load. However, for diluted wastes, the limiting parameter is the hydraulic retention time, due to a slow growth rate of anaerobic bacteria (Young and McCarty 1969, Souza 1986, Lettinga and Pol, 1991). Therefore, for this low concentration slaughterhouse wastewater, the hydraulic retention time was one of the most important limiting factors.

6.2 Process Possibility

The results of experimental study pointed out that the fixed-bed and RAUS could treat the slaughterhouse wastewater with COD of 200-1,000 mg/l and SS 100-300 mg/l at natural conditions without any unusual procedure. Both anaerobic processes functioned properly at ambient temperature with out any additional nutrient requirement. No chemical substance exceeded the toxic level. Even the VFA that usually presents a problem for anaerobic treatment was extremely low.

6.3 Process Comparison

As for the results from the hydraulic limiting factor, both processes efficiency decreased with an increasing hydraulic loading rate. Comparing AnFB to RAUS, AnFB seems to be more practical than RAUS. AnFB could work properly at an optimum hydraulic loading of HRT 6 h. with a volumetric organic loading of greater than 1 kg/(m^3.d), whereas RAUS optimum hydraulic loading was 9 h HRT or a volumetric organic loading rate around 1 kg/(m^3.d) with a simultaneous COD removal efficiency of approximately 50%. Nevertheless, at the optimum hydraulic loading rate RAUS could remove 65% of suspended solids, while AnFB removed only 50%. RAUS had an advantage in suspended solids removal due to its ability to retain high biomass in granular form which could entrap suspended solids in wastewater. On the other hand, AnFB could better remove COD concentration owing to the substrate adsorption of the biomass on the media surface and between the matrix space.

6.4 Process Commissioning

It would be most profitable if the advantages of both AnFB and RAUS were combined. Hybrid reactor which was partially filled with filter media is recommended. Hence, the granular sludge at the bottom of the reactor could be maintained and in the same way media could also fix the biofilm for higher COD removal.

6.5 Advantages of the Process

The anaerobic fixed-bed and RAUS have many advantages over aerobic and old-fashioned anaerobic process for slaughterhouse wastewater treatment as follows :

1) Both processes function efficiently at natural environmental conditions.

2) Biological solids produced is in a small amount.

3) Long solid retention time can be provided without requirement of disposal of excess biological solids.

4) No oxygen is required so the power consumption is very low.

5) The nutrient requirement is not needed from outside sources.

6.6 Disadvantages of the Process

1) Slaughterhouse wastewater contains high suspended solids which have to be removed by pretreatment to prevent clogging in fixed-bed reactor. In case of RAUS, suspended solids can reduce either treatment efficiency and sludge activity.

2) Methane gas as a by-product cannot be benificial due to its low production rate.

6.7 Process Design Information

6.7.1 Design Criteria

For full scale application, recommendations are as follows ;

6.7.1.1 Fixed-bed Reactor

Volumetric organic loading rate	1 kg/(m^3.d)
HRT	6 h.
Upflow velocity	0.6 m/h
Treatment efficiency	50%

6.7.1.2 RAUS

Volumetric organic loading rate	0.9 kg/(m^3.d)
HRT	9 h.
Upflow velocity	0.4 m/h
Treatment efficiency	50%

The volumetric organic loading rate is, however, determined by each wastewater concentration. In the same way, characteristics of the waste and environmental conditions also affected to process treatability.

6.7.2 Reactor Sizing

Lettinga and Pol (1986) decribed that generally liquefaction was the rate limiting step in the overall digester process, and consequently that relatively large reactor volumes were required for liquefaction. The size (volume) of the reactor was mainly dictated by the maximum total daily hydraulic and/or organic load, together with the applicable volumetric loading rates. Therefore the height/area ratio of a reactor was not such a relevant parameter. Lettinga and Pol (1991) illustrated more information that for dilute types of wastewaters (COD-levels below 1000 mg/l) and for operational temperatures exceeding 25°C, the reactor volume generally would be determined by the admissible hydraulic retention time, rather than by the applicable organic space load, particularly for taller reactors.

6.7.3 Phase Seperation

Lettinga and Pol (1986) stated that for soluble wastewater generally no phase separation was required. Only for wastewaters high in suspended solids pre-acidification in a seperate acidification reactor could be beneficial.

6.7.4 Feed Inlet Systems/Mixing

The mixing level in the lower part of the reactor, and consequently the contact level of the microorganisms/substrate, is very important in an advanced reactor to accomplish an optimal contact between sludge and wastewater, i.e., channelling of the wastewater through the sludge-bed or the formation of dead corners in the reactor should be avoided. Generally it is not necessary to use mechanical mixing systems. The mixing is done by the produced gas and/or by the liquid flow at a relatively high volocity. Moreover, excess of mixing may cause the rupture of flocs or granules, thus damaging the system performance. An example of an efficient feed inlet system is that of a uniform distribution of the waste near the bottom of the reactor (10 to 20 cm) through adequately located pipes. (Souza 1986, Lettinga and Pol 1991)

Lettinga and Pol (1991) also concluded that it was not necessary to have a rigorous distribution for very concentrated residues where good mixing was obtained from high gas production. One distribution point for each 7-10 m^2 being sufficient. Regarding very diluted residers for which the gas produced would not contribute very much to mixing, a better distribution was necessary in order to increase the contact substrate/microorganisms, and at lease one distribution point should be used for each 1-2 m^2.