IV EXPERIMENTAL INVESTIGATION

4.1 Experiment Apparatus

The experiment was carried out by using AIT pilot plant reactors which were located at a slaughterhouse in Pathumthani province.The pilot plant was planned at Hannover University and funded by GTZ(Gesellschaft fuer Technische Zusammenarbeit) of the Federal Republic of Germany. The Pilot plant was shown in Fig. 4.1.

Figure 4.1 Pilot plant : General view

The Pilot plant consists of two main processes, anaerobic and aerobic. This experiment was however only performed with the anaerobic process, which comprised fixed-bed reactors and RAUS reactors. The schematic layout of the pilot plant is shown in Fig.4.2.

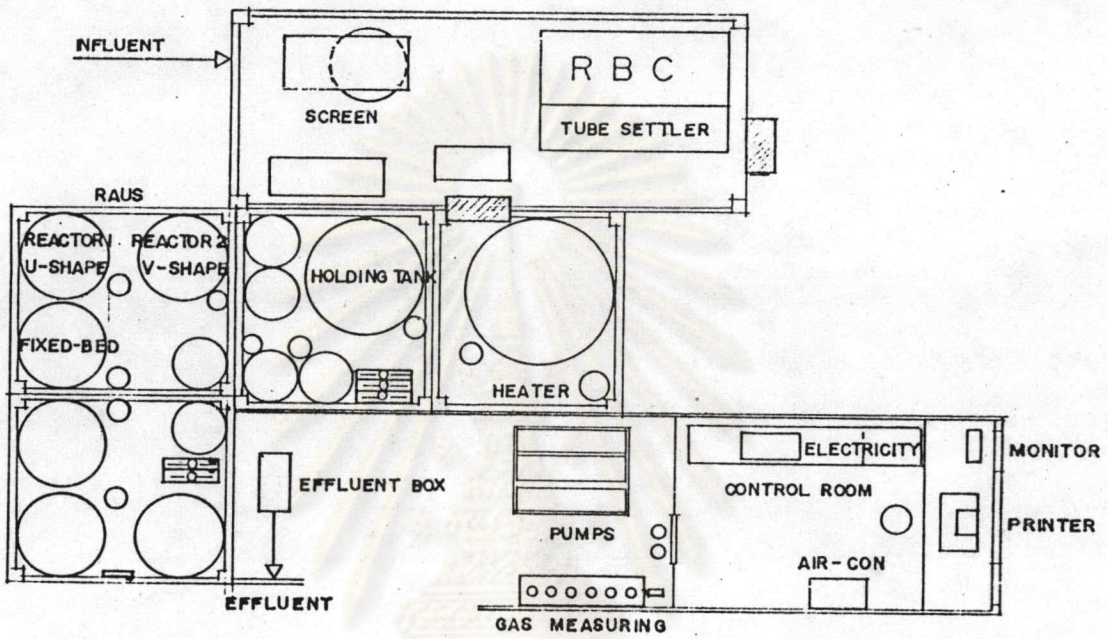


Figure 4.2 Pilot plant schematic layout

Four reactors of 4.5 - 5.0 m height were used. They were manufactured from a high quality stainless steel. The pipe connections were flexible PVC hoses so that the configurations of the process could be set up for optimal testing. The anaerobic reactors were provided with water jackets for heating when the temperature dropped below 30^{o}C. Details of reactors were presented in Table 4.1.

The process in the pilot plant was automatically controlled by the computer system, which could adjust the control of processes and treatment facilities. Current values could be shown on a computer monitor. An alarm for unusal events made it possible to immediately correct or repair malfunctions before they ruined the processes.

Table 4.1 Reactors details

Reactor	height (m)	Surface area (m^2)	Effective Volume (m^3)
Holding tank	4.5	1.77	5.6
Fixed bed reactor	5.0	0.95	3.4
RAUS reactor 1 (U-shape)	5.0	0.95	3.4
RAUS reactor 2 (V-shape)	4.5	0.95	2.9

Twenty four hours available information of both processes was also provided by a printer, which could adjust time intervals and parameters as needed.

Three types of pump were used in the experiment; submersible pump was used for pumping wastewater from flotation sump to screen unit. Screw pumps were used after screening to feed wastewater to the holding tank, fixed bed and RAUS and a peristaltic pump was used when sampling at night was required.

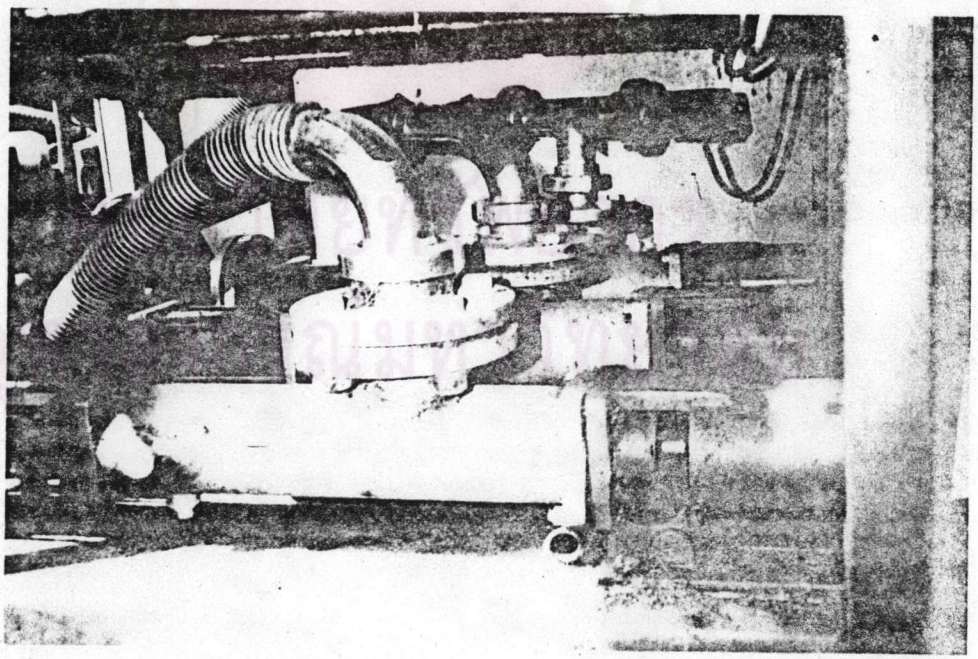


Figure 4.3 Screw pumps in pump room

4.2 Experiment Set-up

The whole set-up of the experiment study can be drawn as shown in Fig. 4.4.

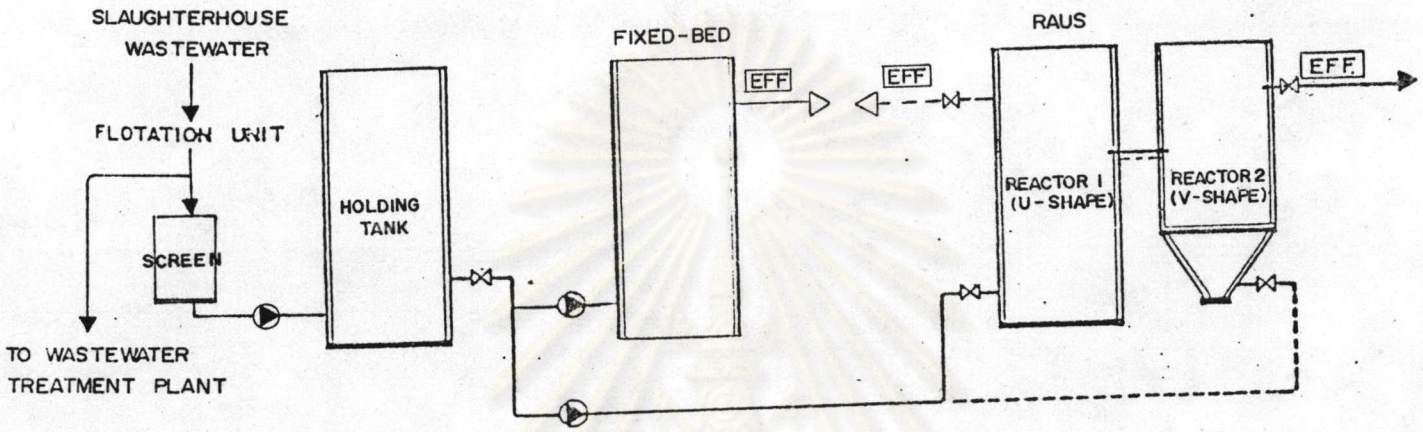


Figure 4.4 Experimental set-up : Schematic diagram

Pilot-plant unit began from the screen. The flotation unit which was used as pre-treatment at the pilot plant was also the slaughterhouse full-scale treatment unit. A holding tank was used for keeping wastewater to feed to experimental reactors. Both processes were running parallel but working seperately. Details of each process is described individually in the following sections.

4.3 Fixed bed reactor

Fixed bed reactor was 5 metres in height with a surface area and effective volume of 0.95 m^2 and 3.4 m^3respectively. Fixed bed reactor was shown in Fig. 4.5.

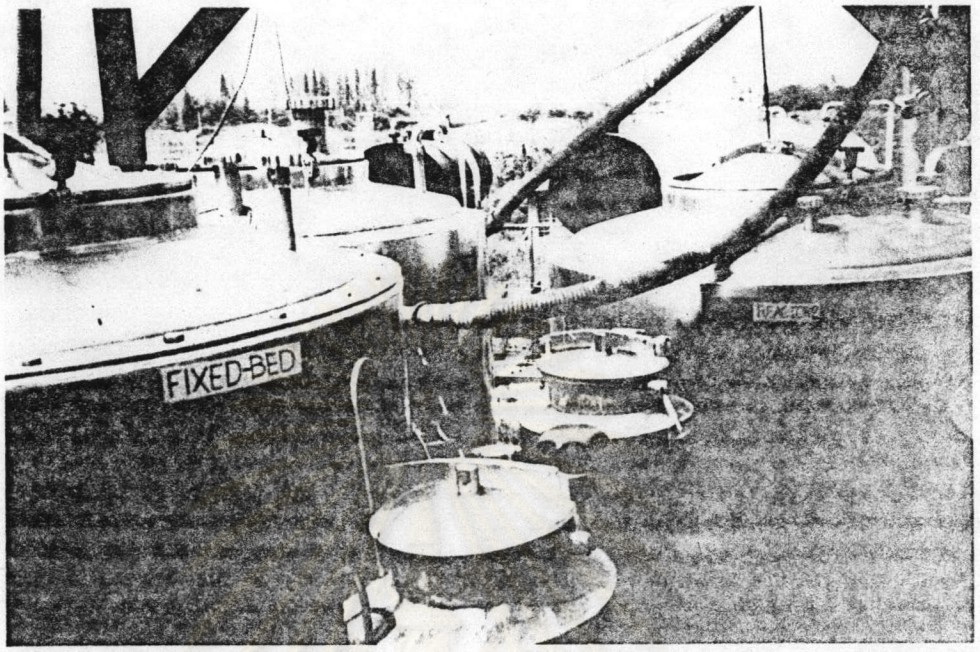


Figure 4.5 Anaerobic Fixed-bed reacter

Inside the reactor, bionet 100 which constructed from NSW (Norctdeutsche Seekabel Werke), Nordenham, Germany was filled as filter media. The bionet 100 was made of polyethylene with a specific area of 100 m^2/m^3. The drawing of filter media is shown in Fig.4.6.

Wastewater was fed at the bottom of the reactor and flowed, upward throughout the reactor height to the effluent pipe at the top. Three ports available for sampling were set at different heights as shown in Fig.4.6. The drawing also illustrates the water jacket and hot water recycle pipes, which were incidentally not applied in this research.

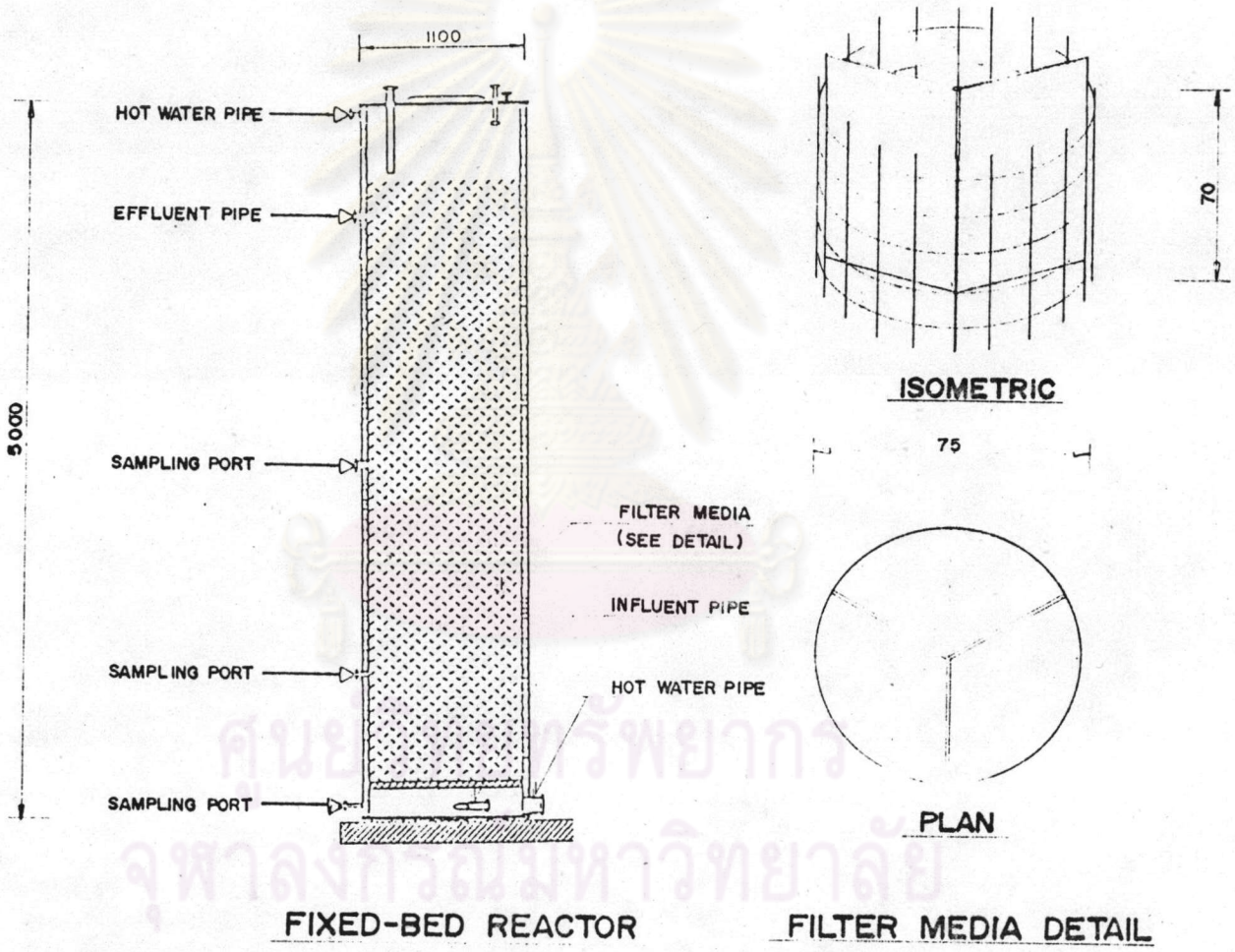


Figure 4.6 Fixed-bed reactor and filter media drawings

4.4 RAUS reactors

RAUS consisted of two reactors as shown in Fig.4.7.

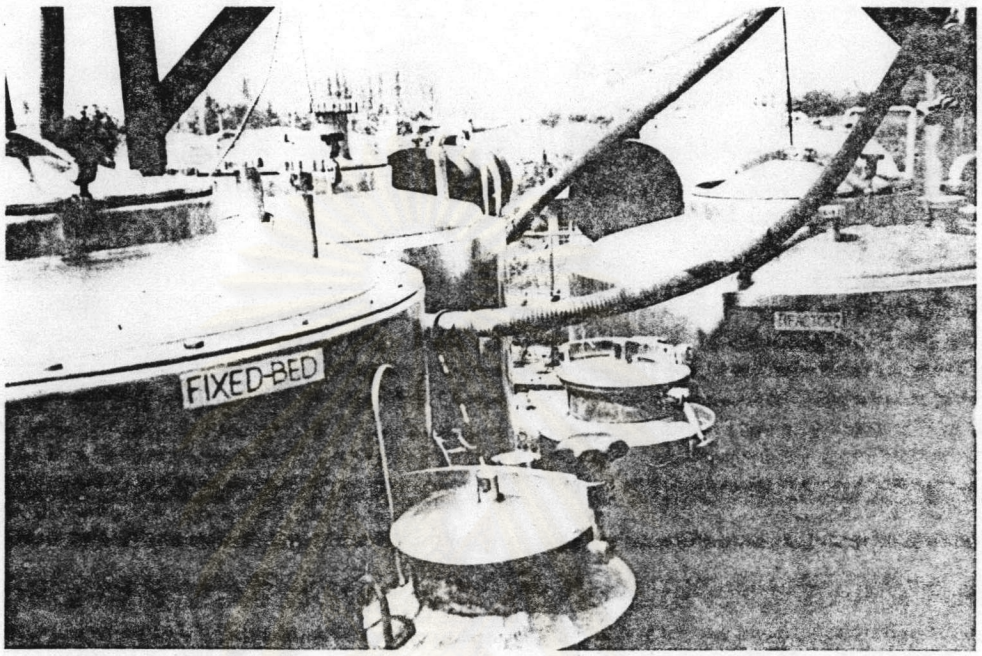
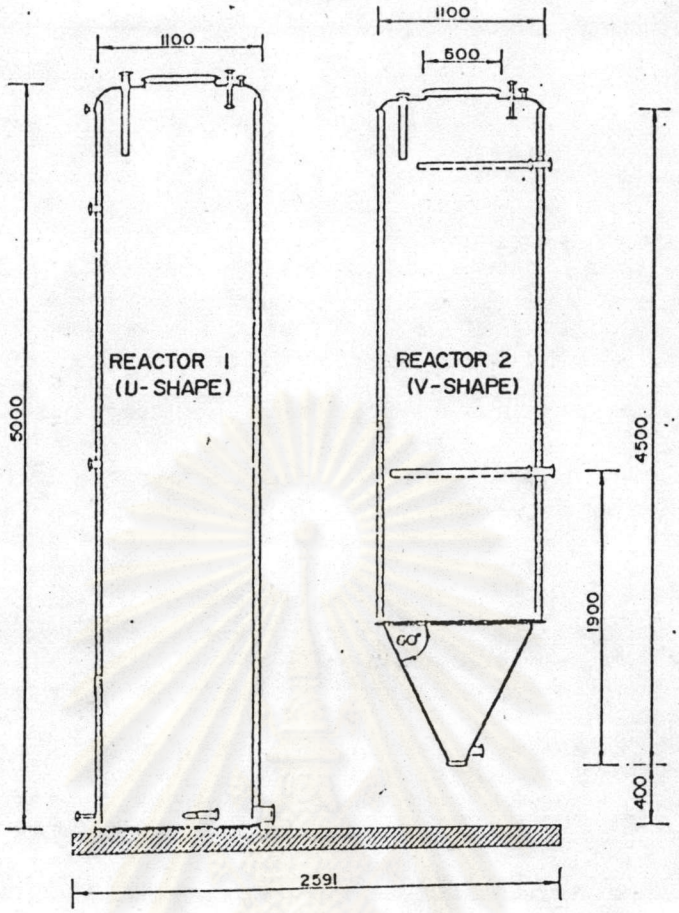


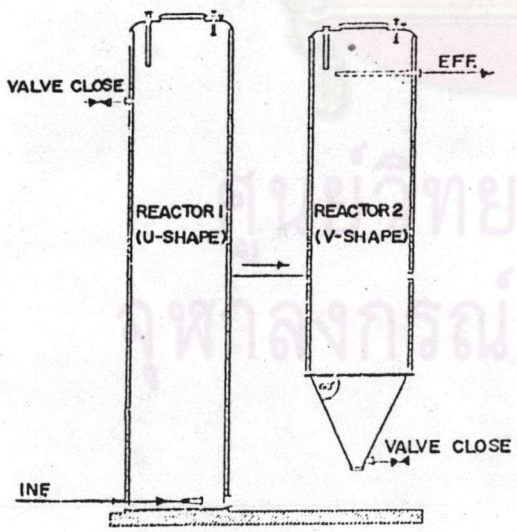
Figure 4.7 Reverse anaerobic upflow system reactor & settler

Wastewater was alternately applied in upflow mode to both reactors at set periods of time. After an interval, reversing was carried out. The configurations of each step is illustrated in Fig. 4.8.

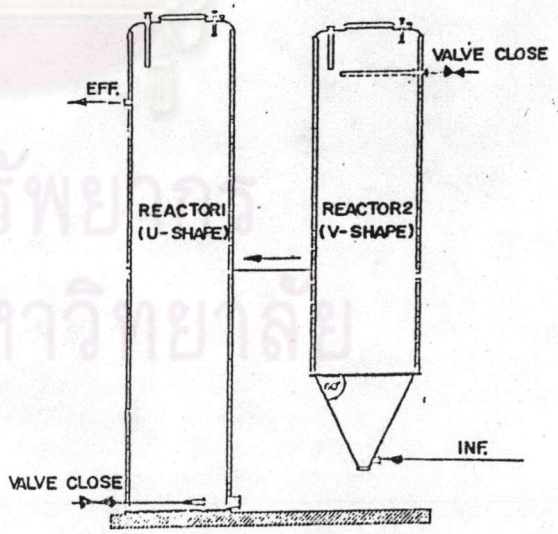
It took six hours for one cycle, after which it was repeated. At the beginning of the cycle, which lasted for two hours, one vessel functioned as a reactor and the other as a settler. After that, the feeding was stopped for one hour sedimentation, this process would proceed for another two hours. The flow was then reversed and the reactor's function changed, the settler was transformed to be the reactor and vice versa. In addition, sedimentation took place again in the last hour of the cycle. This cycle was repeated 4 times a day. Flow regime of RAUS reactors was shown in Fig.4.9.



DIMENSION OF RAUS IN MILLIMETRES



CONDITION ; NORMAL FLOW
FEEDING TO REACTOR 1



CONDITION ; REVERSE FLOW
FEEDING TO REACTOR 2

NOTE : DURING SEDIMENTATION PERIOD ALL VALVES CLOSE

Fig. 4.8 Dimension and configuration of RAUS

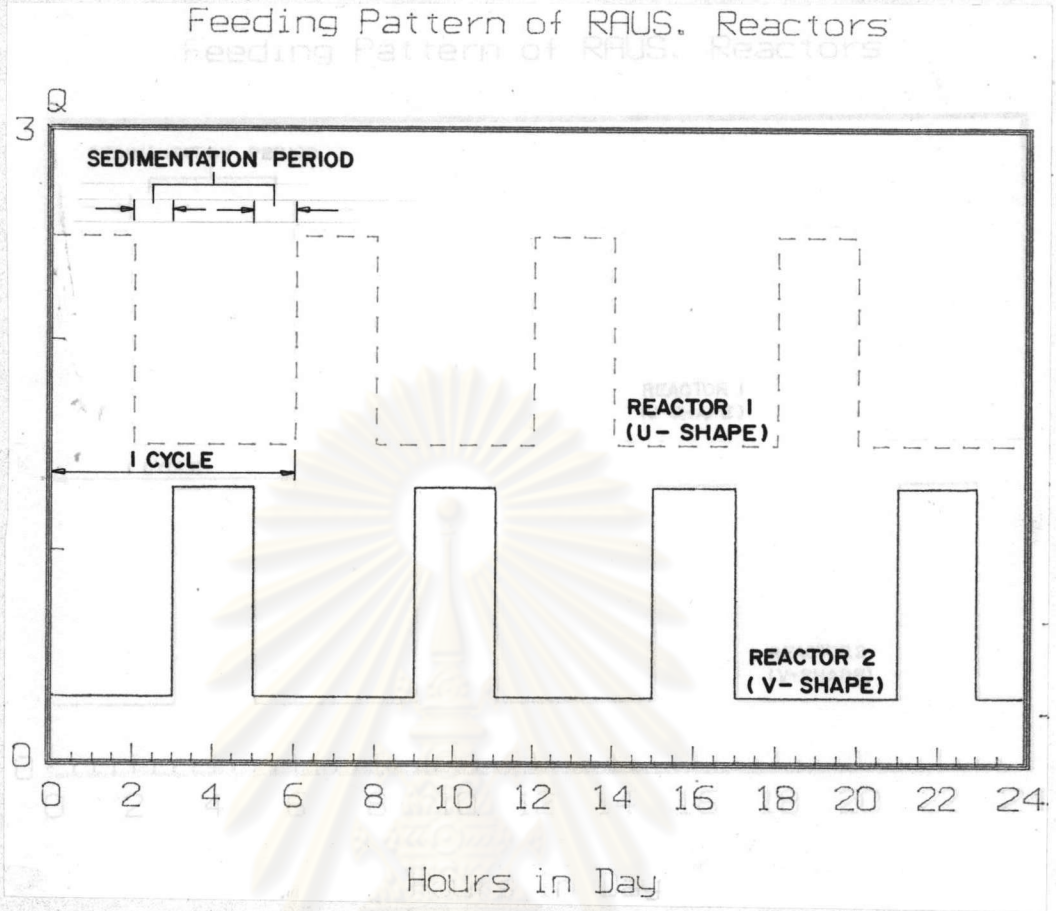


Figure 4.9 Feeding pattern of RAUS

Owing to the reversing flow and no feeding at intervals, all valves have to be closed and opened every one or two hours.Automatic valves were used and controlled by pressure in a close system which was adjusted by a compressor. The procedure was managed by computer.

4.5 Wastewater Used in the Study

The wastewater used in the experimental study was actual wastewater from the slaugterhouse where the pilot plant was located. Wastewaters from different production lines were collected and combined together to a wastewater sump. After being passed through a full scale flotation unit, which was used by slaughterhouse to get rid of hairs, light particles and grease, the wastewater was pumped to a pilot-scale screen.

Screening let only small particles (not larger than 1 mm. in diameter) in the wastewater pass through. Before being fed to experimental reactors, the wastewater was kept in a holding tank. This holding was to prevent wastewater shortage and to ensure the continuity of feeding to the system.

Unavoidingly, the feeding wastewater was affected by alteration in the production activity. The concentration of wastewater was consequently not constant at time in each day.

4.6 Experiment Program

The target of the experimental work was to determine the ultimate hydraulic loading rate for both fixed-bed and RAUS reactors. The hydraulic loading rate was gradually increased by increasing the feeding rate. The increasing flow rate was persued until both processes failed. Flow schedule of each process was shown in Fig.4.10 and 4.11, respectively.

Hydraulic retention time and volumetric organic loading rate, plus hydraulic loading rate for fixed-bed reactor, are also calculated as shown in Table 4.2

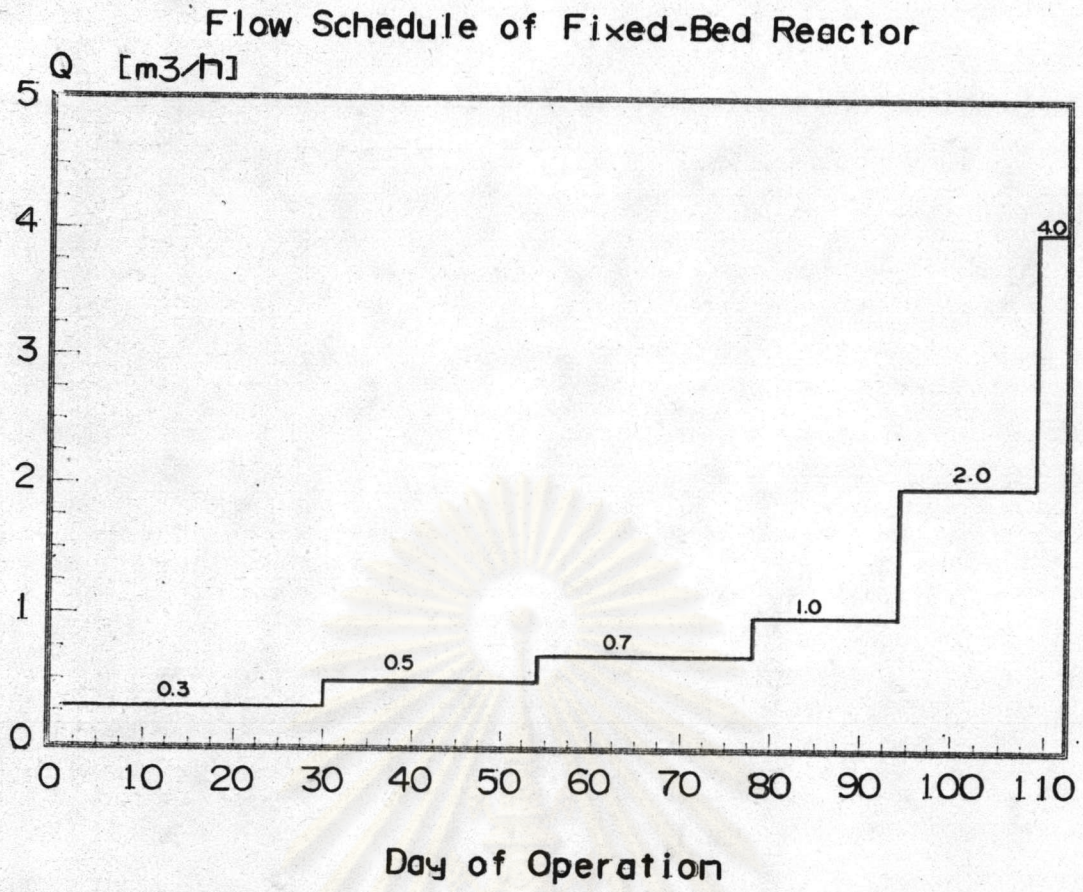


Figure 4.10 Flow schedule of fixed-bed reactor

Table 4.2 HRT and HLR of fixed bed and RAUS

FLOW	FIXED BED REACTOR					RAUS			
(m^3/h)	HRT (h)	HLR* $\frac{m^3}{(m^2.d)}$	VOLR $\frac{kg}{(m^3.d)}$	Operation (d)	No of volume replacement	HRT (h)	VOLR** $\frac{kg}{(m^3.d)}$	Operation (d)	No of volume replacement
0.3	11	0.05	0.94	28	61	21	0.36	44	50
0.5	6.8	0.08	1.00	25	92	13	0.61	29	55
0.7	4.8	0.11	1.43	22	120	9	0.93	24	64
1.0	3.4	0.16	2.38	16	113	6.3	1.62	17	88
2.0	1.7	0.32	5.90	17	198	3.1	1.60	10	78
4.0	0.85	0.64	5.60	4	198	-	-	-	-

Note * base on media specific area of the filter media (100 m^2/m^3)

** base on volume of both reactors added together

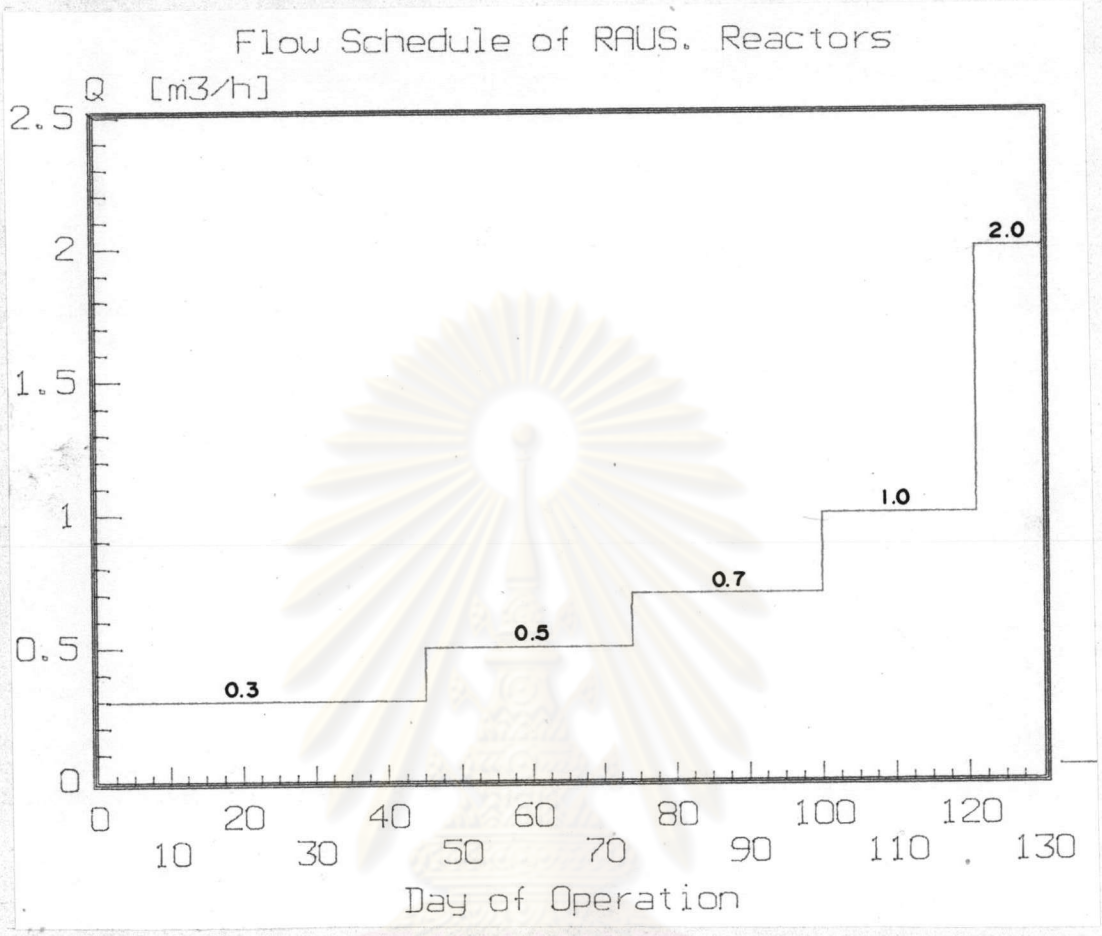


Figure 4.11 Flow schedule of RAUS. reactors

4.7 Sampling and Analysis

Samples were regularly taken three times a week.Composite sampling was done every hour during day time for experimental work with HRT of less than 8 hours. In case of HRT of more than 8 hours composite samples during night time were taken by pump controlled by computer. The treatment efficiency was measured in terms of COD removal. The analysis was done in accordance with "STANDARD METHODS" (APHA, AWWA, WPCF, 1990). The frequency and parameters of anylysis are shown in Table 4.3.

Table 4.3 Parameter and frequency of analysis

Parameter	Sampling Point	Frequency
Temperature	1, 2, 3	3/wk.
pH	1, 2, 3	3/wk.
COD	1, 2, 3	3/wk.
Solids	1, 2, 3	3/wk.
VFA	1, 2, 3	once a week
Alkalinity	1, 2, 3	once a week
Grease & oil	1	once a month
Nitrogen	1	once a month
Phosphorus	1	once a month
Sulphide	1, 2, 3	once a month

Sampling points is shown in Fig.4.12

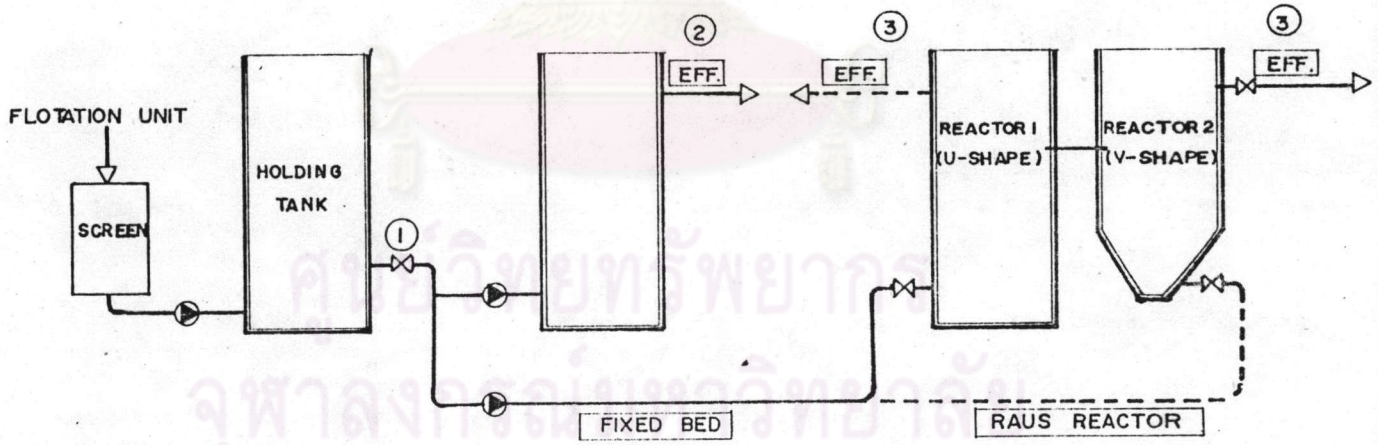


Figure 4.12 Sampling points

The parameter analysed and analytical method are also shown in Table 4.4.

Table 4.4 Parameter and analysis methods

Parameter	Analysis methods
Temperature	Thermometer
pH	Potentionmetric by Digital pH meter
COD	Dichromate Reflux method (Open reflux)
Suspended Solids	Gravimetry (GF-1.2 um pore size)
VFA	Gas chromotography, SHIMADZU GC-14 A
Alkalinity	Methyl orange alkalinity
Grease & Oil	Soxkhlet
Total Nitrogen	Kjehldahl
Ammonia Nitrogen	Distillation, Titrimetric
Phosphorus	Stannous Chloride
Sulphide	Colorometric, Titrimetric