

## CHAPTER VI

### EXPERIMENTAL RESULTS

#### 6.1 Pure water permeation study on reverse osmosis system

The experiment was done by passing pure water, initial conductivity of 240  $\mu\text{mho}$ , through the reverse osmosis system with membrane type T2/15W. The permeate flux and permeate conductivity were measured for each operating pressure which were varied from 40 to 65 Bar. The results are shown in Table 6.1

Data are plotted in Figure 6.1

Table 6.1

Date of experiment : 2/2/81  
Type of feed : Tap water  
Initial conductivity : 240  $\mu\text{mho}$   
System : Reverse osmosis  
Membrane type : T2/15W  
Operating pressure : 40 to 65 Bar  
Temperature : 30 $^{\circ}\text{C}$

Pressure (Bar)	Permeate Flux ( $\text{l/m}^2\text{hr}$ )	Permeate Conductivity ( $\mu\text{mho}$ )
40	48.14	2.0
45	55.81	2.0
50	62.79	2.0
55	69.77	2.0
60	76.74	2.0
65	87.21	2.0

## 6.2 Treatment of reverse osmosis on sugar solution

The sugar solutions of various concentration were passed through the reverse osmosis system, with membrane type T2/15W, to study rejection characteristics. At each concentration, the module was pressurised to different pressure which was varied from 40 to 60 bar. Both of the permeate and the retentate were recycled to the feed tank to maintain the initial concentration of each run. The permeate flux , permeate concentration and retentate concentration were recorded.

The results are shown in Table 6.2

Data are plotted in Figure 6.1

Table 6.2

Date of experiment : 10/10/80  
Type of feed : Sucrose solution  
Initial concentration : 6.4 to 31 Brix  
Membrane type : T2/15W  
Operating pressure : 40 to 60 Bar  
Temperature : 30°C  
Permeate concentration : 0

Initial Concentration (Brix)	Pressure (Bar)	Permeate Flux ( l/m <sup>2</sup> hr )
6.4	40	41.04
	45	47.03
	50	53.67
	55	58.96
	60	64.39
7.5	40	39.12
	45	45.49
	50	51.68
	55	57.34
	60	62.48
9.8	40	34.03
	45	40.64
	50	45.01
	55	51.04
	60	55.08



Table 6.2 Cont.

Initial Concentration (Brix)	Pressure (Bar)	Permeate Flux ( $l/m^2/hr$ )
13.8	40	27.91
	45	33.76
	50	37.71
	55	43.15
	60	45.99
18.0	40	19.84
	45	24.06
	50	27.53
	55	31.72
	60	35.72
21.6	40	12.99
	45	17.29
	50	20.93
	55	24.34
	60	27.18
26.0	40	7.27
	45	10.36
	50	14.14
	55	16.09
	60	20.12
31.0	40	0.84
	45	3.29
	50	5.81
	55	8.05

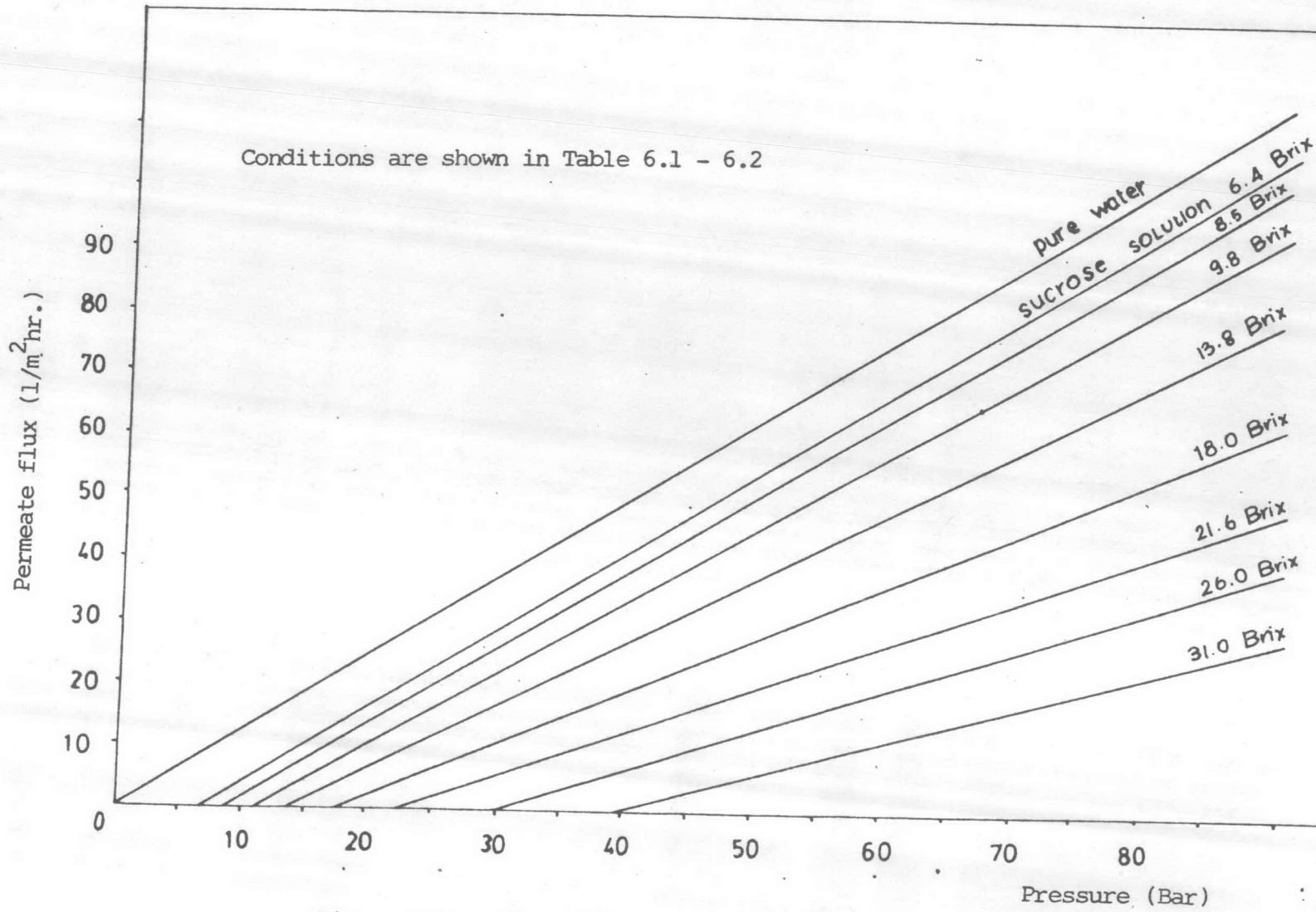


Figure 6.1 Permeate of pure water and sucrose solution vs. pressure

### 6.3 Liquid waste study on Reverse Osmosis system

The liquid pretfiltered with 106 Mesh sieve in order to reject large particles was passed through the Reverse Osmosis system, membrane type T2/15W. The time used to concentrate the liquid waste from the initial concentration of 0.5 to 2.5 °Brix to about 20° Brix was noted. At each period of time the permeate flux, permeate weight and the retentate concentration were recorded. The operating pressure was kept constant at 50 and 60 Bar.

The results are shown in Table 6.3-1 to 6.3-3.

Data are plotted in Figure 6.2 - 6.4

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Table 6.3-1

Date of Experiment : 18/8/80  
 Type of Feed : Liquid waste  
 Initial Concentration : 2.5 Brix  
 System : Reverse Osmosis  
 Membrane type : T2/15W  
 Operating Pressure : 60 Bar

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Wt. of Permeate (kg)	Retentate conc.(Brix)
0.083	46.75	2.3	2.6
0.167	46.75	5.1	2.8
0.25	49.53	7.9	2.8
0.42	49.53	14.1	3.1
0.58	49.53	19.9	3.3
0.66	46.75	24.3	3.3
0.83	46.75	29.8	3.5
1.0	43.95	35.3	3.8
1.17	42.56	40.7	4.0
1.33	42.56	47.5	4.4
1.50	41.16	52.7	4.7
1.67	40.47	57.7	5.0
1.83	39.76	62.7	5.5
2.0	37.67	69.0	6.0
2.08	38.37	71.3	6.2
2.17	37.67	73.7	6.4
2.25	36.28	76.0	6.8
2.33	36.98	78.3	7.2
2.42	38.38	80.7	7.5
2.50	33.49	84.1	8.0
2.67	33.49	88.4	9.0
2.83	32.09	92.6	10.0
3.0	28.61	96.5	11.5

Table 6.3-1 Cont.

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Wt. of Permeate (kg)	Retentate conc. (Brix)
3.08	28.59	98.2	12.2
3.25	22.05	102.9	14.4
3.33	22.33	104.4	15.3
3.42	20.23	105.7	16.6
3.50	17.44	106.9	17.7
3.58	17.44	108.0	18.2
3.67	15.34	109.4	19.0
3.75	15.34	110.1	19.5

Table 6.3-2

Date of Experiment : 21/8/80  
 Type of Feed : Liquid waste  
 Initial Concentration : 0.5 Brix  
 System : Reverse Osmosis  
 Membrane type : T2/15W  
 Operating Pressure : 50 Bar

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Wt. of Permeate (kg)	Retentate conc.(Brix)
0.5	23.38	9.3	0.5
1.0	22.75	20.6	0.6
1.75	24.77	36.6	0.9
3.0	23.52	58.7	1.9
3.5	24.06	69.9	2.0
4.0	23.92	78.7	2.2
4.75	21.92	94.5	3.3
5.0	22.04	99.5	3.5
5.5	21.04	108.0	4.5

Table 6.3-3

Date of Experiment : 19/8/80  
Type of Feed : Liquid waste  
Initial Concentration : 2.3 Brix  
System : Reverse Osmosis  
Membrane type : T2/15W  
Operating Pressure : 60 Bar

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Retentate Conc. (Brix)
0.25	38.38	2.4
0.5	27.21	2.5
0.75	27.21	2.8
1.0	27.21	2.9
1.25	27.91	3.1
1.30	32.79	3.4
1.75	36.28	3.8
2.0	32.09	4.0
2.25	30.69	4.4
2.5	32.09	5.0
2.75	32.09	5.6
2.83	29.99	5.8
3.0	28.61	6.0
3.083	-	-
3.167	29.99	6.8
3.25	29.99	7.0
3.33	-	-
3.417	27.21	7.6
3.58	26.51	9.0
3.92	-	10.0
4.0	-	12.2
4.083	-	14.0



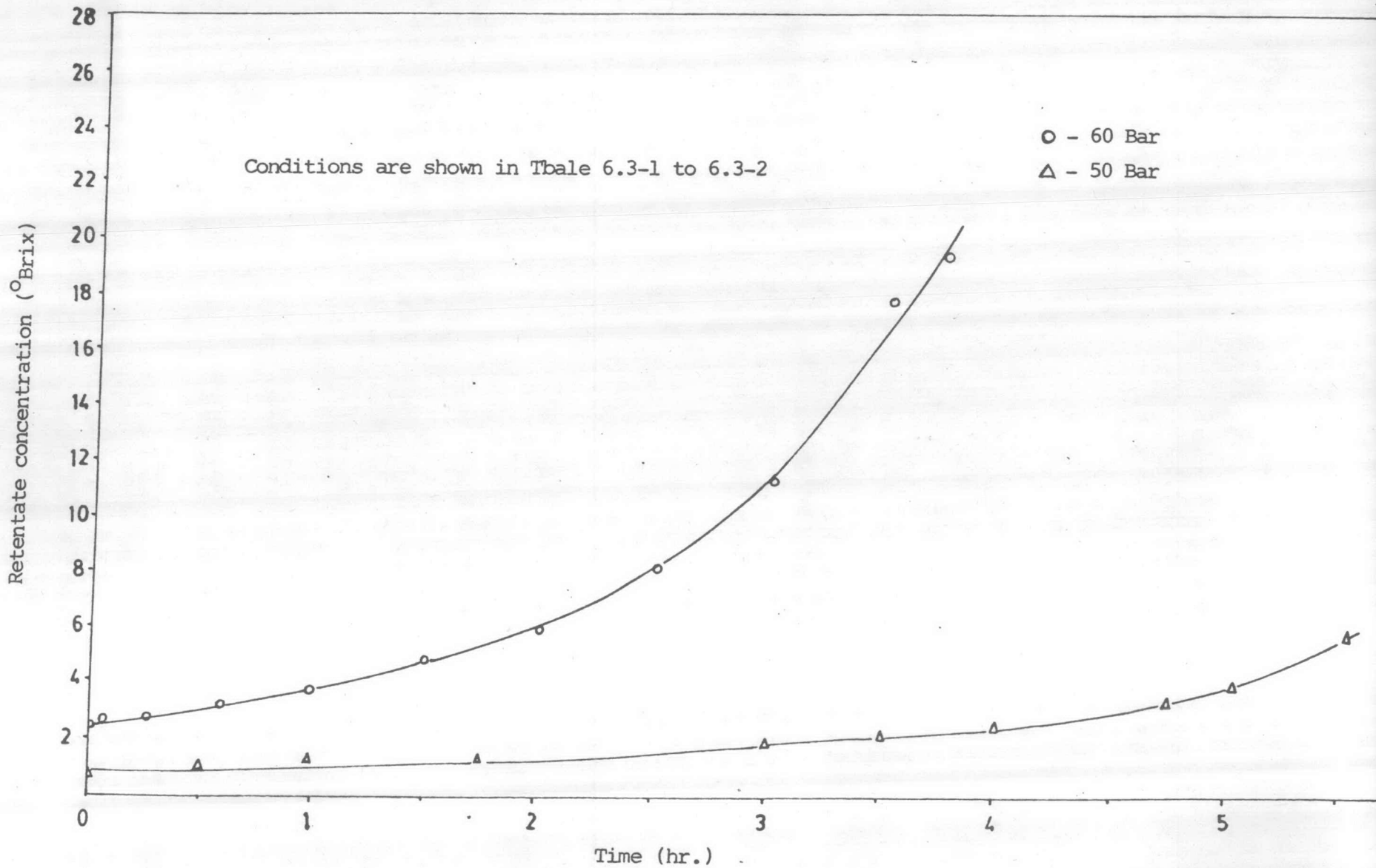


Figure 6.2 Retentate concentration vs time

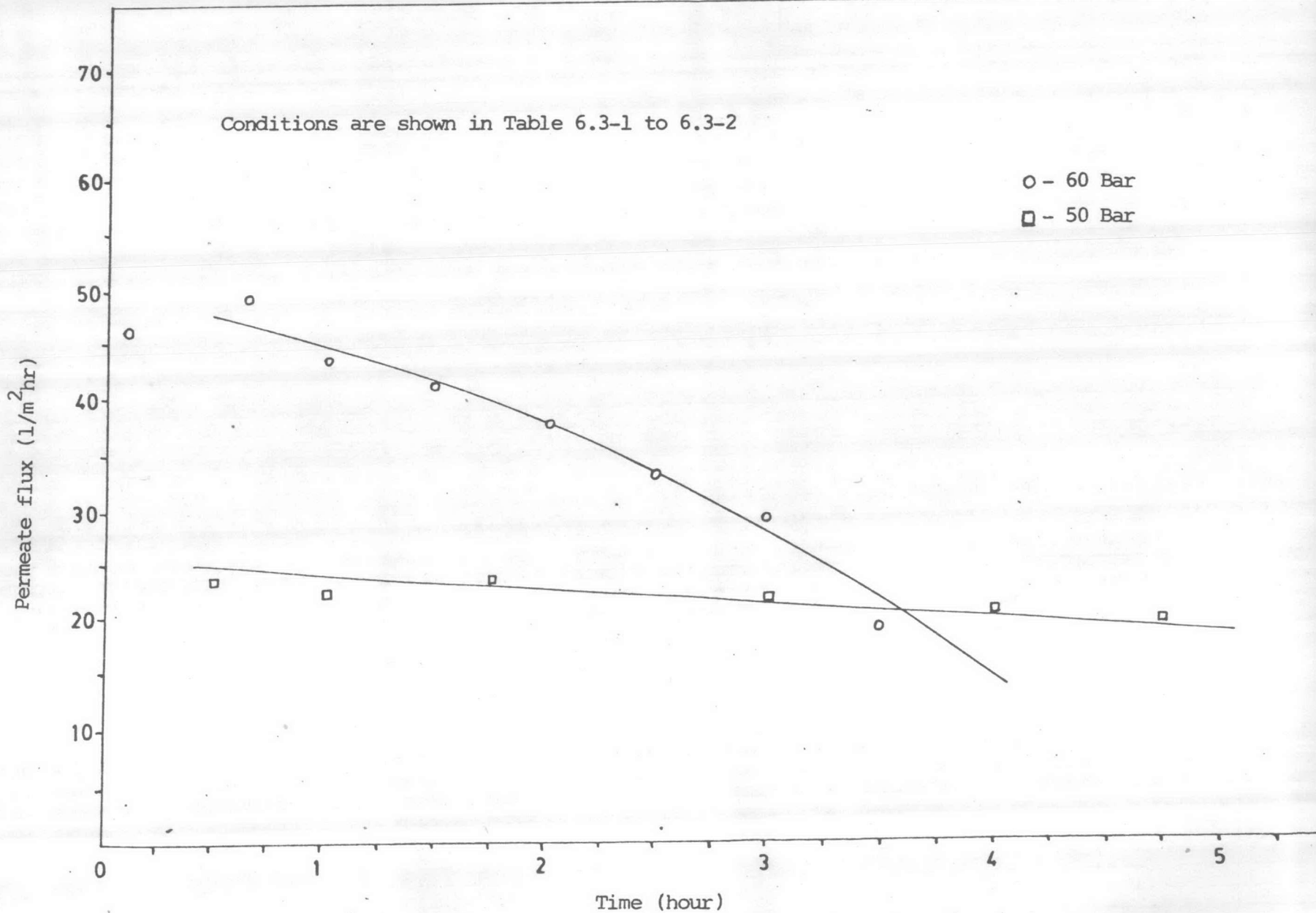


Figure 6.3 Permeate flux vs time

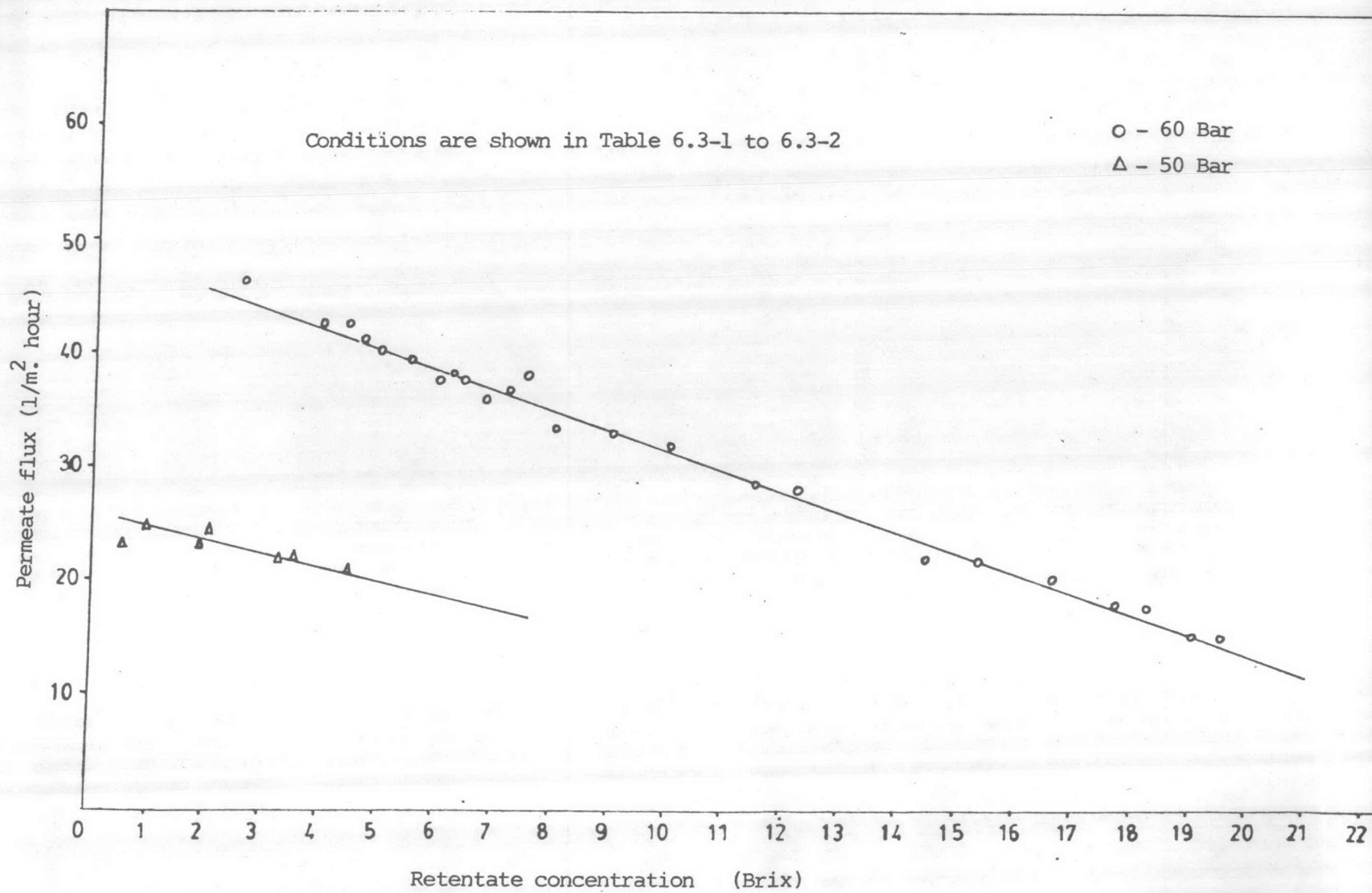


Figure 6.4 Retentate concentration vs permeate flux

#### 6.4 Liquid waste study on Ultrafiltration and Reverse Osmosis system

The experiments were done by passing liquid waste, of different initial concentration, prefiltered with 106 Mesh sieve, through the Ultrafiltration system, membrane type T2/A. The permeate of Ultrafiltration was passed through Reverse Osmosis system, membrane type T2/15W. The permeate flux and retentate concentration of Reverse Osmosis were recorded. The operating pressure of Ultrafiltration was kept constant at 10 Bar but the operating of Reverse Osmosis was varied from 40 to 60 Bar, respectively.

The results are shown in Table 6.4-1 to 6.4-5

Data are plotted in Figure 6.5



Table 6.4-1

Date of Experiment : 16/9/80  
Type of Feed : Liquid waste  
Initial Concentration : 0.6 Brix  
System : Ultrafiltration & Reverse Osmosis  
Membrane type : UF - T2/A, RO - T2/15W  
Operating Pressure : UF - 10 Bar, RO - 40 Bar  
Temperature : 30 degree C  
pH : 4.0

Time (hr)	Permeate Flux ( $l/m^2 hr$ )	Retentate conc.(Brix)
0.28	55.08	0.6
0.50	41.04	0.8
0.75	39.87	1.0
1.0	38.05	1.8
1.25	37.05	2.2
1.50	34.31	3.0

Table 6.4-2

Date of Experiment : 16/9/80  
Type of Feed : Liquid waste  
Initial Concentration : 2.0 Brix  
System : Ultrafiltration & Reverse Osmosis  
Membrane type : UF - T2/A, RO - T2/15W  
Operating Pressure : UF - 10 Bar, RO - 50 Bar  
Temperature : 30 degree C  
pH : 4.0

Time (hr)	Permeate Flux ( $l/m^2/hr$ )	Retentate conc.(Brix)
0.25	46.51	2.3
0.5	49.25	2.7
0.75	45.49	3.0
1.0	37.05	4.0
1.25	36.40	5.4
1.50	30.55	8.0

Table 6.4-3

Date of Experiment : 18/9/80  
Type of Feed : Liquid waste  
Initial Concentration : 4.8 Brix  
System : Ultrafiltration &  
Reverse Osmosis  
Membrane type : UF - T2/A, RO - T2/15W  
Operating Pressure : UF - 10 Bar, RO - 55 Bar  
Temperature : 30 degree C  
pH : 4.0

Time (hr)	Permeate Flux ( $l/m^2 hr$ )	Retentate conc.(Brix)
0.3	39.87	5.5
0.55	36.98	6.5
0.67	39.76	7.2
0.75	38.38	8.0
0.83	34.88	8.4
0.92	34.18	9.0
1.0	33.49	10.0
1.08	32.09	10.7
1.16	27.91	12.0
1.25	26.51	13.0
1.33	24.41	14.3
1.42	16.18	16.0

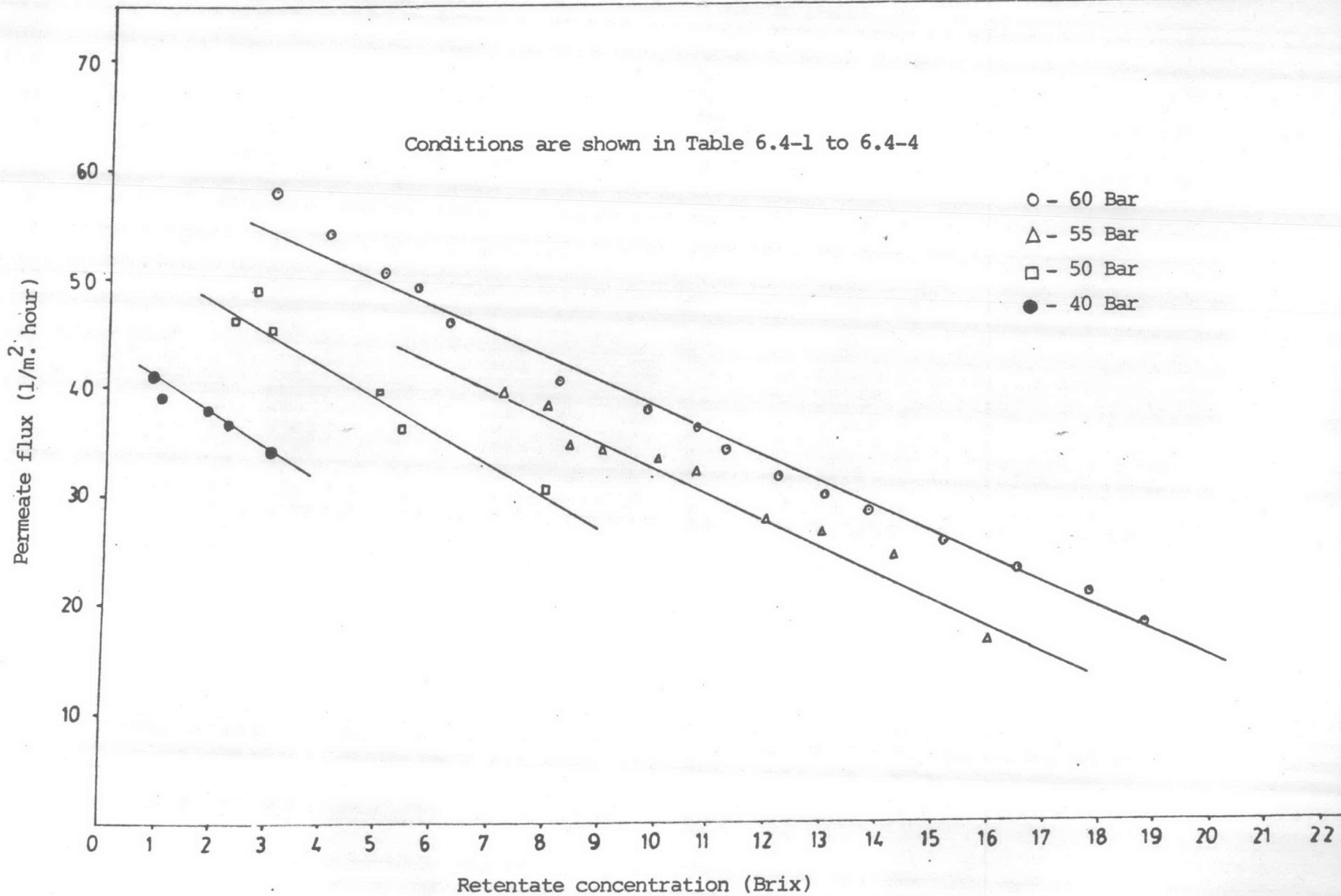


Table 6.4-4

Date of Experiment : 15/9/80  
Type of Feed : Liquid waste  
Initial Concentration : 3 Brix  
System : Ultrafiltration and Reverse Osmosis  
Membrane type : UF - T2/A, RO - T2/15W  
Operating Pressure : UF - 10 Bar, RO - 60 Bar  
Temperature : 31 degree C  
pH : 4.0

Permeate Flux (l/m <sup>2</sup> hr)	Retentate Concentration (Brix)
57.21	3.0
54.41	4.0
50.23	5.0
49.26	5.6
46.75	5.8
47.44	6.2
46.04	6.2
45.35	6.8
40.47	8.2
37.67	9.8
36.98	10.7
34.18	11.2
32.79	12.2
29.99	13.0
28.61	13.8
25.82	15.2
23.02	16.5
20.93	17.8
18.84	18.8





**Figure 6.5** Retentate concentration vs permeate flux

6.5 Liquid waste study on Ultrafiltration and Reverse Osmosis system  
with membrane T6/B

The experiments were done just the same as part (6.4) except that the Ultrafiltration membrane used was changed to T6/B. The Ultrafiltration system was operated at constant pressure of 10 Bar where the Reverse Osmosis system was operated at various pressure from 40 to 60 Bar.

The results are shown in Tables 6.5-1 to 6.5-6

Data are plotted in Figure 6.6 to 6.8

Table 6.5-1

Date of Experiment : 3/3/81  
 Type of Feed : Liquid waste  
 Initial Concentration : 0.8 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane Type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 40 Bar  
 Temperature : 30°C  
 pH : 4.15

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Retentate Conc. (Brix)	Permeate Conc. (Brix)
0.58	36.03	0.8	0
1.25	25.84	1.0	0
2.08	32.45	1.5	0
2.58	26.49	2.0	0
3.08	32.0	3.0	0
3.58	29.27	6.0	0
3.83	25.06	8.8	0.2

Table 6.5-2

Date of Experiment : 5/3/81  
 Type of Feed : Liquid waste  
 Initial Concentration : 0.9 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 45 Bar  
 Temperature : 32 degree C  
 pH : 4.5  
 Permeate concentration : 0

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Retentate Conc. (Brix)
0.16	38.34	1.0
0.33	53.66	1.0
0.50	38.34	1.2
0.83	37.11	1.3
1.084	38.76	1.4
1.33	33.76	1.6
1.58	34.61	1.6
1.83	33.76	1.8
2.08	34.88	2.3
2.33	36.41	2.8
2.58	33.49	3.2
2.83	33.49	4.0
3.084	28.29	5.4
3.33	29.68	6.8
3.50	24.92	8.8
3.58	22.29	10.0





Table 6.5-4

Date of Experiment : 7/3/81  
 Type of Feed : Liquid waste  
 Initial Concentration : 0.6 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 55 Bar  
 Temperature : 33 degree C  
 pH : 4.1

Time (hr)	Permeate Flux ( $l/m^2 \text{hr}$ )	Permeate Wt. (kg)	Retentate Conc. (Brix)
0.25	45.01	-	0.8
0.50	49.25	3.8	1.0
0.75	49.83	15.8	1.0
1.00	49.25	28.1	1.1
1.25	48.39	40.7	1.3
1.50	47.57	52.5	1.6
1.75	45.01	62.6	2.0
2.00	45.75	71.5	2.2
2.25	44.53	82.1	3.0
2.50	42.49	88.1	3.7
2.75	40.06	92.4	5.5
3.00	34.03	99.4	9.4
3.08	23.26	101.8	11.0



Table 6.5-6

Date of Experiment : 7/2/81  
 Type of Feed : Liquid waste  
 Initial Concentration : 2.0 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 60 Bar  
 Temperature : 31 degree C  
 pH : 4.1

Time (hr)	Permeate Flux ( $l/m^2hr$ )	Retentate Conc.(Brix)	Permeate Conc.(Brix)
0.25	39.49	2.4	0
1.00	32.70	4.0	0
2.75	29.07	7.0	0
2.92	22.75	8.4	0
3.25	19.03	11.0	0.1
3.42	19.93	13.3	0.2
3.58	17.44	16.4	0.2
3.67	16.09	17.0	0.2

Table 6.5-7

Date of Experiment	: 3/2/81
Type of Feed	: Liquid waste
Initial Concentration	: 4.0 Brix
System	: Ultrafiltration & Reverse Osmosis
Membrane type	: UF - T6/B, RO - T2/15W
Operating Pressure	: UF - 10 Bar, RO - 60 Bar
Temperature	: 30 degree C

Time (hr)	Permeate Flux ( $l/m^2/hr$ )	Retentate Conc. (Brix)	Permeate Conc.(Brix)
0.25	48.11	4.5	0.2
0.50	46.51	5.0	0.4
0.75	45.01	5.4	0.4
2.00	34.88	9.8	0.5
2.75	26.83	15.4	0.6
3.00	19.19	18.7	0.8
3.25	14.24	20.8	0.8
3.50	10.57	22.5	1.0
3.58	6.67	23.5	1.0

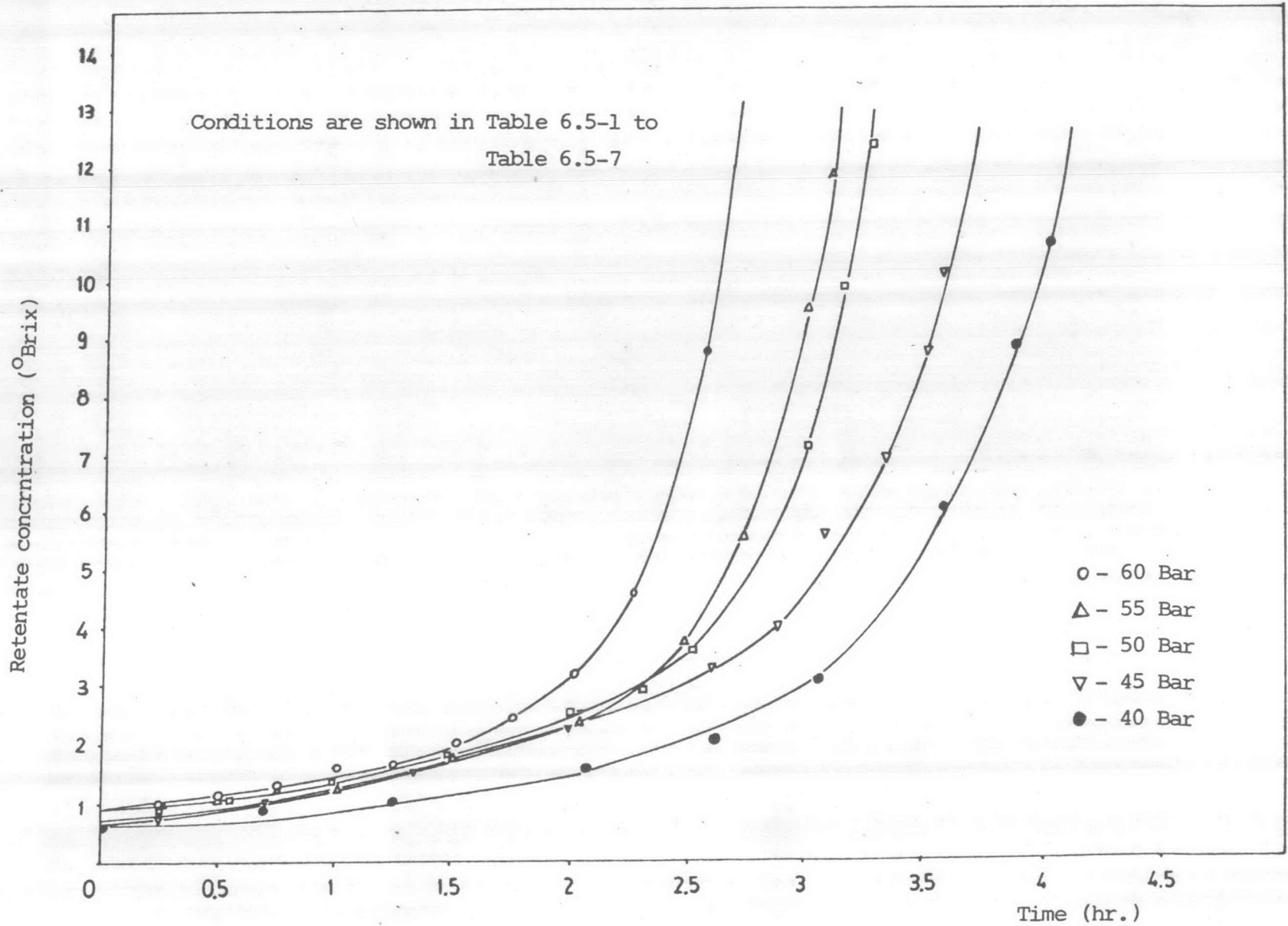


Figure 6.6 Retentate concentration vs time

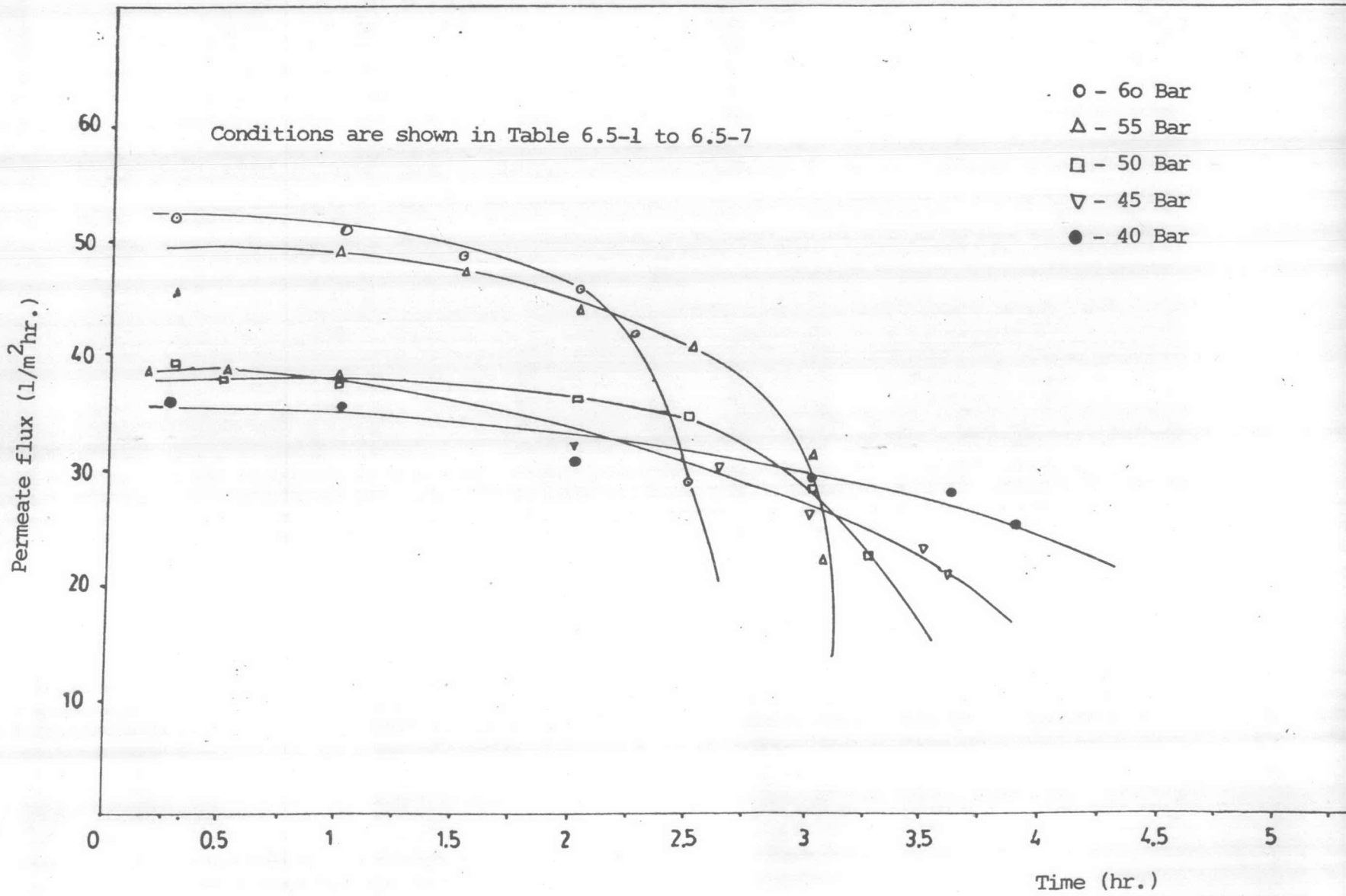


Figure 6.7 Permeate flux vs time

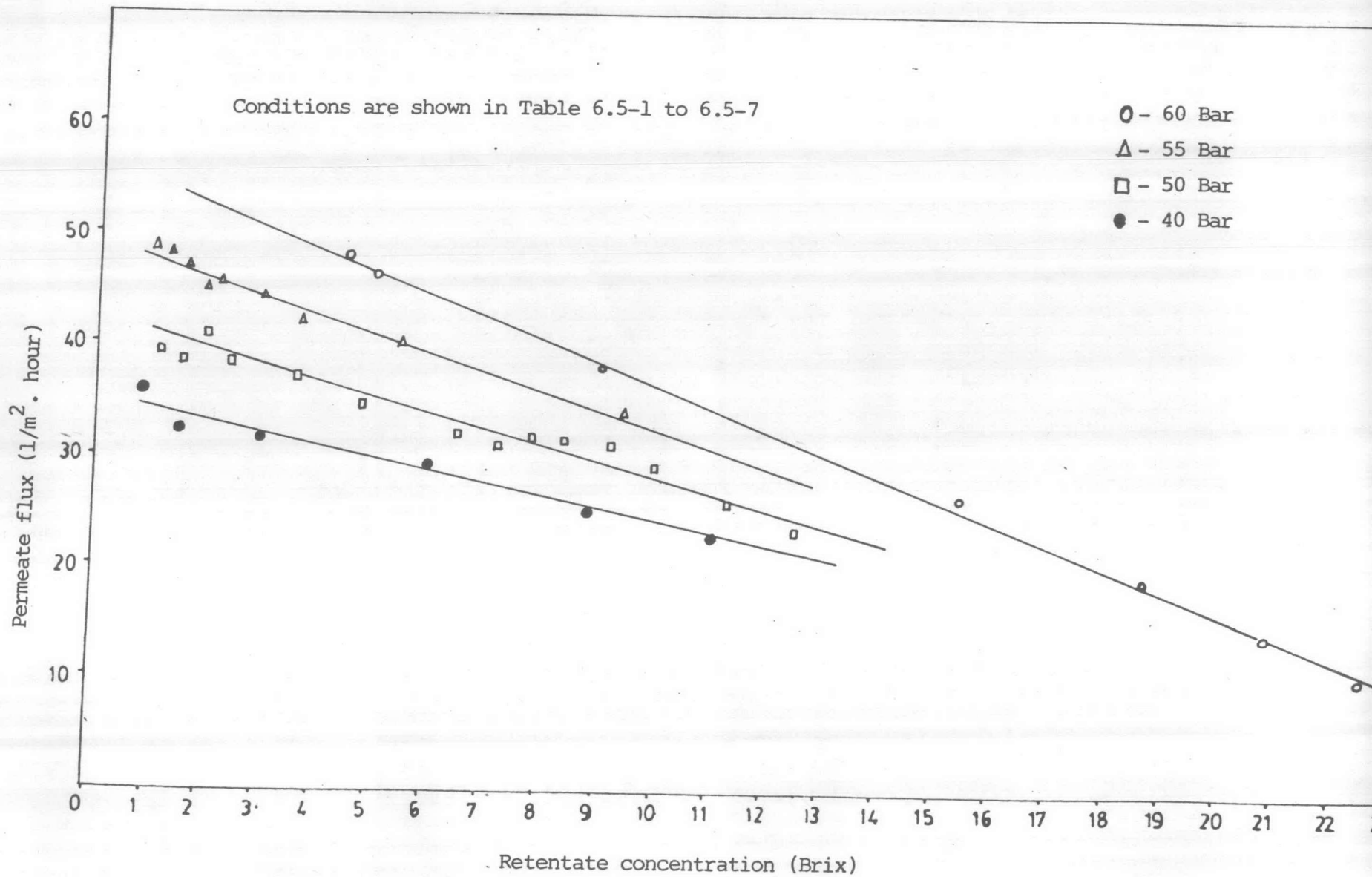


Figure 6.8

Retentate concentration vs permeate flux



## 6.6 Liquid waste study on Ultrafiltration

The experiment was done by passing the liquid waste, pretreated with 106 Mesh sieve, through the Ultrafiltration system, membrane type T6/B. The operating pressure was varied from 5.5 to 9.7 Bar. The permeate flux and permeate concentration were measured at each operating pressure.

The result is shown in Table 6.6

Data are plotted in Figure 6.9

Table 6.6

Date of Experiment : 2/2/81  
Type of Feed : Liquid waste  
Initial Concentration : 1.0 Brix  
System : Ultrafiltration  
Membrane type : T6/B  
Operating Pressure : 5.5 - 9.7 Bar  
Temperature : 31 degree C

Pressure (Bar)	Permeate Flux ( $l/m^2 hr$ )	Permeate Conc. (Brix)
5.5	45.01	0.4
7.5	60.67	0.6
8.0	67.51	0.6
8.5	61.56	0.8
9.7	67.51	0.8

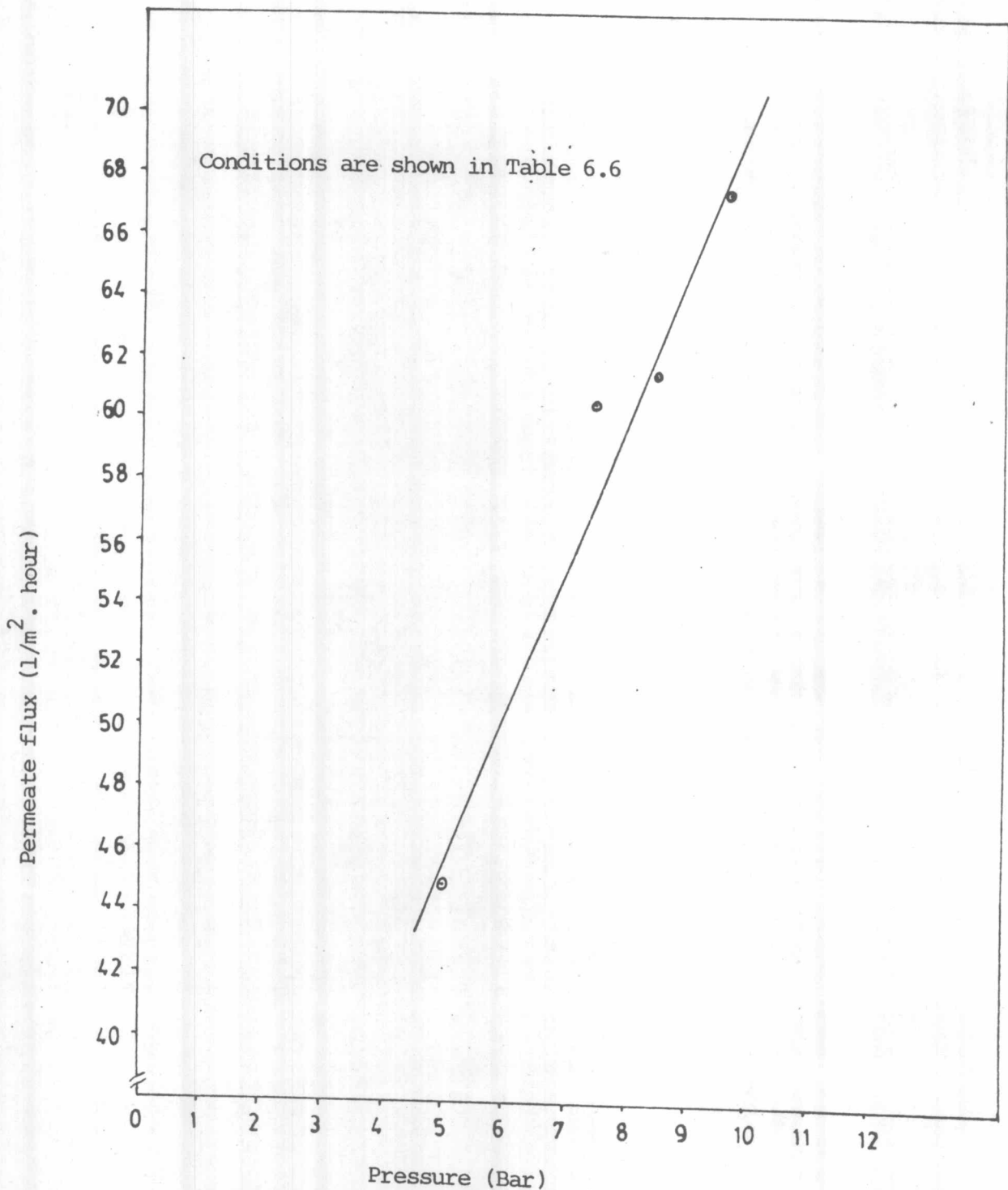


Figure 6.9 Permeate flux vs pressure

## 6.7 Liquid from solidwaste study on Ultrafiltration system

Jouice squeezed from solid pineapple waste, pretreated 160 Mesh sieve, was passed through the Ultrafiltration system, membrane type T6/B. The operating pressure was kept constant at 9.5 Bar. the permeate flux and permeate concentration were recorded in every 1 hour period.

The result is shown in Table 6.7

Data are plotted in Figure 6.10

Table 6.7

Date of Experiment : 6/8/81  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 5.4 Brix  
 System : Ultrafiltration  
 Membrane type : T6/B  
 Operating Pressure : 9.5 Bar  
 Temperature : 31 degree C  
 pH : 3.85

Time (hr)	Permeate Flux ( $l/m^2$ hr)	Inlet Conc. (Brix)	Outlet Conc. (Brix)
0.5	26.66	5.4	4.5
1.0	27.72	5.4	4.5
2.0	29.69	5.6	5.0
3.0	31.71	5.6	5.2

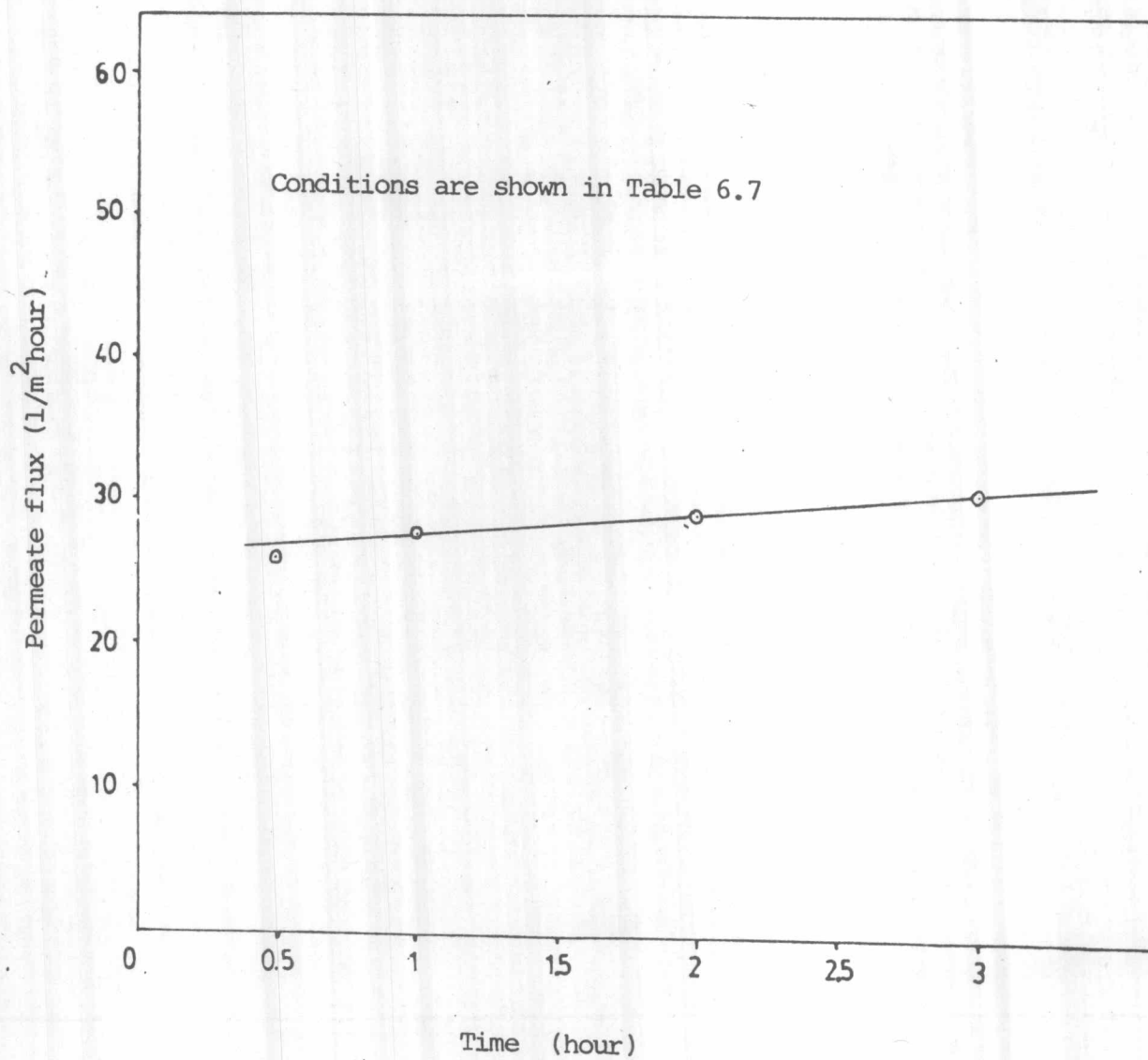


Figure 6.10 Permeate flux vs time

## 6.8 Liquid from solid waste study on Reverse Osmosis system

Juice squeezed from solid pine-apple waste, pretreated with 106 Mesh sieve, was passed through the Reverse Osmosis system, membrane type T2/15W. The operating pressure was kept constant at 40 and 50 Bar. The permeate flux, permeate weight and retentate concentration were recorded. The period of time used to concentrate the liquid from the initial concentration to the final one was noted.

The results are show in Table 6.8-1 to 6.8-2

Data are plotted in Figure 6.11

Table 6.8-1

Date of Experiment : 20/8/80  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 5.5 Brix  
 System : Reverse Osmosis  
 Membrane type : T2/15W  
 Operating Pressure : 40 Bar  
 Temperature : 30 degree C

Time (hr)	Permeate Flux (l/m <sup>2</sup> hr)	Wt. of permeate (kg)	Retentate Conc. (Brix)
0.25	16.74	7.4	5.5
0.50	18.84	14.2	6.0
1.00	14.65	19.0	6.3
1.25	18.84	24.0	6.5
1.50	17.44	27.5	7.0
1.75	18.14	30.8	7.0
2.00	17.44	34.1	7.5
2.25	17.44	37.5	7.8
2.50	17.44	40.8	8.0
2.75	16.74	45.4	8.5
3.00	16.05	48.6	9.0
3.25	16.74	51.4	9.3
3.50	16.05	54.6	10.1
3.75	-	60.8	10.8
4.00	16.05	65.2	11.2
4.25	13.96	67.6	11.5
4.50	9.07	69.8	12.2
4.75	9.76	71.5	12.8
5.00	10.46	73.2	13.2
5.25	6.25	75.2	13.8
5.50	-	76.8	14.2



Table 6.8-2

Date of Experiment : 21/8/80  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 5.5 Brix  
 System : Reverse Osmosis  
 Membrane type : T2/15W  
 Operating Pressure : 50 Bar  
 Temperature : 30 degree C  
 pH :

Time (hr)	Permeate Flux ( $l/m^2 \text{ hr}$ )	Wt. of Permeate (kg)	Retentate Conc.(Brix)
1.33	14.64	25.0	7.0
1.58	27.21	31.8	7.2
1.83	20.23	36.0	7.5
2.25	23.02	42.0	8.0
2.58	20.93	47.0	8.5
3.00	24.41	49.8	9.2
3.33	22.33	56.8	10.0
3.83	22.33	62.3	10.6
4.33	20.23	68.8	12.0
4.83	18.14	75.6	12.8
5.33	14.64	80.6	13.8
5.83	12.56	84.8	14.8

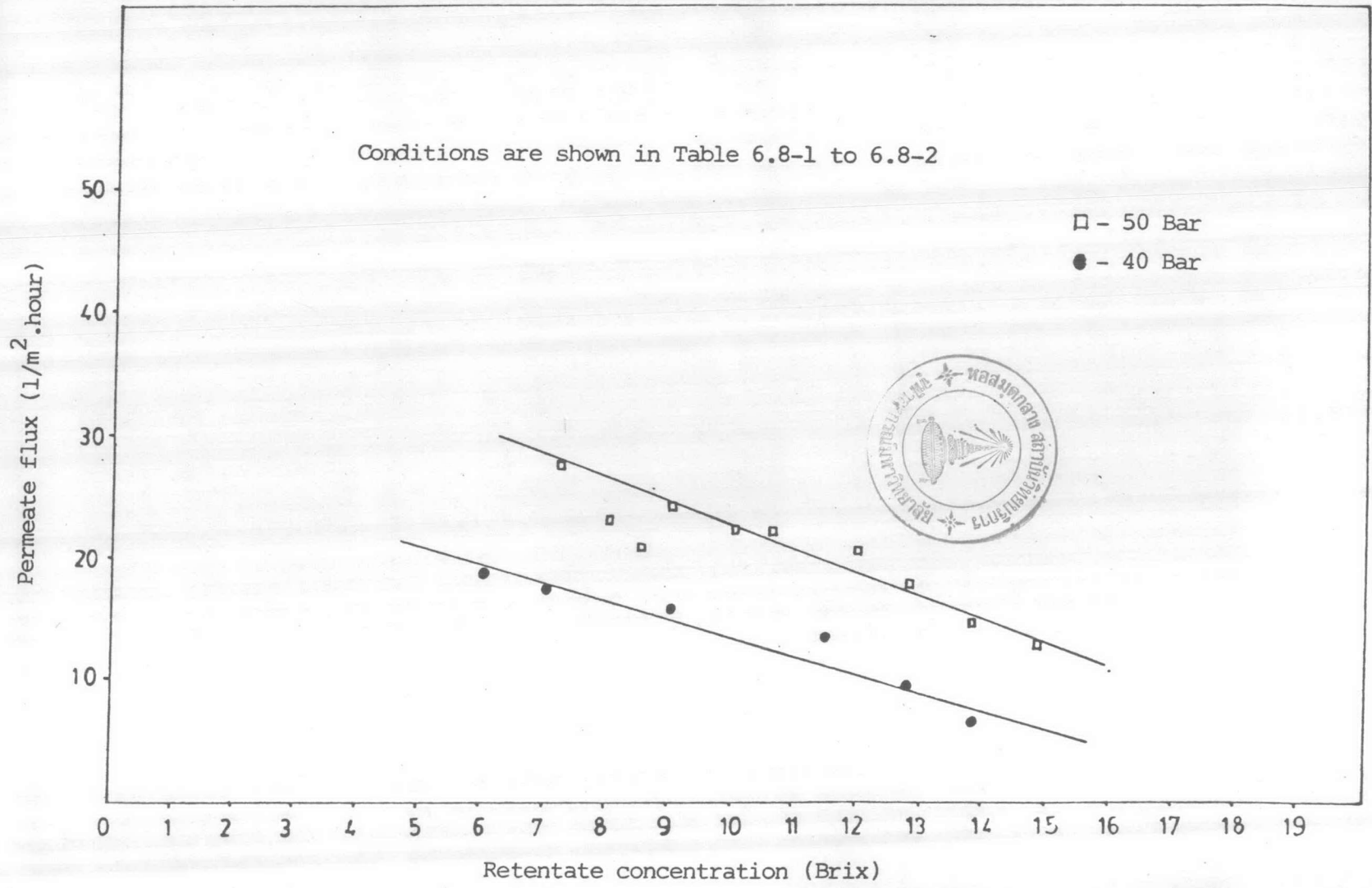


Figure 6.11 Retentate concentration vs permeate flux

### 6.9 Liquid from solid waste study on Ultrafiltration and Reverse Osmosis system

Juice squeezed from solid pineapple waste, pretreated with 160 Mesh sieve, was passed through Ultrafiltration system membrane type T6/B. The operating pressure was at 10 Bar. The permeate of the Ultrafiltration system was then collected and passed through the Reverse Osmosis system, membrane type T2/15W. The Reverse Osmosis operating pressure was kept constant at 55 and 60 Bar for each run. The permeate flux and retentate concentration of the Reverse Osmosis were recorded. The period of time used from the initial concentration to the final one was also noted.

The results are shown in Table 6.9-1 to 6.9-2

Data are plotted in Figure 6.12 to 6.14

Table 6.9-1

Date of Experiment : 13/3/81  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 6.2 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 60 Bar  
 Temperature : 35 degree C  
 pH : 4.0

Time (hr)	Permeate Flux (l/m <sup>2</sup> hr)	Permeate Wt. (kg)	Retentate Conc.(Brix)
0.25	40.06	8.6	6.4
0.50	37.88	17.6	7.4
0.75	27.91	25.0	8.7
1.00	29.68	32.4	10.2
1.25	22.26	39.0	12.5
1.50	21.58	44.6	16.0
1.75	19.38	49.0	19.6
2.00	12.69	52.2	23.6
2.25	-	53.4	25.0

Table 6.9-2

Date of Experiment : 19/3/81  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 3.5 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 55 Bar  
 Temperature : 33 degree C  
 pH : 4.0

Time (hr)	Permeate Flux (l/m <sup>2</sup> hr)	Permeate Wt. (kg)	Retentate Conc.(Brix)
0.25	33.76	7.8	4.0
0.50	38.58	15.8	4.0
0.75	30.33	22.9	4.2
1.00	32.96	29.6	4.6
1.25	31.24	36.4	5.0
1.50	27.27	42.4	5.6
1.75	28.48	48.4	6.0
2.00	27.27	53.6	6.8
2.25	25.92	58.6	7.4
2.83	22.87	69.2	9.5
3.00	22.50	72.5	10.2
3.50	17.16	79.2	13.3
4.00	14.43	85.3	17.2

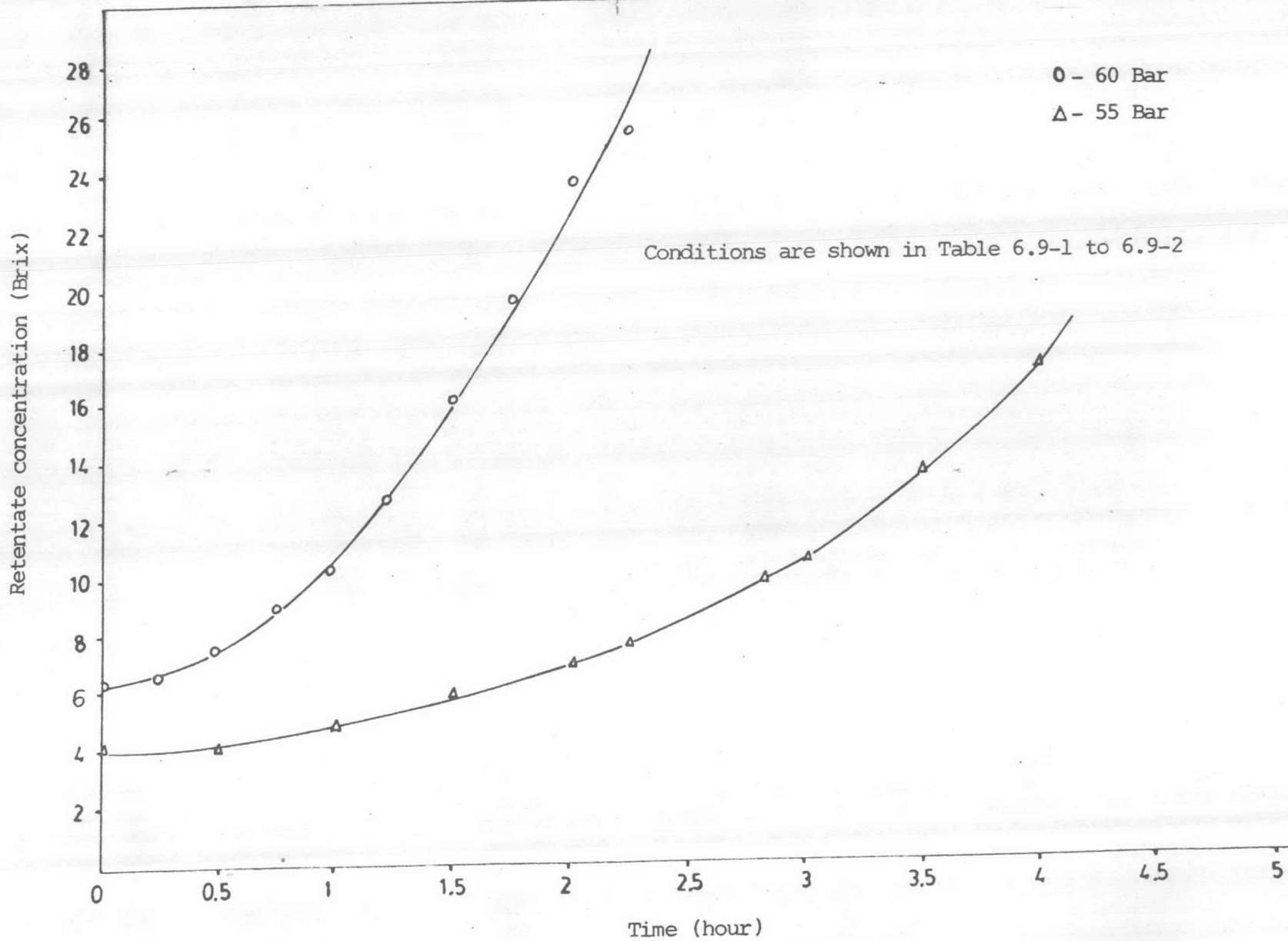


Figure 6.12 Retentate concentration vs time

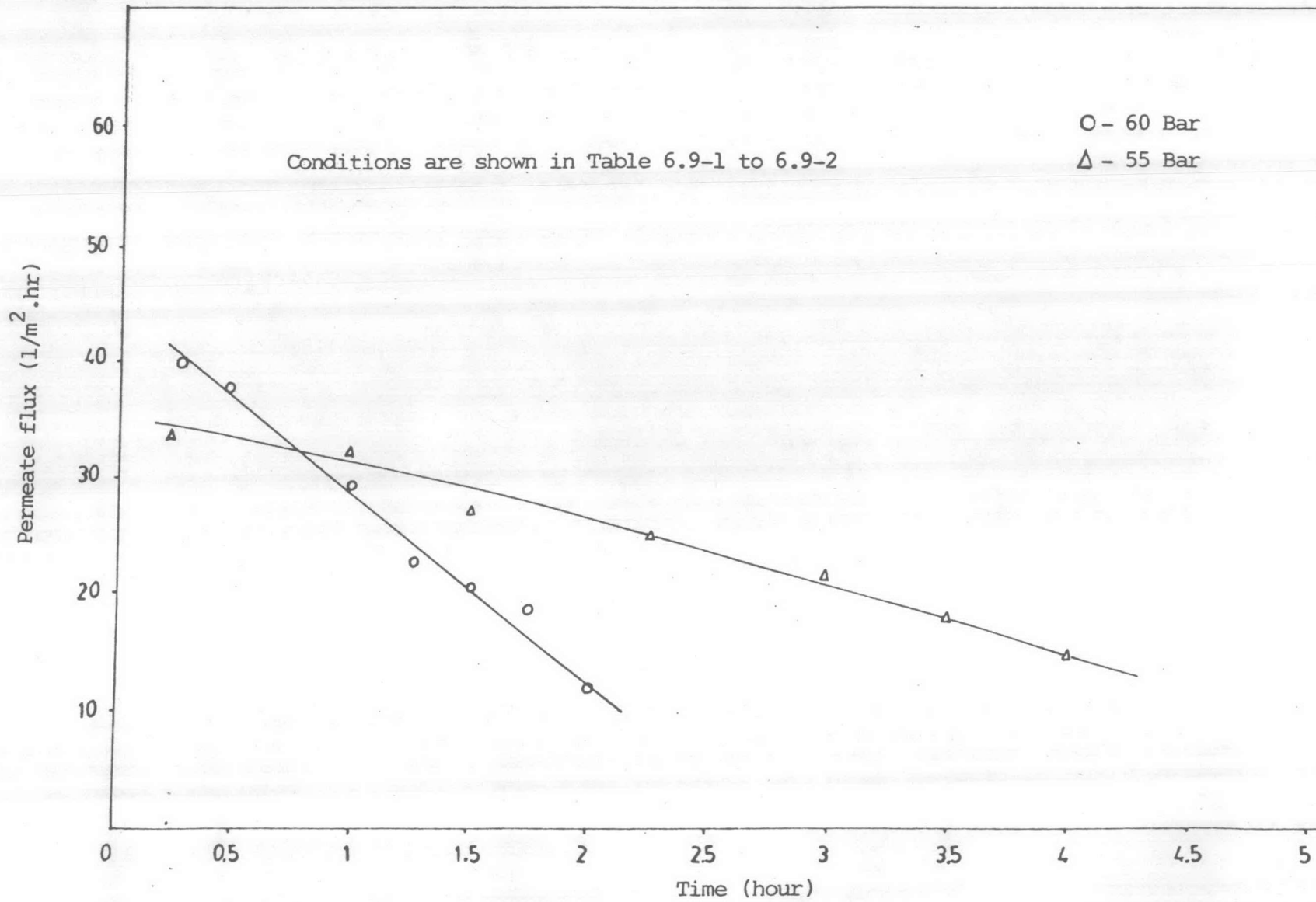


Figure 6.13 Permeate flux vs time



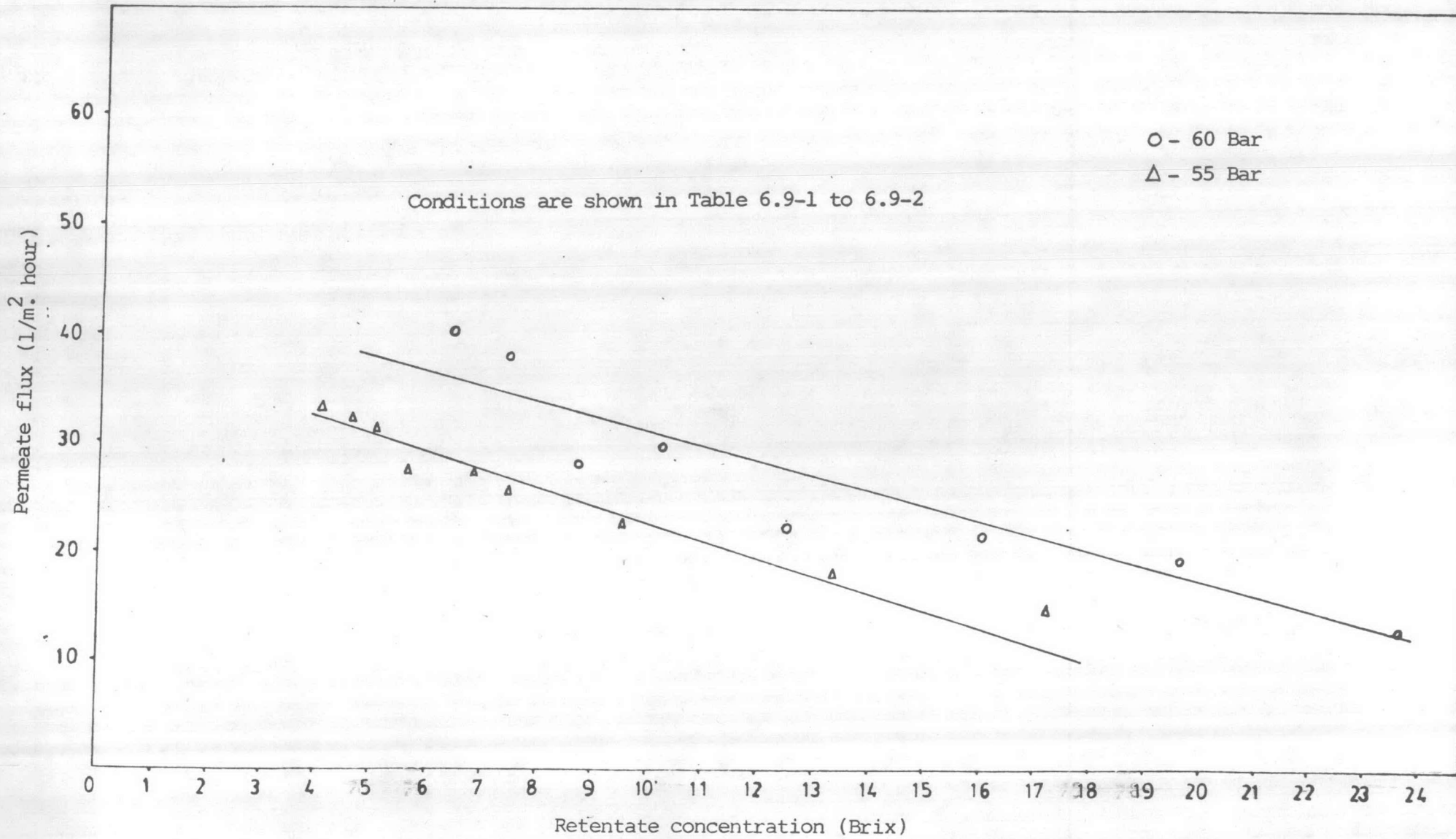


Figure 6.14 Retentate concentration vs permeate flux



## 6.10 Effect of pH on Reverse Osmosis system

The experiment was done by passing juice squeezed from solid pineapple waste, through the Ultrafiltration system, after being pretreated with 160 Mesh sieve. The membrane used in Ultrafiltration system was T6/B type. The operating pressure was kept constant at 10 Bar. The permeate from Ultrafiltration system was collected and its pH was adjusted which was varied from 3.95 to 8.19 by adding dilute NaOH gradually. After being adjusted pH, the permeate of Ultrafiltration was passed through the Reverse Osmosis system, membrane type T2/15W. The Reverse Osmosis permeate was recycled to the feed tank in order to maintain the initial concentration. For each condition of feed, the Reverse Osmosis operating pressure was varied from 40 to 60 Bar. The permeate flux, and the retentate concentrations were recorded.

The results are shown in Table 6.10

Data are plotted in Figure 6.15

Table 6.10

Date of Experiment : 6/8/81  
 Type of Feed : Liquid from solid waste  
 Initial Concentration : 5.0 Brix  
 System : Ultrafiltration & Reverse Osmosis  
 Membrane type : UF - T6/B, RO - T2/15W  
 Operating Pressure : UF - 10 Bar, RO - 40 - 60 Bar  
 Temperature : 31 degree C  
 pH : 3.95 - 8.19

pH Feed	Pressure (Bar)	Permeate Flux (l/m <sup>2</sup> hr)	pH Permeate
3.95	40	29.90	3.95
	50	33.49	3.95
	60	39.87	3.95
4.30	40	24.62	4.20
	50	31.24	4.20
	60	37.38	4.20
4.56	40	27.18	3.93
	50	33.22	3.90
	60	40.25	3.85
4.77	40	26.16	4.03
	50	30.33	3.88
	60	36.09	3.77
5.12	40	23.26	4.04
	50	32.39	3.91
	60	37.04	3.85

Table 6.10 (cont.)

pH Feed	Pressure (Bar)	Permeate Flux ( $l/m^2hr$ )	pH Permeate
5.61	40	24.06	4.41
	50	31.24	4.38
	60	39.49	4.30
6.00	40	22.03	4.73
	50	30.78	4.55
	60	37.38	4.40
7.04	40	14.95	5.14
	50	22.03	5.17
	60	27.18	5.18
8.19	40	16.88	5.33
	50	24.34	5.40
	60	31.01	5.43

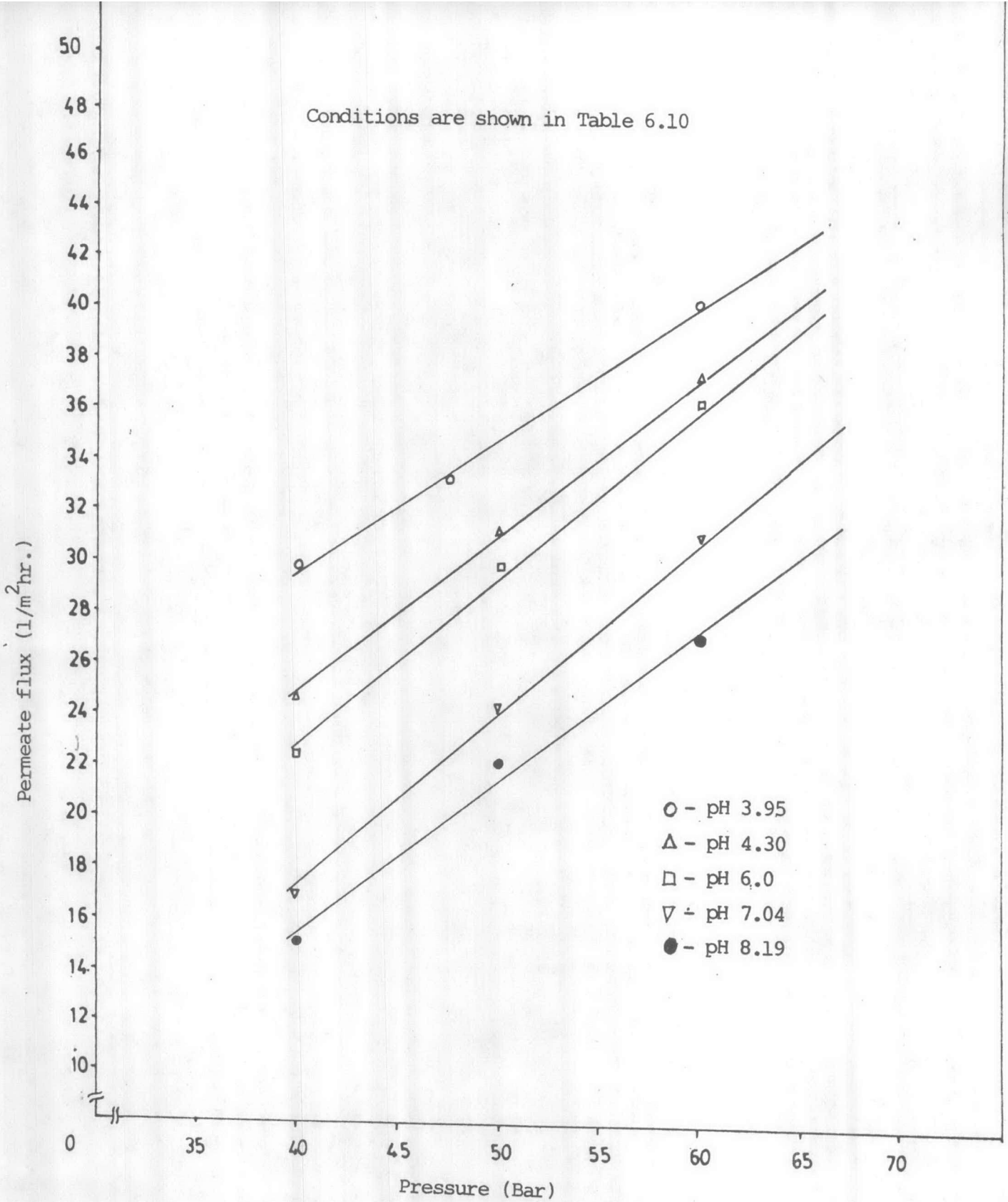


Figure 6.15 Permeate flux vs. pressure

6.11 Energy requirement

Energy requirement for concentrating of liquid waste by Reverse Osmosis, for example, the experiment data from Table 6.3-1 was estimated. The initial concentration of 2.6 Brix of the liquid waste was concentrated to 119.6 Brix by Reverse Osmosis plant. About 110 litres of permeate (water) was removed from the total feed of 120 litres, under the operating pressure of 60 Bar. The energy required for the above conditions is 1,591.63 Btu.

The energy requirement for atmospheric evaporation was also estimated in order to compare the energy requirement between Reverse Osmosis and the other method of concentrating. For the same conditions,  $2.353 \times 10^5$  Btu was required. The ratio of the two values is :

$$\frac{\text{Energy required by Evaporation}}{\text{Energy required by Reverse Osmosis}} = \frac{2.353 \times 10^5}{1,591.63} = 147.84$$

(Sample of calculation is shown in Appendix B)

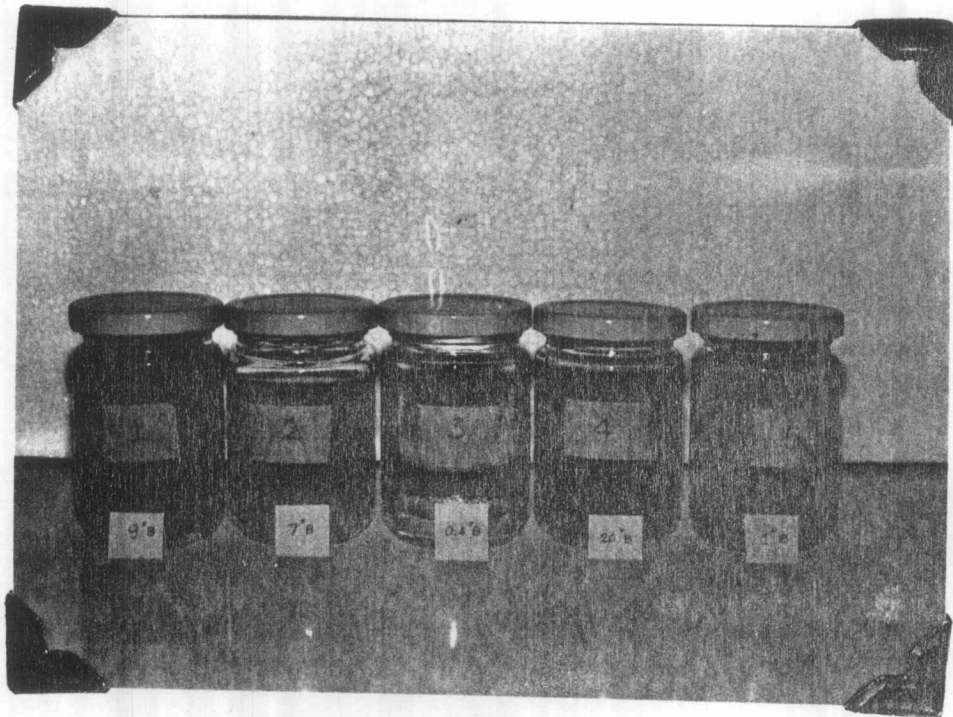


Figure 6.16 No. 1 Liquid squeezed from solid waste  
No. 2 Permeate from UF  
No. 3 Permeate from RO  
No. 4 Final concentrated product from RO  
No. 5 Liquid waste