APPENDICES

APPENDIX 1

Photographs

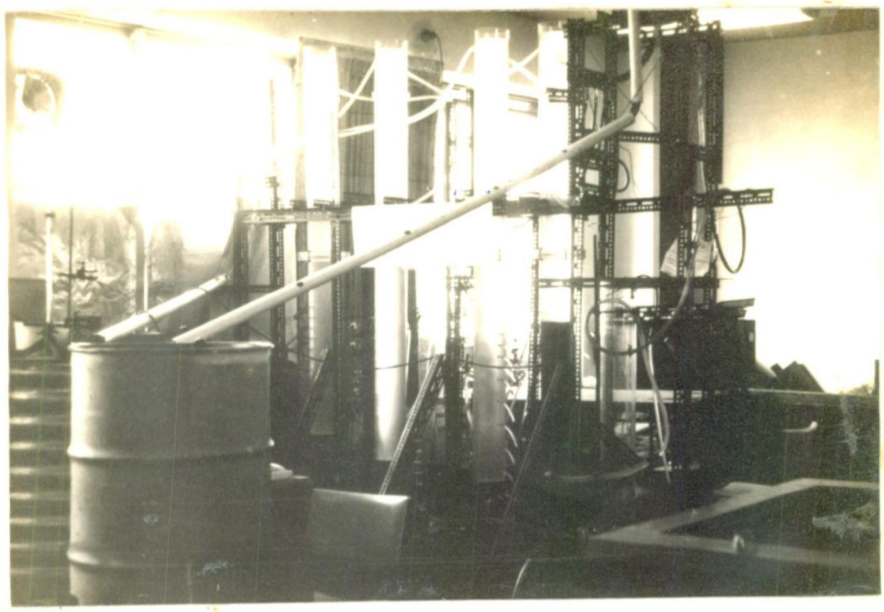


PLATE A1.1 Filtration Apparatus

PLATE A1.2 Filter column showing some of the details of pressure tappings

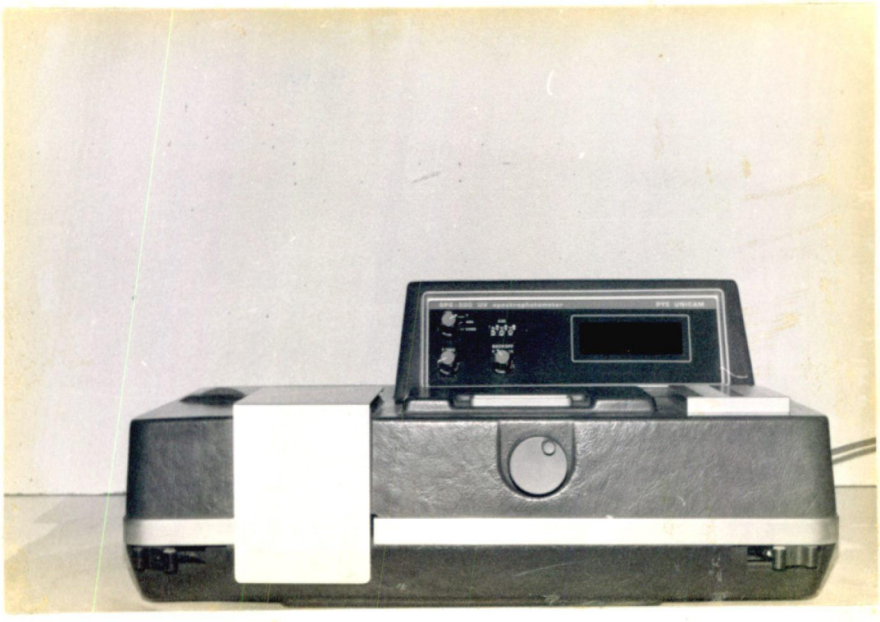


PLATE A1.3 Spectrophotometer

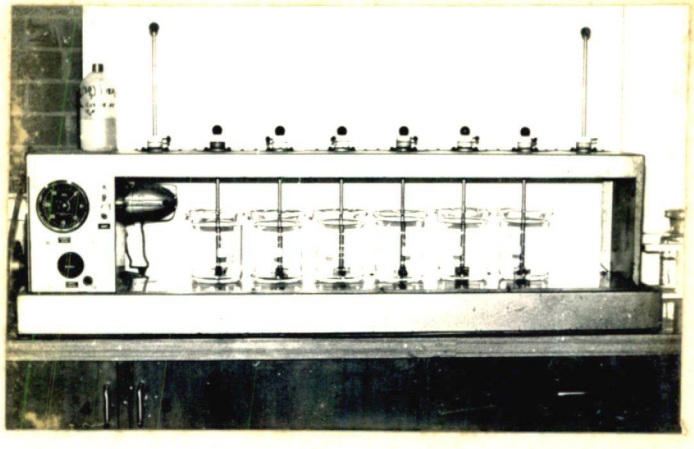


PLATE A1.4 Jar tests apparatus

Length of the paddle = 31 mm

width of the paddle = 91 mm

APPENDIX 2

DETERMINATION OF RELATIVE DENSITY

According to A.S.T.M. Part 19 (1977)

The method required the following components:

(i) 10 g clean dry sample

(ii) stoppered bottle of capacity 50 mL

(iii) distilled water at 20° ± 2°C

(iv) balance with a sensitivity of 0.001 g

The procedure was as follows:

(i) The bottle with stopper was cleaned thoroughly, dried and then weighed to the nearest 0.001 g.
Let the weight be w_1.

(ii) Approximately 10 g of dry sample was added to the bottle and the stopper was replaced. The combined weight of the sample and the stoppered bottle was determined to the nearest 0.001 g.
Let the weight be w_2.

(iii) The bottle with the sample was then filled with distilled water, the stopper was replaced and excess water on the outside of the bottle was wiped. The outside of the bottle was dried and subsequently the total weight was determined to the nearest 0.001 g.
Let the weight be w_3.

(iv) Both the sample and the water were removed from the bottle and the bottle was rinsed with distilled water. The bottle was then refilled with distilled water and

the stopper replaced. The excess water was removed as in (iii) and the weight of the stoppered bottle filled with distilled water was determined to the nearest 0.001 g.

Let the weight be w_4.

$\therefore$ Relative density of the sample = $\dfrac{w_2 - w_1}{(w_4-w_1) - (w_3-w_2)}$

APPENDIX 3

Tubular data for filter runs 1 to 27 and 31 to 39

TABLE A3.1 Results of filter run 1

Rate of filtration = 1.0 m^3/m^2h

Depth of medium = 74.5 cm | Effective size = 0.135 mm | Influent turbidity range = 30 - 60 FTU

Porosity = 93.3% | Uniformity coefficient = 2.96 | pH = 6.95 - 7.1

Type of medium = rice hull ash | Depth of graded gravel = 0.2 m | Temperature = 14 - 18°C

Time (h)	Water Turbidity FTU		Head loss cm of water					pH	
			Tappings 1-3	1 - 4	1 - 5	1 - 10	1 - 11		
	Influent	Filtrate	Dist. from surface 4.5 cm	9.5 cm	14.5 cm	74.5 cm	Total loss 94.5 cm	Influent	Filtrate
0	4.6	3.2	1.2	2.9	3.8	7.0	7.7	7.0	7.0
3	9.0	2.9	1.3	3.1	3.9	7.0	7.7		
5.75	15.0	4.9	1.5	3.3	4.1	7.3	7.9		
20.0	16.0	5.2	1.9	3.9	4.7	7.9	8.7		
23.0	31.0	5.0	2.1	4.2	5.1	8.2	9.0	7.1	
27.0	32.0	5.4	2.2	4.5	5.4	8.6	9.3		
43.75	50.0	6.1	3.4	6.6	7.5	10.3	11.4		
47.0	50.0	6.2	3.5	6.8	7.7	10.9	11.6	7.05	

(Cont'd)

TABLE A3.1 (Cont'd)

51.0	50.0	6.3	3.8	7.2	8.1	11.0	11.8		
53.5	50.0	6.4	4.4	8.1	9.1	12.2	12.8		
68.0	50.0	6.7	5.2	9.6	10.5	13.6	14.2		
75.0	50.0	6.6	5.8	10.5	11.3	14.4	15.1	7.0	
91.5	55.0	6.4	7.0	12.7	13.6	16.5	17.2		
99.25	50.0	6.1	7.5	13.6	14.6	17.6	18.4	7.05	
116.0	50.0	6.2	8.0	14.6	15.5	18.3	19.0		
118.75	60.0	5.7	8.3	15.4	16.3	19.2	19.9	7.05	7.05
123.0	55.0	5.5	8.5	15.9	16.7	19.5	20.3		
126.25	50.0	5.2	8.8	16.4	17.3	20.1	20.8		
140.0	55.0	5.6	9.3	18.1	18.9	21.7	22.3		
142.75	55.0	5.2	9.6	18.8	19.7	22.5	23.2	7.05	7.05
148.0	55.0	5.0	10.0	20.0	20.9	22.9	23.6		
164.0	50.0	5.4	10.9	23.1	24.0	26.9	27.6		
167.0	55.0	5.0	11.2	23.9	24.8	27.8	28.5	7.1	7.1
171.25	60.0	4.8	11.6	25.4	26.3	29.2	29.9		

(Cont'd)

TABLE A3.1 (Cont'd)

188.25	55.0	5.3	12.5	29.0	30.0	33.0	33.7		
190.25	65.0	4.8	12.8	30.3	31.2	34.1	34.9		
196.0	55.0	4.3	13.2	31.2	32.1	35.2	35.9		
212.0	50.0	5.3	13.7	33.8	34.6	37.9	38.7		
214.25	50.0	4.3	14.2	34.9	35.9	39.0	39.7	7.0	7.0
219.25	60.0	4.8	14.2	35.5	36.5	39.7	40.4		
222.0	60.0	4.7	14.3	36.0	37.0	40.0	40.8		
235.0	60.0	5.2	14.7	37.9	38.8	42.0	42.7		
243.0	45.0	4.7	15.1	39.9	40.9	43.6	44.2		
259.5	50.0	5.4	15.9	43.3	44.0	47.0	47.7	7.0	7.0
268.0	60.0	4.9	16.1	44.9	45.9	49.0	49.7		
283.25	50.0	5.4	16.5	49.4	51.3	53.7	54.4		
286.25	60.0	5.2	16.6	50.1	51.2	54.5	55.2	7.1	7.1
291.0	50.0	4.8	16.0	50.5	51.8	54.8	55.5		
307.25	50.0	4.8	17.3	56.6	57.8	61.1	61.7		
315.0	55.0	4.4	17.0	57.7	58.9	62.1	62.7	7.1	7.1

(Cont'd)

TABLE A3.1 (Cont'd)

331.25	50.0	4.3	16.9	58.4	59.6	62.8	63.5		
334.25	55.0	3.2	17.7	65.0	66.25	69.5	70.2	7.1	7.1
338.75	50.0	3.9	17.8	67.0	68.3	71.7	72.3		
341.25	55.0	3.6	17.3	68.3	69.7	73.0	73.7		
356.0	55.0	4.4	17.9	68.8	70.1	73.5	74.2		
358.75	60.0	3.9	17.0	73.4	74.5	77.6	78.2	7.1	7.1
364.5	55.0	3.9	17.2	74.3	75.7	78.8	79.5		
384.75	45.0	2.2	16.8	76.1	77.3	80.7	81.3	7.0	7.0
387.5	50.0	4.3	12.1	74.2	75.7	79.0	79.8		
390.5	55.0	3.5	12.5	77.2	78.7	82.0	82.7		
404.0	50.0	4.1	13.1	78.9	80.4	83.8	84.5	7.0	6.95
411.0	50.0	2.9	12.5	84.8	86.3	89.6	90.2		
427.75	45.0	2.6	12.7	86.6	88.1	91.4	92.1	6.95	6.95
452.0	40.0	2.2	11.9	92.0	95.7	96.8	97.6		
454.75	40.0	2.3	11.5	100.3	102.2	105.6	106.2	7.0	7.0

TABLE A3.2 Results of filter run 2

Rate of filtration = 1.0 m^3/m^2h

Depth of media = 75 cm | Effective size = 0.64 mm | Influent turbidity range = 30 - 60 FTU

Porosity = 44% | Uniformity coefficient = 1.41 | pH = 7.0 - 7.1

Type of media = sand | Depth of graded gravel = 0.2 m | Temperature = 14 - 18°C

Time (h)	Water turbidity FTU		Head loss cm of water					pH	
	Influent	Filtrate	Tappings 1-3	1 - 4	1 - 5	1 - 10	1 - 11	Influent	Filtrate
			Dist. from surface 5	10	15	75	95		
0	4.6	3.5	4.6	5.0	5.1	7.2	7.7	7.0	7.0
3	9.0	3.0	4.7	5.1	5.6	7.3	8.0		
5.75	15.0	5.8	5.5	5.8	6.0	8.0	8.4		
20.0	16.0	6.3	8.0	8.4	8.6	10.6	11.0		
23.0	31.0	6.3	8.6	8.9	9.0	11.1	11.8	7.1	7.1
27.0	32.0	7.0	9.6	9.9	10.1	12.0	12.7		
43.75	50.0	9.4	14.4	14.8	14.9	17.0	17.7		
47.0	50.0	8.8	16.3	16.7	16.8	18.9	19.7	7.05	7.05

(Cont'd)

TABLE A3.2 (Cont'd)

51.0	50.0	9.5	17.5	17.8	17.9	20.0	20.8		
53.5	50.0	10.2	18.6	18.9	19.1	22.1	21.9		
68.0	55.0	9.7	25.2	25.6	25.7	27.8	28.6	7. 0	7.0
75.0	50.0	10.3	28.7	29.0	29.2	31.2	31.9		
91.5	55.0	8.9	37.0	37.3	37.5	39.4	40.0		
99.25	50.0	8.4	39.9	40.2	40.4	42.2	43.4	7.05	7.05
116.0	50.0	7.9	47.9	48.2	48.3	50.1	50.8		
118.75	60.0	7.6	48.7	49.0	49.2	51.0	51.7	7.05	7.05
123.0	55.0	8.0	50.6	50.8	51.0	52.8	53.5		
126.25	50.0	7.6	53.5	53.7	53.9	55.6	56.3		
140.0	55.0	7.2	62.0	62.5	62.8	64.2	64.9	7.05	7.05
142.75	55.0	7.7	63.3	63.7	63.9	65.3	65.8		
148.0	55.0	7.6	68.1	68.5	68.7	70.3	70.7		
164.0	50.0	7.3	77.9	78.2	78.4	79.7	80.3		
167.0	55.0	6.8	84.4	84.6	84.9	86.2	85.7		
171.2	60.0	7.5	88.1	88.4	88.8	90.0	90.5		
188.25	55.0	7.3	101.2	101.6	101.8	103.1	103.8		

TABLE A3.3 Results of filter run 3

Rate of filtration = 0.75 m^3/m^2h

Depth of media = 72.0 cm | Effective size = 0.135 mm | Influent turbidity range = 25 - 60 FTU

Porosity = 93.4% | Uniformity coefficient = 2.96 | Temperature = 13.5 - 17°C

Type of media = rice hull ash | Depth of graded gravel = 0.2 m | pH = 6.95 - 7.1

Time (h)	Water turbidity FTU		Head loss cm of water					pH	
			Tappings 1-4	1 - 5	1 - 6	1 - 10	1 - 11		
	Influent	Filtrate	Dist. from surface 7 cm	12 cm	17 cm	Net loss 72 cm	Total	Influent	Filtrate
0	55	4.6	0.6	0.9	1.4	3.1	3.5	7.0	7.0
3	55	6.5	0.6	1.0	1.3	3.2	3.6		
5.75	55	10.6	0.6	1.0	1.4	3.2	3.6		
21.5	50	10.5	1.0	1.5	1.8	3.7	4.1		
24.5	50	10.5	1.1	1.7	2.0	3.9	4.3	7.0	
29.25	60	10.2	1.4	1.9	2.2	4.1	4.6		
31.75	55	9.8	1.5	2.1	2.4	4.4	4.8		
45.25	50	9.5	2.0	2.2	2.7	5.0	5.4		

(Cont'd)

TABLE A3.3 (Cont'd)

53.25	45	9.2	2.3	2.4	3.4	5.4	5.9		
69.25	50	8.6	3.4	4.5	4.8	6.9	7.4		
77.5	60	8.3	4.0	5.4	5.7	7.9	8.4	7.1	7.1
93.75	50	8.6	5.1	6.9	7.3	9.5	9.9		
96.5	60	8.3	5.2	8.1	8.5	9.7	10.1		
101.25	50	7.9	4.9	7.4	7.7	9.9	10.3		
111.25	50	7.5	6.3	10.1	10.5	12.7	13.2		
120.5	55	7.5	7.1	10.2	10.7	12.9	13.3	7.1	7.1
124.25	55	7.4	5.9	10.9	11.2	13.5	14.0		
141.5	50	7.2	6.3	13.1	13.5	15.8	16.3		
144.5	55	5.6	6.3	13.8	14.2	16.6	17.0	7.1	7.1
149.0	50	6.7	6.0	14.7	15.1	17.6	18.0		
151.0	55	6.9	5.9	14.7	15.1	17.6	18.0		
166.0	55	7.0	5.9	17.1	17.5	20.0	20.5		
168.5	60	6.3	5.6	17.6	18.0	20.5	21.0	7.1	7.1
174.25	55	6.3	5.4	18.2	18.5	21.1	21.5		

(Cont'd)

TABLE A3.3 (Cont'd)

194.5	40	3.4	7.3	23.0	23.4	26.1	26.6	7.0	6.95
197.25	36	4.6	9.3	24.6	25.0	27.9	28.3		
202.75	40	3.8	9.4	24.6	25.0	27.9	28.3		
213.75	32	3.4	10.9	27.8	28.1	31.1	31.5	7.0	6.95
220.75	50	2.9	12.2	28.8	29.1	32.2	32.7		
237.5	40	3.0	13.4	33.5	33.8	37.1	37.5	6.95	6.95
261.75	31	2.5	14.5	40.4	41.9	44.2	44.7		
264.5	38	3.0	14.9	41.1	41.5	45.0	45.5	6.95	6.95
269.25	25	2.7	14.7	42.0	42.5	46.0	46.5		
285.75	40	2.8	14.3	47.4	48.1	51.9	52.3		
288.25	36	2.7	12.4	47.0	47.8	51.5	51.9	7.0	7.0
293.25	45	2.9	13.0	51.1	51.8	55.5	55.9		
309.5	40	2.7	6.9	60.3	61.6	64.9	65.4		
314.5	45	2.8	0.2	61.5	62.3	66.3	66.8	7.0	6.95
319.25	45	2.7	1.9	63.3	63.9	68.0	68.5		

(Cont'd)

TABLE A3.3 (Cont'd)

333.25	45	2.0	0.7	67.1	70.7	75.0	75.5		
336.25	36	2.5	0.5	65.9	71.2	75.5	75.9	7.0	6.95
341.0	50	2.8	0.5	57.8	71.4	75.9	76.1		
358.0	50	2.4	0.3	24.8	71.6	76.2	76.6		
360.5	50	2.2	0.3	24.5	74.4	78.9	79.3	7.0	6.95
365.0	60	2.0	0.1	19.1	74.6	79.1	79.5		
381.75	50	1.9	0.1	16.2	86.6	91.2	91.6		
388.0	60	2.0	0.1	14.5	91.2	95.9	96.1	6.96	6.95
405.25	60	1.6	0.1	11.1	95.7	100.2	100.6		

TABLE A3.4 Results of filter run 4

Rate of filtration = 0.75 m^3/m^2h

Depth of media	= 75 cm	Depth of graded gravel	= 0.2 m
Porosity	= 44%	Influent turbidity range	= 45 - 60 FTU
Type of media	= sand	pH	= 7.0 - 7.1
Effective size	= 0.64 mm	Temperature	= 14 - 18°C
Uniformity coefficient	= 1.41		

Time (h)	Turbidity FTU		Head loss cm of water			
	Influent	Filtrate	at 50 mm	at 100 mm	at 750 mm	Total loss
0	55.0	4.0	1.35	1.65	3.9	4.2
3	55.0	17.0	1.35	2.3	4.5	4.8
5.75	55.0	18.0	2.7	3.1	5.3	5.6
21.5	50.0	18.0	7.1	7.8	9.6	10.1
24.5	50.0	17.0	8.7	9.0	11.1	11.5
29.25	60.0	17.0	11.6	11.9	13.9	14.3
31.75	55.0	15.0	13.6	13.9	16.0	16.4
45.25	50.0	16.0	26.2	26.2	28.6	29.0
53.25	45.0	14.0	35.1	35.3	37.5	38.0
69.25	50	14.0	66.0	66.4	69.6	70.1
77.5	60	14.0	78.0	78.3	80.5	81.0
93.75	50	13.0	91.5	91.7	94.6	95.0
100.0	-	-	97.0	97.3	99.5	100.1

TABLE A3.5 Results of filter run 5

Rate of filtration = 0.5 m^3/m^2h

Depth of media	= 76.5 cm	Effective size	= 0.135 mm	Influent turbidity range	= 36 - 60 FTU
Porosity	= 92.6%	Uniformity coefficient	= 2.96	Temperature	= 16.5 - 18°C
Type of media	= rice hull ash	Depth of graded gravel	= 0.2 m	pH	= 6.95 - 7.1

Time (h)	Water turbidity FTU		Head loss cm of water				pH	
	Influent	Filtrate	1 - 3 at 6.5 cm	1 - 4 at 11.5 cm	1 - 10 at 76.5 cm	1 - 11 total	Influent	Filtrate
0	35.0	4.0	0.3	0.6	1.8	2.3	7.0	7.8
2.25	40	4.8	0.5	0.8	2.0	2.5		
17.75	50	5.0	1.0	1.3	2.2	2.8		
20.25	55	5.5	0.7	1.0	2.3	2.9		
20.5	50	5.7	1.0	1.3	2.4	3.0	7.0	7.3
41.75	50	5.3	0.8	1.1	3.4	3.9		
44.25	55	4.5	1.9	2.2	3.4	4.0	7.0	7.2
49.25	60	5.2	2.3	2.6	3.8	4.4		

(Cont'd)

TABLE A3.5 (Cont'd)

63.5	50	3.9	4.6	5.0	6.2	6.8	7.0	7.0
73.0	45	3.3	5.8	6.1	7.3	7.9		
89.0	40	3.0	8.9	9.2	10.8	11.4		
113.5	36	2.9	12.0	12.3	13.5	14.2	7.0	7.0
116.5	50	2.7	11.9	12.3	13.6	14.3		
121.5	50	3.3	12.2	12.5	13.8	14.4		
123.5	45	2.6	12.7	13.0	14.3	15.0		
137.25	40	2.7	13.0	13.4	14.6	15.3		
140.25	45	2.6	13.3	13.6	15.8	15.5	7.1	7.2
142.0	--	-	13.1	13.6	15.2	15.9		
143.25	45	3.0	13.3	13.7	15.2	15.0		
161.25	40	2.5	14.3	14.8	16.5	17.2		
164.0	50	2.0	14.2	14.7	16.6	17.3	7.1	7.1
169.5	50	2.8	14.2	14.7	16.9	17.6		
186.0	40	2.5	15.1	15.6	17.8	18.5		

(Cont'd)

TABLE A3.5 (Cont'd)

188.25	45	3.0	14.8	15.3	17.3	18.0		
193.0	60	3.0	15.05	16.5	18.9	19.6	7.0	7.0
209.25	45	3.0	19.3	20.0	21.4	22.0		
212.25	50	2.0	19.6	20.2	22.1	22.8	7.1	7.1
217.25	30	2.4	20.3	20.8	22.9	23.5		
233.0	40	1.9	22.9	23.4	25.3	26.0	7.0	7.0
238.25	50	1.5	23.4	24.0	26.3	27.0		
240.75	50	1.7	23.8	24.6	27.1	27.8	6.95	6.95
257.1	40	1.7	25.0	27.1	28.5	29.1		
281.25	36	1.6	28.0	29.0	31.3	32.0	6.95	6.95
284.5	50	1.6	28.6	30.6	33.2	33.8		
289.0	50	1.6	28.5	31.5	35.1	35.8		
291.5	55	1.6	29.7	32.7	35.6	36.3		
305.0	50	1.6	30.0	33.4	36.3	37.0	7.0	7.0

TABLE A3.6 Results of filter run 6

Rate of filtration = 0.5 m^3/m^2h

Depth of media	= 75 cm	Effective size	= 0.64 mm	Influent turbidity range	= 40 - 60 FTU
Porosity	= 44%	Uniformity coefficient	= 1.41	Temperature	= 16.5 - 18°C
Type of media	= sand	Depth of graded gravel	= 0.2 m	pH	= 6.95 - 7.1

Time	Turbidity FTU		Head loss cm of water				pH	
(h)	Influent	Filtrate	1 - 3 at 5 cm	1 - 5 at 15 cm	1 - 10 at 75 cm	1 - 11 at 95 cm	Influent	Filtrate
0	40	4.3	0.2	0.5	1.6	2.2	7.1	7.1
3	40	5.0	0.3	0.6	1.7	2.36		
4.75	40	8.0	0.3	0.7	1.7	2.4		
8.0	40	8.0	0.3	0.8	1.6	2.5		
24.0	40	5.0	2.8	3.1	4.2	5.1	7.0	7.0
26.5	50	4.0	3.7	4.1	5.2	6.1		
32.25	50	5.0	5.6	4.1	5.2	6.1		
32.25	50	5.0	5.6	5.9	6.2	7.1		
48.75	40	5.0	12.3	12.7	14.2	15.1	6.95	7.0

(Cont'd)

TABLE A3.6

51.0	50	5.0	12.2	12.6	13.9	14.8		
55.75	60	5.0	14.9	15.1	16.5	17.4		
72.0	45	5.0	24.2	24.6	26.1	27.1	6.95	6.95
75.0	50	5.0	25.5	25.8	27.3	28.4		
80.0	50	3.0	29.0	29.3	30.5	31.6		
95.75	40	3.0	41.2	41.4	42.1	42.8	6.95	6.95
101.0	45	3.2	45.3	45.6	47.2	38.2		
103.5	50	3.0	46.7	47.1	48.3	49.5		
119.74	40	3.0	61.1	61.6	63.1	64.0	7.0	7.0
144.0	36	3.0	83.3	83.6	85.0	86.0		
147.25	50	3.0	84.3	84.8	87.0	88.0	7.0	7.0
151.75	50	3.5	93.3	93.7	95.1	96.0		
154.25	50	3.5	94.2	94.6	96.0	97.0		
167.75	50	3.0	107.5	108.0	109.2	100.0	7.0	6.95

TABLE A3.7 Results of filter run 7

Rate of filtration = 0.25 m^3/m^2h

Depth of media = 75 cm | Effective size = 0.135 mm | Influent turbidity range = 32 - 60 FTU

Porosity = 94% | Uniformity coefficient = 2.96 | Temperature = 18 - 20°C

Type of media = rice hull ash | Depth of graded gravel = 0.2 cm | pH = 7 - 7.15

Time (h)	Turbidity FTU		Head loss cm of water			pH	
	Influent	Filtrate	1 - 3 5 cm	1 - 10 75 cm	1 - 11 Total 95 cm	In	Out
0	35.0	3.0	1.3	1.6	1.8	7.1	8.0
18.75	40	3.0	1.3	1.7	1.9		
27.75	55	2.0	1.8	2.3	2.5		
27.75	50	2.0	2.1	2.6	2.8		
43.25	40	1.5	2.9	3.4	3.6	7.1	7.1
48.0	45	1.5	3.1	3.6	3.8		
51.25	45	1.5	3.3	3.8	4.0		
67.25	45	1.5	3.7	4.0	4.2	7.0	7.0
71.25	45	1.5	3.7	4.3	4.4		

(Cont'd)

TABLE A3.7 (Cont'd)

74.25	55	1.5	4.0	4.5	4.7		
90.5	55	1.5	4.5	5.1	5.3	7.1	7.1
98.25	60	1.5	4.5	5.0	5.2		
114.75	40	1.5	4.6	5.3	5.4	7.1	7.1
138.5	55	1.5	4.6	5.4	5.6		
144.0	50	1.5	4.3	5.0	5.2	7.1	7.1
147.5	55	1.5	4.4	5.2	5.4		
162.75	40	1.5	4.5	5.3	5.5	7.1	7.1
168.5	45	1.5	4.5	5.1	5.3		
173.25	50	1.5	4.5	5.3	5.4		
186.0	36	1.5	4.8	5.5	5.7	7.1	7.1
192.75	36	1.5	4.6	5.3	5.5		
196.25	40	1.5	4.5	5.2	5.4		
210.5	32	1.5	4.8	5.4	5.6	7.1	7.2
215.5	45	1.0	4.4	5.0	5.2		

(Cont'd)

TABLE A3.7 (Cont'd)

221.25	50	1.5	4.7	5.2	5.4		
233	45	1.0	5.0	5.6	5.8	7.15	7.2
240.5	38	1.0	4.6	5.2	5.4		
258.5	36	0.9	5.2	5.8	6.0	7.1	7.1
283.5	40	0.9	5.0	5.8	6.0		
307.0	32	0.9	5.0	5.6	5.8	7.1	7.1
311.75	40	1.5	5.0	5.6	5.8		
314.5	55	1.0	4.8	5.3	5.5		
331.25	40	0.9	4.7	5.2	5.4	7.1	7.1
335.0	32	0.9	4.7	5.2	5.4	7.1	7.1
355.25	32	0.9	4.8	5.4	5.6	7.1	7.1
363.25	32	0.6	4.8	5.4	5.6		
379.5	35	0.6	4.9	5.6	5.8	7.1	7.1
383.75	32	0.6	4.9	5.5	5.7		
397.25	50	0.6	5.1	5.6	5.8		

(Cont'd)

TABLE A3.7 (Cont'd)

403.25	40	0.8	5.3	5.9	6.1	7.15	7.15
407.25	40	0.6	5.2	5.8	6.0		
411.75	58	0.6	5.2	6.0	6.2		
426.75	50	1.0	5.7	6.1	6.3	7.1	7.1
450.75	32	1.0	5.9	6.3	6.5	7.05	7.0

TABLE A3.8 Results of filter run 8

Rate of filtration = 0.25 m^3/m^2h

Type of media = sand | Depth of media = 75 cm | Influent turbidity range = 22 - 60 FTU

Unifomity coefficient = 1.41 | Porosity = 44% | Temperature = 17.5 - 21.0°C

Effective size = 0.64 mm | Depth of graded gravel = 20 cm | pH = 7.0 - 7.15

Time	Turbidity FTU		Head loss cm of water				pH	
(h)	Influent	Filtrate	1 - 3 5 cm	1 - 4 10 cm	1 - 10 Net 75 cm	1 - 11 Total 95 cm	In	Out
0	35	3.0	0.2	0.4	1.0	1.6	7.15	7.15
18.75	40	5.0	0.6	0.7	1.3	1.9		
24.75	55	5.0	0.8	0.9	1.7	2.3		
27.75	50	3.0	1.1	1.2	2.0	2.6		
43.25	40	3.5	2.0	2.2	3.0	3.6	7.1	7.1
48.0	45	5.0	2.2	2.4	3.0	3.6		
51.25	45	5.0	2.4	2.6	3.3	3.9		
67.25	45	5.0	4.1	4.2	5.0	5.7	7.0	7.1

(Cont'd)

TABLE A3.8 (Cont'd)

71.25	45	4.5	4.3	4.5	5.1	5.8		
74.25	55	3.0	4.7	4.9	5.3	6.0		
90.5	55	3.0	7.0	7.2	8.0	8.6	7.1	7.0
98.25	60	3.0	8.4	8.5	9.3	10.0		
114.75	40	3.0	10.8	11.0	11.7	12.4	7.1	7.0
138.5	55	2.0	15.1	15.2	16.1	16.8		
144.0	50	2.0	-	-		18.0	7.1	7.1
147.5	55	2.0	17.6	17.7	18.6	19.3		
162.75	40	1.5	20.2	20.4	21.2	21.9	7.1	7.1
168.5	45	2.0	21.3	21.5	22.0	22.5		
173.25	50	2.0	22.3	22.5	23.1	23.6		
185.0	30	1.5	26.4	26.6	27.2	27.7	7.1	7.1
192.75	36	1.5	27.7	27.9	28.6	29.1		
196.25	40	1.5	28.7	29.0	29.6	30.1		
210.5	32	1.5	32.2	32.5	32.9	33.5	7.1	7.1
215.5	45	1.0	33.8	34.0	34.6	35.1		

(Cont'd)

TABLE A3.8 (Cont'd)

221.25	50	1.0	36.4	36.7	37.4	37.8		
233.0	45	1.5	41.2	41.5	42.2	42.8	7.15	7.1
240.5	38	1.0	45.1	45.4	45.8	46.3		
258.5	36	1.0	60.8	61.2	61.9	62.4	7.1	7.1
283.5	40	0.9	74.7	75.0	75.5	76.0		
307.0	22	0.6	89.8	90.1	90.6	91.1	7.1	7.1
311.75	40	1.0	89.4	89.8	90.2	90.8		
314.5	55	1.0	87.4	87.3	88.7	89.2		
331.25	40	0.9	105.7	106.1	106.5	107.0		
335.0	32	0.9	107.4	107.6	109.1	109.6	7.1	7.1

TABLE A3.9 Results of filter run 9

Rate of filtration = 2.0 m^3/m^2h

Depth of media = 73 cm | Effective size = 0.135 mm | Influent turbidity range = 20 - 25 FTU

Porosity = 93.6% | Uniformity coefficient = 2.96 | Temperature = 20 - 22°C

Type of media = rice hull ash | Depth of graded gravel = 0.2 m | pH = 7.1 - 7.2

Time	Turbidity FTU		Head loss cm of water					pH		Depth of matter penetration Dist. from top media in cm
(h)	Influent	Filtrate	1 - 4 8 cm	1 - 5 13 cm	1 - 6 18 cm	73 cm	Total 93 cm	In	Out	
0	22.0	3.0	5.2	6.6	6.9	10.8	14.3	7.2	7.2	
1	22.0	5.0	8.0	9.7	10.0	13.5	17.4			
2	22.0	7.0	8.3	10.0	10.4	14.3	17.8			
3	22.0	7.0	8.4	10.2	10.6	14.5	18.1			
4	24.0	7.0	8.8	10.6	10.9	14.8	18.4			
6	22.0	7.0	9.3	11.2	11.7	15.7	19.3			
19	20.0	7.0	12.1	15.5	15.7	19.8	23.4			
20	20.0	7.0	13.0	17.3	16.7	19.7	24.2			

(Cont'd)

TABLE A3.9 (Cont'd)

21	20.0	7.0	13.3	17.0	17.4	21.6	25.3			
22	22.0	7.0	13.4	17.2	17.6	21.8	25.5			
24	21.0	7.0	13.9	18.0	18.4	22.7	26.3			
27	22.0	7.0	15.1	20.0	20.5	24.8	28.6			
29	21.0	7.0	15.9	21.2	21.6	26.0	29.7			
43	22.0	7.0	24.9	36.3	36.9	41.9	45.3			
44	22.0	7.0	25.7	37.9	38.5	43.7	47.0			
45	22.0	7.0	26.5	39.1	39.8	44.6	48.4	7.1	7.2	4.0
46	22.0	7.0	27.1	40.1	40.8	45.6	49.5			
48	22.0	7.0	28.1	41.6	42.3	47.1	51.0			
49	25.0	7.0	28.5	42.5	43.2	48.1	52.0			
50	24.0	6.0	29.1	43.4	44.0	49.0	53.0			
51.75	22.0	6.0	30.0	44.7	45.4	50.8	54.7			
54	22.0	6.0	30.7	46.6	47.4	52.7	56.6			
65.75	22.0	6.0	34.5	56.5	57.7	63.3	67.2			
66.0	22.0	6.0	35.0	57.9	59.0	64.8	68.8	7.1	7.1	4.5

(Cont'd)

TABLE A3.9 (Cont'd)

68	24.0	6.0	35.0	58.4	59.6	65.4	69.4			
73	22.0	6.0	35.5	59.9	62.7	68.5	72.5			5.0
74	22.0	6.0	35.6	60.2	63.4	69.2	73.3			
75	22.0	7.0	35.7	59.8	63.0	69.8	73.8			
91.25	20.0	6.0	37.6	55.2	74.6	7.90	84.1	7.1	7.1	7.0
92.5	22.0	6.0	37.7	65.6	75.6	81.1	85.1			
94.25	22.0	6.0	37.3	50.3	75.7	81.2	85.3			
96.25	22.0	5.0	37.0	47.4	76.1	8.17	85.8			
97.75	25.0	6.0	37.6	48.1	77.1	83.2	87.0			
99.0	22.0	6.0	37.3	47.1	77.3	83.6	87.6	7.1	7.1	7.5
115.25	22.0	5.0	13.4	43.2	92.0	97.0	101.0	2.1	7.1	8.0

TABLE A3.10 Results of filter run 10

Rate of filtration 2.0 m^3/m^2h

Type of media = sand | Depth of media = 75 cm | Temperature = 20 - 22°C

Uniformity coefficient = 1.41 | Depth of graded gravel = 20 cm | pH = 7.0 - 7.1

Effective size = 0.64 mm | Influent turbidity range = 20 - 25 F.T.U.

Time	Turbidity FTU		Head loss cm of water					pH	
(h)	Influent	Filtrate	Tappings 1-3	1 - 4	1 - 6	1 - 10	1 - 11	Influent	Filtrate
			5 cm	10 cm	20 cm	75 cm	Total		
0	22.0	3.0	0.4	1.1	2.4	7.0	11.3	7.1	7.1
1	22.0	9.0	1.5	2.2	3.6	8.1	12.6		
2	22.0	8.0	1.7	2.4	3.8	8.3	12.7		
3	22.0	9.0	1.6	2.4	3.7	8.2	12.6		
4	24.0	8.0	2.8	3.5	3.9	8.3	12.8		
6	22.0	9.0	2.8	3.5	3.9	8.4	12.9	7.1	7.1
19	20.0	9.0	3.4	4.2	5.7	10.0	14.9		
20	20.0	8.0	3.6	4.6	5.9	10.3	15.0	7.1	7.1

(Cont'd)

TABLE A3.10 (Cont'd)

21	20.0	10.0	4.0	4.9	6.4	10.8	15.4		
22	22.0	10.0	4.3	5.1	6.6	11.1	15.8		
24	21.0	10.0	5.0	5.8	7.3	11.8	15.9	7.0	7.0
27.75	22.0	9.0	7.1	8.0	9.5	13.8	18.4		
29.75	21.0	10.0	8.3	9.2	10.8	15.1	19.7		
43.0	22.0	8.0	32.4	33.5	35.2	39.6	44.0		
44	22.0	8.0	34.8	35.8	37.4	41.6	46.1	7.0	7.0
45	22.0	8.0	39.1	40.2	41.7	45.7	50.5		
46	22.0	7.0	44.0	45.2	46.1	54.9	54.9		
48	22.0	7.0	52.1	53.1	54.7	59.4	64.2	7.1	7.1
49	25.0	7.0	55.0	56.0	57.6	63.2	67.0		
50	24.0	8.0	59.0	60.1	61.7	66.1	70.7		
51.75	22.0	8.0	65.3	66.5	68.1	72.6	76.5	7.1	7.1
54.	22.0	7.0	73.9	74.9	76.3	80.2	85.0		
65.75	22.0	7.0	94.1	106.2	107.7	101.9	116.9		
66	22.0	7.0	90.0	99.6	103.1	105.4	110.1	7.1	7.1

TABLE A3.11 Results of filter run 11

Type of media = rice hull ash
Uniformity coefficient = 2.96
Effective size = 0.135 mm

Rate of filtration = 4.0 m^3/m^2h
Depth of media = 75.0 cm
Porosity = 92.8%
Depth of graded gravel = 20 cm

Influent turbidity range = 16 - 28 FTU
pH = 7.1 - 7.2
Temperature = 24 - 25°C

Time (h)	Turbidity FTU		Head loss cm of water							pH		Depth of media cm	Depth of matter penetration cm
	Influent	Filtrate	1 - 3 5	1 - 4 10	1 - 5 15	1 - 7 25	1 - 8 35	1 - 10 75	Total 95	In	Out		
0	17.0	5.7	8.4	11.5	13.1	14.6	19.2	23.4	26.6	7.2	7.2	75.0	
1.0	16.0	5.0	9.5	12.5	14.4	15.8	19.3	24.5	28.0				
2.0	17.0	6.4	10.6	13.7	15.6	17.1	20.9	25.9	29.3			74.5	
3.0	16.0	6.8	11.8	14.9	16.8	18.3	22.1	27.4	30.7				
4.0	16.0	7.0	13.2	16.3	18.3	19.8	23.7	28.9	32.3			74.2	
5.0	15.0	7.0	13.4	16.7	18.7	20.2	24.2	29.4	32.9				
6.0		7.0	13.95	18.2	20.4	21.9	25.9	31.2	34.8	7.2	7.2	74	
7.0	16.0	7.4	16.4	19.8	22.0	23.4	27.6	32.9	36.4			73.8	
8.0	17.0	7.6	17.9	21.5	23.7	25.1	29.3	33.7	38.2				
9.0	17.0	7.8	18.8	22.5	24.8	26.3	30.6	36.9	38.6			73.3	3.0

(Cont'd)

TABLE A3.11 (Cont'd)

12.0	18.0	8.1	26.0	30.9	33.3	34.7	38.3	44.6	48.3	7.2	7.2	73.0	
13.0	22.0	8.1	26.9	23.8	36.4	37.6	42.6	47.9	51.6				
14.0	20.0	8.4	22.5	36.5	40.1	40.3	45.3	50.8	54.5			72.8	
15.0	22.0	8.5	10.5	39.6	42.2	43.5	48.6	54.4	58.1			72.5	
17.0	25.0	8.6	1.2	46.8	49.8	51.2	56.8	62.9	66.3			72.0	3.6
18.5	24.0	9.2	0.3	54.0	57.1	58.5	64.6	70.5	74.2	7.1	7.2	71.8	
22.5	22.0	8.9	-	76.7	82.1	84.4	91.5	97.6	101.4			70.7	
23.5	25.0	8.8	-	82.3	89.0	90.4	98.9	105.4	109.0			70.0	4.5
24.0	28.0	8.4	-	79.9	92.4	94.5	103.6	110.0	113.7	7.1	7.2	69.8	

TABLE A3.12 Results of filter run 12

Rate of filtration = 4.0 m^3/m^2h

Type of media = sand | Depth of media = 75 cm | Influent turbidity range = 16 - 29 FTU

Effective size = 0.64 mm | Porosity = 44% | pH = 7.0 - 7.2

Uniformity coefficient = 1.41 | Depth of graded gravel = 20 cm | Temperature = 25 - 25°C

Time	Turbidity FTU		Head loss cm of water						pH	
(h)	Influent	Filtrate	1 - 3 at 5 cm	1 - 4 10 cm	1 - 7 25 cm	1 - 9 55 cm	1 - 10 75 cm	Total 95 cm	In	Out
0	17	4.5	3.1	5.0	9.2	14.8	21.6	31.6	7.2	7.2
1.0	16	5.5	3.5	5.3	9.6	15.1	21.8	31.9		
2.0	17	7.8	3.7	5.6	9.9	15.3	22.0	32.1		
3.0	16	8.4	3.9	5.8	10.2	15.6	22.2	32.2		
4.0	16	9.1	4.2	6.2	10.4	16.0	22.7	32.7		
5.0	15	9.5	4.4	6.3	10.6	16.2	22.9	32.9		
6.0		9.3	4.5	6.5	10.8	16.4	23.0	33.1	7.2	7.2
7.0	16	9.2	4.7	6.7	11.0	16.7	23.3	33.2		
8.0	17	10.0	4.9	6.9	11.2	16.8	23.4	33.4		

(Cont'd)

TABLE A3.12 (Cont'd)

9.0	17	10.0	5.1	7.1	11.6	17.1	23.7	33.7		
12.0	18	10.0	5.7	7.9	12.2	17.9	24.5	34.6	7.2	7.15
13.0	22	11.0	6.1	8.2	12.5	18.2	24.9	35.0		
14.0	20	11.0	6.4	8.5	12.9	18.5	25.1	35.2		
15.7	22	12.0	6.7	8.9	13.3	18.9	25.2	35.3		
17.0	25	12.0	7.5	9.8	14.1	19.6	26.3	36.2		
18.5	24	13.0	8.2	10.4	14.9	20.6	27.1	37.1	7.1	7.1
22.5	22	14.0	11.3	13.6	19.2	23.8	30.4	40.4		
23.5	25	13.0	12.4	14.5	19.1	24.8	31.3	41.4		
24.5	25	13.0	13.6	16.0	20.6	26.2	32.7	42.7	7.1	7.1
26.5	25	13.0	16.6	18.9	23.6	29.2	35.6	45.6		
27.5	25	12.0	18.0	20.4	25.0	30.6	37.3	47.3		
29.75	24	12.0	22.1	24.5	29.2	34.6	41.2	51.2		
30.75	24	12.0	23.9	26.1	30.9	36.6	43.6	53.7	7.1	7.1
33.5	24	11.0	28.7	31.2	35.7	41.2	46.6	56.6		
35.5	24	12.0	31.6	34.0	38.5	43.3	50.0	60.0	7.0	7.05

TABLE A3.13 Results of filter run 13

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash Depth of graded gravel = 0.2 m

Original porosity = 92.6% Influent turbidity range

Original depth = 74 cm = 70 - 90 FTU

Temperature = 20 - 25°C

Time (h)	Depth of medium (cm)	Turbidity FTU		Total head loss cm of water
		Influent	Filtrate	
0	74.0	70	4.0	7.2
4.75		70	14.0	7.7
9.0		75	14.0	8.4
24.0	73.5	75	13.0	10.9
28.0		75	12.0	11.6
32.0		70	12.0	12.7
48.0	73.2	75	11.0	15.8
52.25		70	10.0	16.3
56.0		70	10.0	16.9
72.0	72.6	75	11.0	18.5
79.5		75	11.0	19.3
96.0	72.3	75	11.0	20.4
103.25		75	11.0	20.4
120.0	72.3	80	11.0	22.1
127.25		75	11.0	22.9
144.0	71.8	75	10.0	25.5
151.25		75	11.0	26.7
175.0	71.3	75	10.0	30.3
192.0	71.2	80	9.5	32.5
199.5		75	9.0	33.5

(Cont'd)

TABLE A3.13 (Cont'd)

216.0	70.4	75	9.2	33.9
223.5		75	9.7	38.0
240.0	70.3	75	10.0	40.1
247.5		80	10.0	41.9
263.5	69.9	75	10.0	44.0
273.75		80	9.7	49.3
288.0	68.9	75	9.5	52.6
295.0		75	8.5	56.6
312.0	68.0	80	8.5	56.1
319.5		80	8.5	62.3
336.0	67.8	80	8.8	64.1
343.5		75	8.3	66.9
360.0	66.6	80	8.7	71.2
367.75		80	9.9	73.4
384.0	66.3	80	9.4	79.8
391.25		75	9.7	82.4
408.0	66.3	75	7.3	87.0
416.0		75	9.4	88.9

TABLE A3.14 Results of filter run 14

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash Depth of graded gravel = 0.2 m

Original depth of media = 52 cm Influent turbidity = 70 - 90 FTU

Original porosity = 93.25% Temperature = 20 - 25°C

Time (h)	Depth of medium (cm)	Turbidity FTU		Head loss cm of water
		Influent	Filtrate	
0	52.0	70	5.3	9.4
4.75		70	16	11.3
9.0		75	15	14.3
24.0	51.4	75	15	20.6
28.0		75	13	23.0
32.0		70	14	24.7
48.0	50.8	75	13	30.4
52.25		70	12	32.0
56.0		70	13	33.3
72.0	50.3	75	12	37.4
79.5		75	12	40.9
96.0	49.5	75	13	44.0
103.25		75	13	44.8
120.0	49.2	80	13	49.1
127.25		75	13	50.2
144.0	49.0	75	13	54.0
151.25		75	13	54.8
175.25	48.2	75	11	58.3
192.0	48.0	80	11	60.8
199.5		75	11	61.2

(Cont'd)

TABLE A3.14 (Cont'd)

216.0	47.5	75	11	62.5
223.5		75	11	63.2
240.0	47.3	75	11	65.1
247.5		80	11	66.3
263.5	47.0	75	11	65.1
273.75		80	11	69.4
288.0	46.5	75	12	70.3
295.25		75	12	71.5
312.0	45.7	80	12	71.3
319.5		80	13	75.4
336.0	45.5	80	13	74.0
343.5		75	12	75.6
360.0	45.5	80	11	76.7
367.0		80	12	76.2
384.0	45.0	80	12	78.2
391.25		75	12	78.9
408.0	44.8	75	12.0	79.4
416.0		75	12.0	79.6

TABLE A3.15 Results of filter run 15

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash

Depth of graded gravel = 0.2 m

Original depth of media = 33.5 cm

Influent turbidity range = 70 - 90 FTU

Original porosity = 91.4%

Temperature = 20 - 25°C

Time (h)	Depth of medium (cm)	Turbidity FTU		Head loss cm of water
		Influent	Piltrate	
0	33.5	70	5.4	3.8
4.0		70	20.0	4.5
24.0	33.4	75	20.0	6.2
31.25		70	21.0	7.4
48.0	33.2	75.0	21.0	8.5
54.75		70	20.0	8.9
79.0		75.0	20.0	10.2
96.0	32.9	75.0	20.0	10.8
103.0		75.0	21.0	11.4
120.0	32.9	80.0	20.0	12.4
127.25		75.0	21.0	13.5
144.0	32.7	75.0	21.0	15.0
151.25		75.0	22.0	17.1
168.0		75.0	20.0	17.5
175.25		75.0	21.0	19.8
192.0	32.5	80	21.0	20.5
199.0		75	22.0	22.5
216.0	32.3	75	22.0	24.0
223.0		75.0	22.0	24.6

(Cont'd)

TABLE A3.15 (Cont/d)

240.0	32.1	75.0	22.0	24.9
247.25		80.0	22.0	26.0
264.0	31.8	75.0	22.0	26.8
271.0		80.0	22.0	27.5
288.0	31.7	75.0	22.0	28.8
295.5		75.0	22.0	29.5
312.0	31.5	80.0	25.0	30.7
336.5	31.4	80.0	25.0	31.3
344.0		75.0	21.0	32.8
360.0	31.3	80.0	21.0	32.1
367.75	31.3	80.0	21.0	32.1
384.0	31.2	80.0	20.0	35.1

TABLE A3.16 Results of filter run 16

Rate of filtration = 1.0 m^3/m^2h Depth of graded gravel = 0.2 m

Depth of media = 72.0 cm Influent turbidity = 20 - 25 FTU

Porosity = 93.1% Temperature = 20 - 22°C

Type = rice hull ash

Time (h)	Depth of media (cm)	Turbidity FTU		Head loss cm of water
		Influent	Filtrate	
0	72.8	20	3.0	5.2
6.5		20	3.8	9.3
24.0	71.7	21	3.9	10.0
30.5		21	3.9	12.5
48	71.4	20	4.3	14.0
54.5		20	3.3	14.9
72	71.2	20	4.3	16.3
78.5		21	4.2	17.2
96	71.0	22	4.4	18.7
102.5		22	4.3	19.1
119.0	70.9	24	4.5	20.4
126		24	4.0	21.1
144	70.8	22	4.2	22.1
150.75		20	3.8	23.3
168	70.7	22	4.7	24.0
174		22	4.3	24.0
191.0	70.5	22	4.4	25.0
198.5		21	4.1	25.7
216	70.3	22	4.1	25.2
222.5		21	3.8	25.9

(Cont'd)

TABLE A3.16 (Cont'd)

240	70.2	20	4.6	25.8
246.5		21	4.2	25.9
264	70.0	20	4.5	26.0
270		25	4.5	27.6
288	69.9	24	4.5	27.7
294		20	4.3	27.8
312	69.8	20	4.3	27.5
336	69.6	21.0	4.3	29.0

TABLE A3.17 Results of filter run 17

Rate of filtration = 1.0 m^3/m^2h Depth of graded gravel = 0.2 m

Type = rice hull ash Influent turbidity range

Depth of media = 53.0 cm = 20 - 25 FTU

Porosity = 96.6% Temperature = 20 - 22°C

Time (h)	Depth of media (cm)	Turbidity FTU		Head loss cm of water
		Influent	Filtrate	
0	53.0	20	2.2	3.1
6.5		20	4.5	6.1
24.0	52.4	21	4.5	7.1
30.5		21	4.7	8.1
48.0	52.3	20	4.5	9.0
54.5		20	4.7	10.5
72.0	52.1	20	4.4	11.9
78.5		21	5.2	14.1
96.0	51.8	22	4.7	15.7
102.5		22	4.5	18.5
119.0	51.4	24	4.9	20.0
126.0		24	4.7	22.1
144.0	51.0	22	4.7	24.4
150.75		20	5.0	24.6
168.0	50.8	22	4.8	26.2
174.0		22	4.8	27.0
191.0	50.5	22	5.3	28.0
198.5		21	5.0	27.7
216.0	50.3	22	4.6	29.0
222.5		21	4.5	29.3

(Cont'd)

TABLE A3.17 (Cont'd)

240.0	50.2	20	4.7	30.6
246.5		21	4.5	31.4
264.0	50.1	20	4.7	32.0
270.0		25	5.5	32.4
288.0	50.0	24	5.0	33.2
294.0		20	4.5	33.7
312.0	49.7	20	4.7	34.1
336.0		21	4.3	34.2

TABLE A3.18 Results of filter run 18

Rate of filtration = 1.0 $m^3/m^2 h$ Depth of graded gravel = 0.2 m

Depth of media = 38.3 cm Influent turbidity range = 20 - 25 FTU

Porosity = 94.2% Temperature = 20 - 22°C

Time (h)	Depth of media (cm)	Turbidity FTU		Head loss cm of water
		Influent	Filtrate	
0	38.3	20	2.0	3.0
6.5		20	6.0	3.3
24.0	38.0	21	5.5	4.0
30.5		21	6.5	4.3
48.0	37.9	20	6.5	4.9
54.5		20	6.1	5.1
72.0	37.9	20	6.5	5.5
78.5		21	6.2	5.9
96.0	37.9	22	6.4	6.2
102.5		22	6.5	6.5
119.0	37.8	24	6.5	7.1
126.0		24	6.4	7.5
144.0	37.7	22	6.5	7.9
150.75		20	7.1	7.9
168.0	37.6	22	6.4	8.6
174.0		22	6.3	8.8
191.0	37.6	22	6.3	9.1
198.5		21	5.9	9.5
216.0	37.4	22	5.8	10.4
222.5		21	5.3	10.9

(Cont'd)

TABLE A3.18 (Cont'd)

240.0	37.4	20	5.5	11.6
246.5		21	5.1	12.2
264.0	37.3	20	5.4	13.8
270.0		25	6.4	14.1
288	37.3	24	6.2	15.6
294.0		20	5.2	16.7
312	37.1	21	5.1	18.4

TABLE A3.19 Clear water experiments - Results of filter run 19

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash Source of water = tap water

Original depth = 52.5 cm pH = 7.1

Porosity = 93.4% Temperature = 20 - 22°C

Time (d)	Head loss cm of water	Depth of Media (cm)
0	3.1	52.5
1	4.8	51.9
2	5.0	51.7
3	5.6	51.6
4	6.7	51.5
5	7.2	51.3
6	8.0	51.2
7	8.3	51.1
8	8.5	51.0
9	9.3	50.9
10	9.8	50.8
11	10.1	50.7

TABLE A3.20 Clear water experiments - results of filter run 20

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash Temperature = 20 - 22°C

Original depth of media = 31.4 cm Source of water = tap water

Original porosity = 92.9% Depth of graded gravel = 20 cm

Time (d)	Total head loss cm of water	Depth of media (cm)
0	6.0	31.4
1	6.1	31.0
2	6.4	30.8
3	8.0	30.6
4	9.8	30.5
5	10.9	30.4
6	12.1	30.3
7	13.8	30.1
8	16.0	30.0
9	17.2	29.8
10	19.0	29.7

TABLE A3.21 Clear water experiments - results of filter run 21

Rate of filtration = 1.0 m^3/m^2h

Original depth of media = 78.0 cm Original porosity = 93.6%

Time (d)	Head loss cm of water	Depth of media (cm)
0	2.5	78.0
1	3.2	77.7
2	3.8	77.4
3	4.4	77.1
4	5.1	77.0
5	6.1	76.7
6	6.7	76.6
7	6.8	76.6
8	6.7	76.5
9	6.9	76.4
10	7.1	76.4
11	7.1	76.3
12	7.6	76.2
13	8.2	76.0
14	9.6	75.8
15	9.3	75.6
16	9.4	75.5
17	9.5	75.3
18	10.1	75.1
19	10.4	75.0
20	11.0	74.9

TABLE A3.22 Results of filter run 22

Rate of filtration = 0.25 m^3/m^2h

Type of media = rice hull ash

Depth of media = 77.9 cm

Porosity = 90%

Depth of graded gravel = 0.2 m

Influent turbidity range = 45 - 75 FTU

Time (d)	Depth of media (cm)	Turbidity FTU		Head loss cm of water		
		Influent	Filtrate	Tappings 1-4 at 12.9 cm	Tappings 1-6 at 22.9 cm	Total at 97.9 cm
0	77.9	65	5.0	1.7	2.4	2.7
1	77.8	75	6.2	1.9	2.0	2.9
2	-	70	6.6	1.9	2.0	2.9
3	77.7	65	6.2	2.1	2.2	3.0
4	-	80	7.8	2.2	2.3	3.1
5	77.65	70	8.5	2.2	2.3	3.1
6	77.6	70	8.1	2.4	2.4	3.2
7	77.5	75	7.8	2.5	2.5	3.3
8	77.5	70	7.6	2.7	2.7	3.4

(Cont'd)

TABLE A3.22 (Cont'd)

9	77.5	70	7.8	2.9	2.9	3.5
10	77.4	65	6.9	3.0	3.0	3.7
11	77.3	65	6.9	3.2	3.2	3.9
12	77.2	65	7.4	3.2	3.4	4.0
13	77.15	65	7.6	3.4	3.5	4.2
14	77.14	75	8.0	3.7	4.0	4.8
15	77.0	75	8.5	4.1	4.3	5.0
16	76.9	75	8.5	4.0	4.2	4.98
17	76.8	70	8.2	4.1	4.3	5.1
18	76.8	75	7.9	4.6	4.7	5.3
19	76.7	65	8.2	4.8	4.9	5.4
20	76.7	75	8.0	4.9	5.1	5.9
21	76.7	75	8.6	5.4	5.7	6.4
22	76.6	70	7.9	5.7	6.0	6.6
23	76.5	70	8.2	6.1	6.2	7.0
24	76.4	70	8.6	6.4	6.5	7.3

(Cont'd)

TABLE A3.22 (Cont'd)

25	76.4	75	7.7	6.7	6.8	7.6
26	76.3	70	7.5	6.9	7.0	7.9
27	76.2	70	7.4	7.4	7.6	8.2
28	76.1	65	7.3	7.7	7.9	8.7
29	75.9	65	6.7	7.9	8.1	8.8
30	75.8	70	7.2	8.9	9.0	10.1
31	75.7	70	6.7	9.2	9.3	10.2
32	75.6	65	6.3	9.7	9.8	10.7
33	75.4	65	67	9.3	9.4	10.3
34	75.2	65	6.4	9.3	9.7	10.6
35	75.2	70	6.8	9.8	10.0	10.9
36	75.1	70	6.3	10.9	11.2	12.1
37	75.0	65	5.6	11.2	11.7	12.7
38	74.9	70	6.7	12.9	13.2	14.2
39	74.8	65	6.0	14.3	14.7	15.7
40	74.7	65.0	6.1	16.2	16.7	17.8

(Cont'd)

TABLE A3.22 (Cont'd)

41	-	-				
42	74.3	60	5.7	18.4	20.3	21.4
43	74.1	60	5.6	16.5	20.9	22.2
44	73.9	55	5.0	15.6	23.6	25.0
45	73.7	60	5.7	16.3	27.0	28.6
46	73.1	65	5.7	11.8	32.2	34.0
47	72.5	60	5.5	9.9	40.0	41.9
48	71.8	50	4.7	4.2	47.1	49.1
49	71.0	50	5.1	2.1	52.5	55.1
50	70.3	50	5.7	-	65.0	67.4
51	69.8	45	5.5	-	71.0	72.5
52	69.3	50	4.7	-	81.6	84.1
53	68.3	55	5.5	-	89.0	90.2
54	67.7	50	5.1	-	98.0	99.8
56	66.5	45	4.5	-	100.5	102.0

TABLE A3.23 Results of filter run 23

Type of medium = rice hull ash Original depth of medium = 77.4 cm

Effective size = 0.135 mm, Depth of graded gravel = 0.20 m

Uniformity coefficient = 2.96

Time (d)	Depth of medium (cm)
0	77.4
1	77.3
3	77.3
6	77.3
10	77.0
13	76.9
17	76.4
21	75.8

TABLE A3.24 Results of filter run 24 - Bacterial removal

Rate of filtration = 1.0 m^3/m^2h

Type of media = rice hull ash Original depth of media = 77.5 cm

Effective size = 0.135 mm Depth of graded gravel = 0.2 m

Uniformity coefficient = 2.96

Time (h)	Head loss cm of water	Viable counts of *E. coli* at 37°C (no/mL)		Efficiency (%)	Depth of media (cm)
		In	Out		
0	3.4	< 10	< 10		77.5
4	3.5	970	300	69.1	
28	4.2	no counts were taken			77.3
52	5.4				77.1
76	5.9	1600	260	83.8	77.0
94	6.2	2290	510	77.7	
124	6.4	1100	30	97.3	76.7
148	6.7	1550	85	84.5	76.6
172	7.2	185	< 10	> 94.6	
196	7.4	100	15	85.0	76.2
220	7.6	160	10	93.8	75.9
244	7.8	320	20	93.8	75.8

TABLE A3.25 Results of filter run 25

Rate of filtration = 1.0 m^3/m^2h

Type of medium = sand Depth of media = 75 cm

Effective size = 0.64 mm Porosity = 44%

Uniformity coefficient = 1.41

Time (h)	Head loss (cm of water)	Viable counts of *E. coli* at 37°C (no/mL)		Efficiency (%)
		In	Out	
0	3.2	< 10	< 10	
4	3.5	335	100	70.1
28	7.3	no counts were made		
52	18.9			
76	28.1	1500	460	69.3
94	30.6	1680	600	64.3
124	33.0	1100	200	81.8
148	37.5	1050	230	78.1
172	40.9	200	40	80.0
196	47.0	70	17	75.7
220	53.8	140	25	82.1
244	60.5	300	70	76.7

TABLE A3.26 Results of filter run 26

Rate of filtration = 0.5 m^3/m^2h

Type of media = rice hull ash Depth of medium = 75.6 cm

Effective size = 0.135 mm Porosity = 93.7%

Uniformity coefficient = 2.96

Time (h)	Head loss (cm of water)	Viable counts of *E. coli* at 37°C (no/mL)		Efficiency (%)	Depth of medium (cm)
		In	Out		
0	2.7	< 10	< 10	-	75.6
4	2.8	3000	880	70.7	
28	4.3	500	70	86.0	75.3
52	4.5	1200	240	80.0	
76	4.7	110	15	86.4	75.0
100	4.8	no counts were made		-	
124	5.0	1950	110	94.4	
148	5.1	380	< 10	> 97.4	74.5
172	5.5	330	< 10	> 97.0	74.4
196	5.8	700	< 10	> 98.6	
220	5.9	810	35	95.7	74.2

TABLE A3.27 Results of filter run 27

Rate of filtration = 0.5 cm^3/m^2h

Type of medium = sand Porosity = 44%

Effective size = 0.64 mm Uniformity coefficient = 1.41

Depth of medium = 75 cm

Time (h)	Head loss (cm of water)	Viable counts of *E. coli* at 37°C (no/mL)		Efficiency (%)
		In	Out	
0	2.1	< 10	< 10	-
4	2.3	6000	2340	61.0
28	2.3	1120	100	91.1
52	2.9	240	95	60.4
76	3.8	90	10	88.9
100	5.2	240	50	79.2
124	6.6	1580	230	85.4
148	9.0	95	< 10	> 89.5
172	11.8	500	50	90.0
196	15.6	880	70	92.0
220	19.3	900	40	95.6

TABLE A3.28 Results of filter run 31

Series filtration

Primary filter		Secondary filter	
Depth of R.H.A. medium	= 75.8 cm	Depth of R.H.A. medium	= 77.8 cm
Porosity	= 93.6%	Porosity	= 93.3%
Depth of graded gravel	= .2 m	Depth of graded gravel	= .2 m
Rate of filtration	= 1.0 m^3/m^2h	Rate of filtration	= 0.5 m^3/m^2h

Time (d)	Turbidity FTU			Head loss cm of water				Depth of media cm	
	Influent	Filtrate		Primary		Secondary		Primary	Secondary
		Primary	Secondary	Gross	Net	Gross	Net		
0	29	3.1		5.2	4.4			75.8	
1	29	8.0		7.4	6.4	3.4	3.1	75.5	77.8
2	26	7.0	5.8	11.4	10.2	3.5	3.1	74.9	77.0
3	26	6.7	5.3	15.3	14.2	3.8	3.6	74.5	77.0
4	26	6.0	4.7	20.0	18.9	3.7	3.3	73.9	76.8
5	27	5.2	3.7	23.4	22.4	4.0	3.6	73.5	76.8
6	25	5.0	3.3	26.7	25.7	4.4	4.0	73.1	76.8
7	27	5.0	3.0	30.3	29.4	4.3	3.9	72.6	76.6

(Cont'd)

TABLE A3.28 (Cont'd)

8	26	4.7	2.5	33.0	32.0	4.6	4.1	72.2	76.5
9	25	4.7	2.5	35.0	34.1	4.7	4.3	71.8	76.4
10	31	4.7	2.0	39.0	38.0	4.9	4.4	71.2	76.3
11	26	4.7	2.2	42.8	41.9	5.1	4.6	70.7	76.1
12	26	4.7	2.2	44.1	43.1	5.4	4.1	70.1	76.1
13	26	4.5	2.25	47.4	46.5	5.5	5.1	69.5	75.9
14	25	4.2	2.0	54.5	53.6	6.4	5.6	68.6	75.8
15	28	4.5	2.0	60.1	59.2	6.2	5.5	67.8	75.7
16	25	4.2	1.8	66.8	65.8	5.9	5.5	67.1	75.5
17	26	4.0	1.5	72.5	71.4	6.1	5.5	66.2	75.4
18	26	4.2	1.5	75.8	74.7	6.3	5.8	65.4	75.4
19	26	3.9	1.3	77.4	76.5	6.5	6.1	64.7	75.2
20	25	3.9	1.5	78.0	76.9	6.5	6.2	64.0	75.0
21	26	3.8	1.5	88.4	79.3	6.3	6.0	63.3	74.8
22	28	3.6	1.5	82.3	81.3	6.5	6.2	62.6	74.8
23	26	3.4	1.5	83.9	82.9	6.5	6.2	62.0	74.7

(Cont'd)

TABLE A3.28 (Cont'd)

24	26	3.2	1.7	83.4	82.4	6.5	6.2	61.4	74.6
24.5				9.9	8.9	6.3	6.0	77.5	
25	34	7.0	2.0	39.2	38.1	6.3	6.0	76.6	74.4
26	27	5.7	1.6	52.6	51.3	6.1	5.5	-	74.2
27	26	4.4	1.6	58.7	57.4	6.0	5.6	75.9	74.4
28	23	3.6	1.5	64.5	63.1	5.7	5.4	75.4	74.3
29	34	3.4	1.4	76.9	75.1	6.0	5.7	75.2	74.2
30	31	2.8	1.4	79.7	77.7	6.4	6.1	74.4	74.2
31	25	2.3	1.4	79.9	77.9	6.5	6.1	73.9	74.2
32	24	1.9	1.4	80.6	78.6	6.6	6.1	73.5	74.2
33	21	1.6	1.4	80.6	79.0	6.9	6.4	73.2	74.2
34	34	1.6	1.2	87.4	86.1	7.2	6.8	72.8	74.2
35	30	1.7	1.1	96.2	96.2	7.2	6.8	71.8	74.1
36	26	1.7	1.2	97.6	96.6	7.3	6.8	70.9	74.1
37	27	1.6	1.1	99.7	98.3	7.3	6.9	70.1	74.0
38			1.6	12.1	11.1			77.8	73.9

(Cont'd)

TABLE A3.28 (Cont'd)

39	30	3.4	1.6	21.6	19.6	7.6	6.3	77.0	73.6
40	25	2.5	1.4	24.0	22.1	7.9	7.5	76.8	73.5
41	22	2.4	1.3	25.5	23.7	8.8	8.3	76.6	73.3
42	22	2.0	1.3	27.6	25.0	8.4	7.9	76.4	73.3
43	23	1.7	1.4	29.5	28.0	7.4	6.9	76.1	73.2
44	34	1.8	1.3	34.3	33	8.3	7.8	75.8	73.1
45	27	1.4		37.0	35.7			75.1	
46	23	1.5		40.5	37.6			74.8	
47	21	1.1		44.4	43.0			74.5	
48	27	1.1		49.4	48.1			74.1	
49	24	1.3		53.8	52.5			73.6	
50	26	1.2		62.2	60.9			72.6	
51	26	1.2		70.5	69.8			71.5	
52	25	1.1		77.0	75.9			70.2	
53	25	1.1		79.2	78.1			69.3	
55	22	1.1		86.1	85.0			67.9	

(Cont'd)

TABLE A3.28 (Cont'd)

56	23	1.2	90.9	89.7	67.0
57	20	1.2	92.1	90.9	66.1
58	22	1.2	94.9	93.7	65.6

TABLE A3.29 Results of thin layer filter runs 32A and 32B

Rate of filtration = 1.0 m^3/m^2h

Run	Depth of media (mm)	Porosity (%)
32A	50	94.2
32B	95	93.9

Time (h)	Suspended solids concentration (mg/L)			Head loss (cm of water)	
	Influent	Filtrate			
		32A	32B	32A	32B
0	8.4	-	-	1.0	4.8
1.0	21.0	4.9	5.4	1.3	5.4
2.0	18.5	6.2	6.7	1.5	5.8
4.0	18.0	9.0	7.6	2.1	6.6
7.0	18.0	10.0	8.0	2.8	7.5
9.45	15.7	9.0	7.6	3.5	8.6
22.25	13.8	8.0	6.2	5.6	12.2
23.25	14.5	8.7	6.7	5.7	12.3
25.25	13.8	8.0	6.0	6.0	12.4
27.5	13.4	8.0	6.2	6.7	14.3
30.5	13.4	8.7	5.4	7.2	15.6
46.75	13.8	7.2	6.2	9.3	20.5
49.25	15.0	8.0	5.8	9.5	23.5
51.75	14.5	8.7	6.2	9.6	22.9
54.25	14.8	9.0	6.2	9.7	23.5
56.5	14.2	8.7	6.2	10.2	24.1
71.25	14.2	7.6	5.4	11.3	26.5
78.5	13.8	9.0	6.2	11.9	28.0
95.5	14.2	9.0	6.2	12.6	30.0

(Cont'd)

TABLE A3.29 (Cont'd)

102.5	13.8	7.6	4.9	13.4	29.0
119.0	12.4	6.2	3.5	14.3	32.2
126.5	13.0	7.6	4.9	14.6	33.3
143.0	13.4	5.8	3.7	14.8	34.6
145.25	15.0	7.6	4.9	15.2	35.2
147.75	15.0	8.0	5.4	15.5	35.9
150.5	15.0	8.0	5.7	15.7	36.3
153.0	12.0	7.5	5.4	15.8	37.3
167.5	13.8	6.2	3.9	16.0	37.7
169.25	15.0	7.2	4.2	16.8	39.9
171.75	14.0	7.0	4.5	16.3	39.6
174.5	13.5	6.7	4.5	17.3	42.0
191.25	12.0	5.8	3.0	18.0	42.5
193.25	13.0	6.2	3.0	17.5	43.4
195.75	13.0	5.8	3.5	19.6	42.7
198.5	12.4	6.2	3.0	19.2	43.4
215.0	11.0	4.9	2.5	19.3	44.7
217.25	13.4	5.4	3.0	20.2	46.0
220.25	13.0	6.7	3.5	20.8	45.9
222.5	12.4	6.7	3.5	21.2	46.3
239.0	15.0	5.8	3.0	20.9	49.0
246.25	13.4	6.7	3.9	22.2	51.4
263.25	11.4	5.8	3.0	23.2	54.5
270.5	12.0	6.2	3.5	24.0	54.0
287.25	11.4	5.4	3.0	24.0	56.7
289.25	11.4	5.8	3.5	24.6	56.4
291.75	12.0	6.0	3.0	24.6	56.2

(Cont'd)

TABLE A3.29 (Cont'd)

294.25	11.4	6.2	4.9	24.6	56.5
297.0	11.0	3.9	3.0	25.4	57.0
311.0	16.0	4.9	2.5	25.0	57.3
313.25	16.0	4.9	3.5	27.2	59.9
316.25	15.0	6.7	3.9	27.8	61.7
318.5	12.4	6.2	3.5	27.1	60.6
320.75	12.4	6.7	3.9	27.1	62.6
335.25	16.0	6.2	3.5	27.4	61.6
337.25	15.5	7.2	3.9	28.6	63.1
339.5	13.5	7.2	4.5	28.5	65.5
342.25	13.5	6.7	3.9	28.0	64.8
344.75	13.0	7.2	4.5	28.6	64.8
359.25	12.0	5.4	3.0	30.2	66.7
361.5	15.5	7.2	3.9	29.8	67.9
364.5	15.0	7.6	4.9	29.8	67.5
366.5	15.0	8.0	4.9	29.3	67.3
383.5	14.4	6.2	3.5	30.7	71.1

TABLE A3.30 Results of thin layer filter runs 33A and 33B

Rate of filtration = 1.0 m^3/m^2h

Run	Depth of media (mm)	Porosity (%)
33A	50	94.2
33B	90	93.6

Time (h)	Suspended solids concentration (mg/L)			Head loss (cm of water)	
	Influent	Filtrate			
		33A	33B	33A	33B
0	8.4	2.0	-	0.3	0.6
1	15.5	6.7	4.5	0.4	0.7
3	14.9	7.6	5.7	0.7	1.1
4.5	14.9	7.6	6.2	1.0	1.4
6.0	14.9	7.2	5.7	1.4	1.7
8.25	13.7	7.6	5.7	2.2	2.4
22.0	13.0	7.6	5.7	4.8	6.2
28.5	17.0	9.0	6.2	5.2	6.8
25.0	16.6	9.5	6.7	5.4	7.7
27.0	16.6	9.5	6.7	6.0	7.9
28.5	16.0	10.0	7.5	6.0	9.6
30.0	16.6	10.0	7.2	6.3	10.4
32.5	15.7	9.8	6.2	6.8	11.7
46.0	13.7	9.0	6.2	7.6	16.2
47.5	17.1	10.0	6.7	7.9	17.1
49.0	17.1	10.0	7.2	8.1	18.0
51.0	17.1	10.4	7.2	8.3	18.6
52.5	16.6	10.4	6.7	8.3	20.2
54.0	17.1	10.4	7.2	8.6	21.1

(Cont'd)

TABLE A3.30 (Cont'd)

70.25	15.7	9.0	5.7	8.8	25.8
77.5	16.6	11.0	6.7	9.5	29.3
94.0	14.9	8.0	5.7	9.6	31.8
101.5	17.1	9.5	6.2	10.2	34.3
118.5	18.0	9.5	5.4	10.6	36.7
120.5	17.5	10.0	5.7	11.1	38.0
123.0	17.1	9.5	6.2	11.1	38.4
125.0	16.0	9.5	6.2	11.0	39.0
127.75	16.0	9.0	5.7	11.2	39.3
142.5	14.7	8.0	4.9	11.7	40.1
144.5	14.4	8.6	5.4	11.5	40.5
147.0	14.4	8.0	4.9	11.5	42.1
149.0	14.4	8.6	4.9	11.6	41.4
151.75	14.4	8.0	5.1	11.9	42.8
166.75	13.3	7.6	4.5	12.7	44.5
168.75	17.5	8.0	4.9	12.4	44.4
171.0	14.5	8.0	4.9	12.6	44.8
173.0	15.0	8.6	5.5	12.2	45.9
176.0	14.5	8.0	5.4	13.1	47.4
189.75	13.4	7.6	4.9	13.3	49.0
199.0	14.4	8.0	5.4	13.6	53.0

TABLE A3.31 Results of thin layer filter runs 34A and 34B

Rate of filtration = 1.0 m^3/m^2h

Run	Depth of media (mm)	Porosity (%)
34A	50	94.2
34B	100	94.2

Time (h)	Suspended solids concentration (mg/L)			Head loss (cm of water)	
	Influent	Filtrate			
		34A	34B	34A	34B
0	12.4	-	-	1.9	1.8
1.0	14.25	7.0	4.2	2.3	2.1
3.0	13.75	7.0	5.1	3.0	2.7
4.0	14.25	7.6	5.1	3.4	2.9
5.0	15.6	7.6	5.3	3.4	3.1
6.0	14.75	7.6	5.1	3.7	3.4
8.25	15.6	8.0	5.65	4.6	3.9
21.5	19.4	10.4	7.8	6.8	6.1
23.0	21.25	11.8	9.0	7.4	7.1
25.0	19.9	11.8	8.5	8.1	8.9
27.0	18.5	10.5	8.0	8.5	8.3
30.0	18.5	11.4	7.6	8.8	9.4
32.5	16.5	10.0	7.0	9.2	10.1
46.25	22.75	10.75	8.25	10.3	12.4
53.25	19.4	12.25	9.5	11.3	14.3
70.0	21.25	10.0	8.0	11.7	16.8
77.25	16.6	10.9	7.7	12.2	18.4
94.5	18.0	8.5	6.1	12.8	20.3
99.0	16.6	9.0	6.6	13.0	21.4

(Cont'd)

TABLE A3.31 (Cont'd)

104.25	16.0	9.0	6.6	12.9	24.0
118.25	20.75	9.0	7.0	13.5	23.1
123.0	18.0	10.5	7.0	14.2	23.8
128.25	16.5	9.5	7.0	14.7	24.3
142.0	15.2	8.5	5.7	14.9	25.1
149.25	14.75	9.0	6.1	15.5	25.5
166.25	18.0	8.0	5.1	15.0	27.4
170.5	18.0	9.0	6.1	16.6	29.1
175.0	14.75	8.5	5.7	17.1	29.2
190.0	14.25	7.5	4.6	16.6	30.3

TABLE A3.32 Results of thin layer filter runs 35A to 35D

Rate of filtration = 1.0 m^3/m^2h

Run	Depth of media	Porosity %
35A	50	94.2
35B	100	94.2
35C	190	93.6
35D	260	93.3

Time (h)	Suspended solids concentration mg/L					Head loss cm of water			
	Influent	Filtrate							
		35A	35B	35C	35D	35A	35B	35C	35D
0	14.5	-	-	-	-	4.3	3.8	4.1	3.5
2.5	14.5	9.5	6.7	4.9	3.9	5.3	4.7	4.5	4.0
16.0	15.0	9.3	7.0	5.0	3.9	7.0	6.2	7.7	7.1
17.0	14.5	9.0	7.2	4.9	3.9	7.4	7.5	8.2	7.5
18.0	15.5	9.0	7.2	4.9	3.9	7.7	7.9	8.6	8.1
19.0	15.2	8.6	6.7	4.9	3.5	8.0	8.0	9.0	8.4

(Cont'd)

TABLE A3.32 (Cont'd)

25.25	14.5	9.0	6.7	4.9	3.5	9.3	9.5	11.3	9.8
40.0	17.5	8.6	6.2	4.7	3.0	10.4	11.7	15.7	14.1
45.0	14.5	9.5	6.7	4.5	3.5	11.0	12.8	17.6	16.2
46.0	13.5	8.4	6.2	3.9	3.5	11.2	12.0	18.1	16.6
47.0	14.5	8.2	6.2	3.9	2.7	11.0	12.9	18.4	17.0
48.0	14.5	8.8	7.0	4.5	3.0	11.0	13.0	18.7	17.1
49.75	13.5	8.4	6.5	4.5	2.9	11.1	13.2	19.1	17.6
64.0	14.5	10.8	5.4	3.5	2.5	12.3	14.7	21.6	20.6
65.0	15.0	10.5	5.7	3.9	2.5	12.3	15.2	22.1	21.7
67.0	15.0	10.8	5.7	3.9	3.0	13.0	15.5	23.3	22.6
71.0	14.5	8.6	6.2	4.5	3.5	13.0	16.1	24.3	23.5
72.0	14.0	8.6	6.2	4.1	3.0	12.9	16.3	24.4	23.8
88.0	31.25	8.4	6.2	4.5	3.0	13.7	17.6	26.9	26.9
89.0	14.5	8.3	5.7	3.9	2.5	13.8	17.9	27.6	27.6
96.0	13.75	8.2	5.7	3.5	2.5	14.2	18.7	29.3	29.3

(Cont'd)

TABLE A3.32 (Cont'd)

112.0	14.0	7.7	5.0	3.0	2.0	14.2	19.0	29.5	31.6
113.0	14.0	7.7	5.0	3.5	2.2	14.4	19.4	30.6	31.6
115.0	14.0	7.7	5.4	3.5	2.2	14.9	19.8	30.3	32.4
117.0	13.75	7.7	5.4	3.5	2.5	14.7	20.0	30.8	32.7
119.0	14.0	7.8	5.8	3.9	2.2	14.8	20.4	30.9	33.2
120.0	14.0	8.2	5.4	3.5	2.5	14.7	20.2	31.1	33.1
122.25	14.0	8.6	5.4	3.5	2.5	15.5	20.5	31.2	33.1
136.25	15.0	8.6	5.4	3.5	2.5	15.0	21.6	32.2	35.1
137.0	14.5	7.8	5.4	3.9	3.0	15.3	21.7	32.7	35.8
139.0	15.5	8.2	5.4	3.7	2.5	14.9	22.2	33.6	36.5
141.0	14.5	8.2	5.8	3.9	3.0	15.6	22.6	33.9	36.9
142.25	14.5	8.6	6.2	3.9	3.0	15.6	23.4	33.9	37.0
144.25	15.0	8.6	5.4	3.5	3.0	15.8	22.4	34.1	37.3
160.5	16.0	8.2	6.2	3.9	2.5	16.5	23.7	34.3	38.9
162.5	15.5	8.6	6.2	3.7	3.0	17.2	24.5	37.1	40.0

(Cont'd)

TABLE A3.32 (Cont'd)

164.5	15.0	8.6	6.2	4.5	2.7	17.3	25.1	37.1	40.7
166.5	15.0	8.6	5.8	3.5	3.0	17.0	27.1	37.4	41.0
168.5	13.4	7.6	6.2	3.9	2.7		24.8	37.5	41.6
170.25	14.0	8.6	6.2	4.5	3.0	17.3	25.1	27.8	42.0
184.25	15.5	7.6	5.8	3.9	2.5	17.3	26.2	38.3	43.2
186.25	16.5	8.0	6.7	4.2	2.5	17.7	27.4	41.2	46.3
188.5	17.0	9.5	6.7	4.5	3.0	17.8	27.6	41.3	46.4
190.5	16.0	9.5	7.4	4.9	3.0	18.3	27.5	41.1	46.6
191.5	16.0	4.0	6.3	4.5	2.5	17.6	27.4	41.5	47.5
207.5	16.0	8.2	5.7	3.9	2.7	18.9	28.4	43.6	50.9
208.75	17.8	9.5	8.7	3.9	3.0	18.8	29.4	44.3	51.2
209.75	16.5	9.0	6.7	4.5	3.0	19.1	30.0	44.4	51.3
210.75	17.0	10.0	6.7	4.9	3.0	19.3	29.9	45.0	51.2
212.75	15.5	9.0	7.4	4.5	3.0	18.5	29.7	45.2	53.1
214.25	16.0	9.0	6.7	3.9	3.5	19.2	30.2	45.1	52.7

(Cont'd)

TABLE A3.32 (Cont'd)

215.75	14.0	8.6	6.3	3.9	3.0	18.7	29.6	45.2	53.8
218.0	16.0	8.6	6.7	4.5	3.5	19.1	30.4	45.2	53.2
232.0	17.5	8.2	5.7	4.5	3.0	19.6	30.9	46.7	55.0
233.0	17.5	8.6	6.7	3.9	3.0	20.0	31.3	46.6	56.7
239.25	15.5	8.6	6.7	4.5	3.5	19.7	32.2	47.9	58.2
256.0	19.0	8.6	6.7	4.1	3.0	20.7	33.0	49.1	59.9
263.75	15.0	9.0	7.4	4.9	3.5	20.8	34.1	50.1	61.3
280.25	20.5	7.4	5.4	3.5	2.5	20.9	34.7	50.5	62.1
290.25	18.3	8.6	6.7	3.9	3.0	21.6	35.2	51.4	64.1
292.25	17.5	8.8	6.7	3.9	3.0	21.8	36.0	52.3	63.0
294.25	16.5	9.0	6.7	3.9	2.5	21.3	35.9	51.6	64.0
295.5	15.0	8.6	6.7	3.9	3.0	21.3	35.6	51.6	63.0
296.25	16.0	8.6	6.7	3.9	2.5	21.2	35.4	51.6	64.0
312.75	14.5	7.7	5.4	3.9	2.5	22.0	36.2	52.2	65.7

TABLE A3.33 Results of thin layer filter runs 36A to 36C

Rate of filtration = 0.75 m^3/m^2h

Run	Depth of medium mm	Porosity %
36A	47	92.8
36B	90	92.1
36C	175	91.9

Time (h)	Suspended solids concentration (mg/L)				Head loss cm of water		
	Influent	Filtrate					
		36A	36B	36C	36A	36B	36C
0	17.4	0.05	-	-	0.6	1.9	2.6
3.0	28.5	13.4	9.0	8.0	0.7	2.1	2.9
6.0	31.4	14.7	16.0	9.5	0.8	2.4	3.4
8.25	29.5	15.7	10.5	9.5	1.0	2.6	3.7
22.5	26.6	13.8	11.4	8.6	2.6	4.5	6.4
24.0	27.5	13.8	11.4	9.0	2.8	5.0	7.1

(Cont'd)

TABLE A3.33 (Cont'd)

27.25	27.0	13.4	10.0	8.6	3.2	5.9	7.9
30.0	27.0	13.4	11.0	8.0	3.7	6.7	8.6
46.0	23.8	11.5	10.0	7.2	6.5	10.0	13.5
48.0	25.5	12.0	10.0	7.2	6.6	10.5	13.9
51.0	25.1	11.5	10.0	7.2	7.0	11.1	14.8
53.5	28.0	12.0	10.5	7.6	7.5	12.4	15.8
56.0	28.0	13.0	11.4	8.0	8.0	13.0	17.0
70.25	23.5	11.5	10.5	7.2	10.7	17.6	22.6
77.25	27.5	13.0	11.4	8.0	12.4	19.4	25.3
94.0	24.7	12.0	10.5	6.7	15.5	23.6	28.5
101.25	27.5	12.4	11.0	8.0	16.0	25.3	30.6
118.5	25.7	13.0	10.5	8.0	20.6	25.3	33.8
120.5	29.5	13.4	10.5	7.6	20.7	29.5	34.2
123.0	29.0	13.4	10.5	8.0	21.6	29.8	35.6
125.75	28.5	13.4	11.0	8.0	22.4	30.1	36.2

(Cont'd)

TABLE A3.33 (Cont'd)

128.0	28.5	13.4	11.0	8.0	22.9	30.5	36.6
142.0	25.7	13.8	11.0	8.6	26.1	31.8	39.8
144.5	27.0	13.0	10.0	7.6	26.4	32.5	40.2
147.0	28.0	13.4	11.0	8.6	27.3	33.0	39.6
149.5	28.5	13.4	10.5	8.0	27.8	33.5	41.0
166.25	28.0	13.4	10.0	7.6	31.3	35.7	42.0
168.5	28.5	13.5	10.0	7.5	32.1	36.7	43.2
172.5	28.0	13.8	10.5	8.0	33.2	37.3	43.9
175.0	28.0	14.8	11.4	9.0	34.2	38.0	44.0
190.25	26.5	13.4	10.0	9.0	36.4	41.1	75.6
192.5	29.0	13.8	10.0	8.0	36.7	41.5	45.8
195.0	29.0	13.4	10.5	8.0	37.3	41.8	45.8
197.0	29.7	14.4	10.5	8.6	37.4	42.3	45.8
214.75	25.7	12.5	9.0	7.2	40.0	45.1	48.2
216.75	30.0	13.4	9.0	7.6	40.4	45.2	48.7

(Cont'd)

TABLE A3.33 (Cont'd)

222.25	28.0	13.4	9.5	8.0	41.6	46.1	49.5
238.25	29.0	13.5	9.0	8.0	43.0	48.0	49.8
246.0	29.0	14.4	9.5	7.6	44.5	48.5	51.0
264.25	27.2	13.4	9.0	7.6	46.3	49.7	54.0

TABLE A3.34 Results of filter run 37

Rate of filtration = 0.75 m^3/m^2h

Average depth of filter media = 685 mm Porosity = 91.66%

Time of filtration (h)	Suspended solids concentration (mg/L)	
	Influent	Filtrate
0	28.0	-
6.0	31.4	4.8
22.5	26.6	4.8
27.25	27.0	5.0
30.0	27.0	5.0
46.0	23.8	4.8
48.0	25.5	4.8
51.0	25.1	4.8
53.5	28.0	5.3
70.25	23.5	4.5
77.25	27.5	4.2
94.0	24.7	4.0
101.25	27.5	4.0
118.5	25.7	3.0
123.0	29.0	2.5
142.0	25.7	4.0
149.5	28.5	3.5
168.5	28.5	3.5
190.25	26.5	3.0
195.0	29.0	3.0

TABLE A3.35 Results of thin layer filter runs 38A to 38C

Rate of filtration = 0.5 m^3/m^2h

Filter run	Depth of media	Porosity %
38A	50	93.1
38B	110	93.5
38C	205	93.0

Time (h)	Suspended solids concentration (mg/L)				Head loss cm of water		
	Influent	Filtrate					
		38A	38B	38C	38A	38B	38C
0					1.1	1.7	2.1
2.75	32.3	13.4	10.5	5.5	1.2	1.9	2.8
5.25	31.5	14.7	11.4	5.8	1.4	2.2	3.7
7.75	34.0	15.0	11.4	5.8	1.6	2.6	3.8
21.75	27.6	15.5	11.0	5.8	2.2	4.1	9.9
24.0	27.0	14.7	11.4	7.2	2.3	4.3	10.5

(Cont'd)

TABLE A3.35 (Cont'd)

26.75	26.0	14.7	11.4	7.2	2.3	4.6	10.4
29.75	27.6	14.7	11.4	7.6	2.4	4.3	9.9
46.0	25.7	13.8	11.0	6.2	3.2	6.3	13.7
48.0	27.6	14.7	11.0	6.7	3.2	6.5	14.2
50.0	26.0	13.5	10.0	5.8	3.4	6.8	14.8
53.25	27.6	13.8	10.5	5.8	3.5	6.9	15.5
56.0	28.0	14.4	10.5	5.8	3.7	7.2	16.3
70.0	25.7	13.0	9.5	5.4	4.2	8.3	18.4
77.25	27.0	13.0	9.5	5.4	4.6	9.1	19.6
94.0	25.0	13.0	8.8	5.5	5.2	10.2	21.0
118.0	26.0	13.4	9.5	4.9	5.9	11.3	23.4
120.25	28.5	13.8	11.0	5.8	5.7	11.5	23.8
122.75	27.6	13.4	10.5	5.8	6.1	11.9	24.5
125.25	27.0	13.4	10.5	5.8	6.1	11.9	24.5
128.0	28.0	13.8	10.0	5.4	6.2	11.7	24.8

(Cont'd)

TABLE A3.35 (Cont'd)

142.25	24.8	12.4	9.5	4.9	6.7	12.3	25.9
144.25	28.5	13.4	10.2	5.8	6.6	12.4	26.0
148.75	28.0	13.8	10.5	6.2	6.7	12.9	26.4
152.0	26.7	13.0	9.0	4.9	6.9	13.2	26.9
165.75	24.8	12.4	8.6	4.5	7.4	13.6	27.8
168.75	28.0	13.0	9.5	4.9	7.2	13.4	27.8
175.0	26.7	13.0	9.5	5.4	7.4	14.0	28.3
190.0	26.0	13.0	9.5	5.4	8.0	14.4	29.5
192.25	27.0	12.4	9.5	4.9	8.4	14.3	30.1
194.75	26.7	12.4	9.0	5.4	8.4	14.8	30.1
197.25	27.6	13.0	9.5	5.5	8.2	14.7	30.3
214.25	25.1	12.0	7.6	4.9	9.2	15.1	30.7
216.25	26.3	13.4	10.5	5.8	9.7	15.4	30.7
218.75	30.0	14.4	11.0	6.2	9.5	15.5	31.2
220.75	30.0	13.0	9.5	5.4	8.4	15.9	31.5

TABLE A3.36 Results of filter run 39

Rate of filtration = 0.5 m^3/m^2h

Average depth of medium = 685 mm Porosity = 91.96%

Time (h)	Suspended solids concentration (mg/L)	
	Influent	Filtrate
0	25.8	0.0
2.75	32.3	2.5
5.25	31.5	1.5
7.75	34.0	2.0
21.75	27.6	1.5
24.0	27.0	2.0
26.75	26.0	1.5
29.75	27.0	1.5
46.0	26.0	1.0
48.0	27.6	1.5
50.0	25.7	1.2
53.25	27.6	1.0
56.0	28.0	1.7
70.0	25.7	1.0
71.25	27.0	1.0
94.0	25.0	1.0
118.0	26.0	0.5
120.25	28.5	1.0
122.75	27.6	1.0
125.25	27.0	1.0
128.0	28.0	1.0

(Cont'd)

TABLE A3.36 (Cont'd)

142.25	24.8	0.5
144.25	28.5	1.0
148.75	28.0	1.5
152.0	26.7	1.5
165.75	24.8	1.0
168.75	28.0	0.5
175.0	26.7	0.9
190.0	26.0	1.0
192.25	27.0	1.0
194.75	26.7	0.5
197.25	27.6	1.0
214.25	25.1	0
216.25	26.3	1.0
218.75	30.0	1.5
220.75	30.0	1.0

APPENDIX 4

Results of semi-quantitative emission spectrographic analysis of rice hull ash

Element	Detection Limit	% w/w in Sample	
		Sample 1	Sample 2
Silver	0.0001	< 0.0001	< 0.0001
Aluminium	0.0002	0.05	0.05
Arsenic	0.1	< 0.01	< 0.01
Boron	0.0005	0.01	0.01
Barium	0.1	< 0.01	< 0.01
Baryllium	0.0002	< 0.001	< 0.001
Bismuth	0.001	< 0.001	< 0.001
Calcium	0.0001	2	2
Cadmium	0.01	< 0.01	< 0.01
Cobalt	0.002	< 0.01	< 0.01
Chromium	0.0003	< 0.01	< 0.01
Copper	0.0001	0.005	0.005
Iron	0.0005	0.05	0.05
Magnesium	0.0005	2	2
Molybdenum	0.0005	< 0.001	< 0.001
Manganese	0.0002	0.05	0.05
Sodium	0.02	< 0.02	< 0.02
Nickel	0.002	< 0.002	< 0.002
Phosphorus	0.2	1	1
Lead	0.001	< 0.001	< 0.001
Antimony	0.01	< 0.01	< 0.01
Silicon	0.001	Major	Major
Tin	0.002	< 0.002	< 0.002

(Cont'd)

(Cont'd)

Titanium	0.0003	< 0.003	< 0.003
Vanadium	0.0005	< 0.005	< 0.005
Zinc	0.05	< 0.05	< 0.05
Zirconium	0.01	< 0.01	< 0.01
Tungsten	0.05	< 0.05	< 0.01

APPENDIX 5

CALIBRATION CURVES

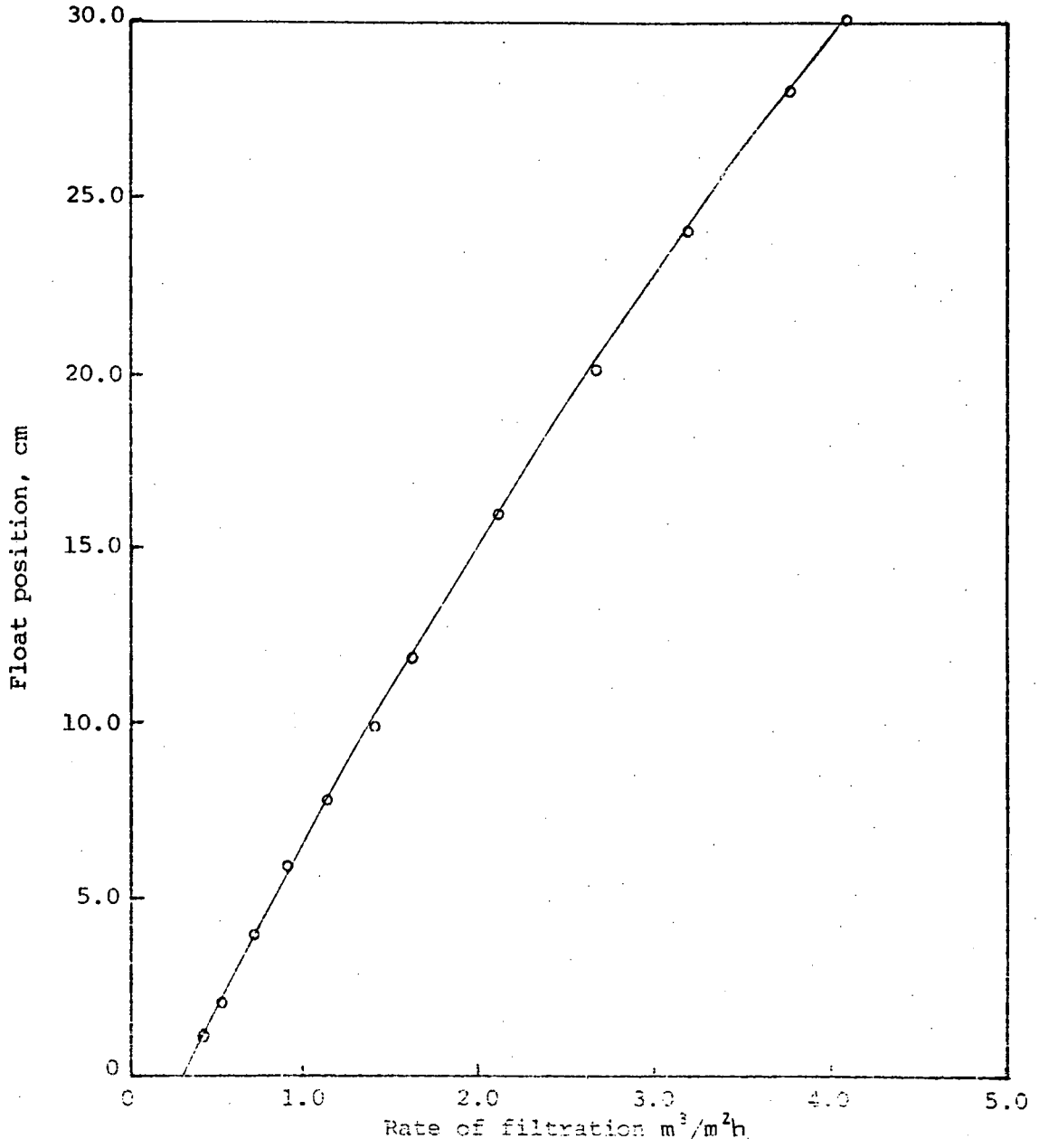


FIG. A5.1 Calibration curve for Rotameter (Metric 7 x G)

APPENDIX A5.2 Hilger Spekker Absorptiometer

The major components of the absorptiometer are photocells, two identical sample containers (quartz glass), lense systems, heat absorbing filters, iris diaphragm, cam shaped variable aperture diaphragm, 100 W projection lamp, spot galvanometer and a variable resistance. The lamp which is mounted in the central lamp house is operated from the electric mains supply. The photocell mounted on the right hand side of the lamp receives light that has been passed through a heat absorbing filter, iris diaphragm, lense system, and a colour filter. The photocell mounted on the left side receives light that has been passed through a variable aperture diaphragm, the sample of absorbing medium, lense system and a colour filter. The variable aperture diaphragm is fitted with a large calibrated drum and enables the light falling on the photocell on the left hand side of the lamp to be varied by known amounts. The drum calibration compares the optical density of the two samples. The photocells are connected in opposition across the spot galvanometer, so that when the photoelectric currents given by the cells are equal, the galvanometer records a zero deflection. The following method was adopted to compare the optical density of two samples.

(1) The sample having a higher optical density was placed in position within the beam and the variable aperture diaphragm was opened to its full extent (i.e., zero drum reading). Light received by the two photocells was balanced, using the iris diaphragm with reference to the spot galvanometer.

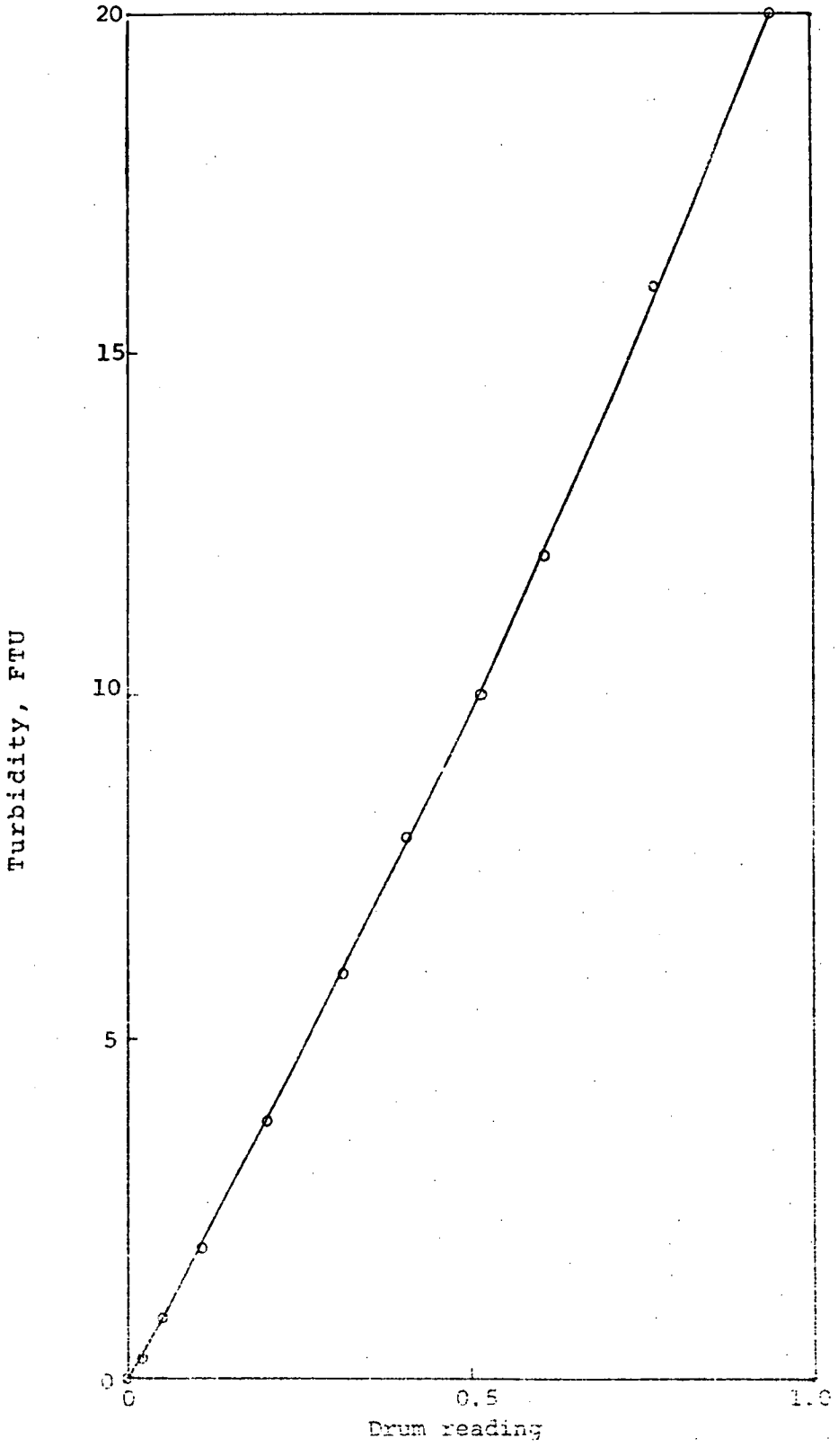


FIG. A5.2 Calibration curve for Absorptiometer

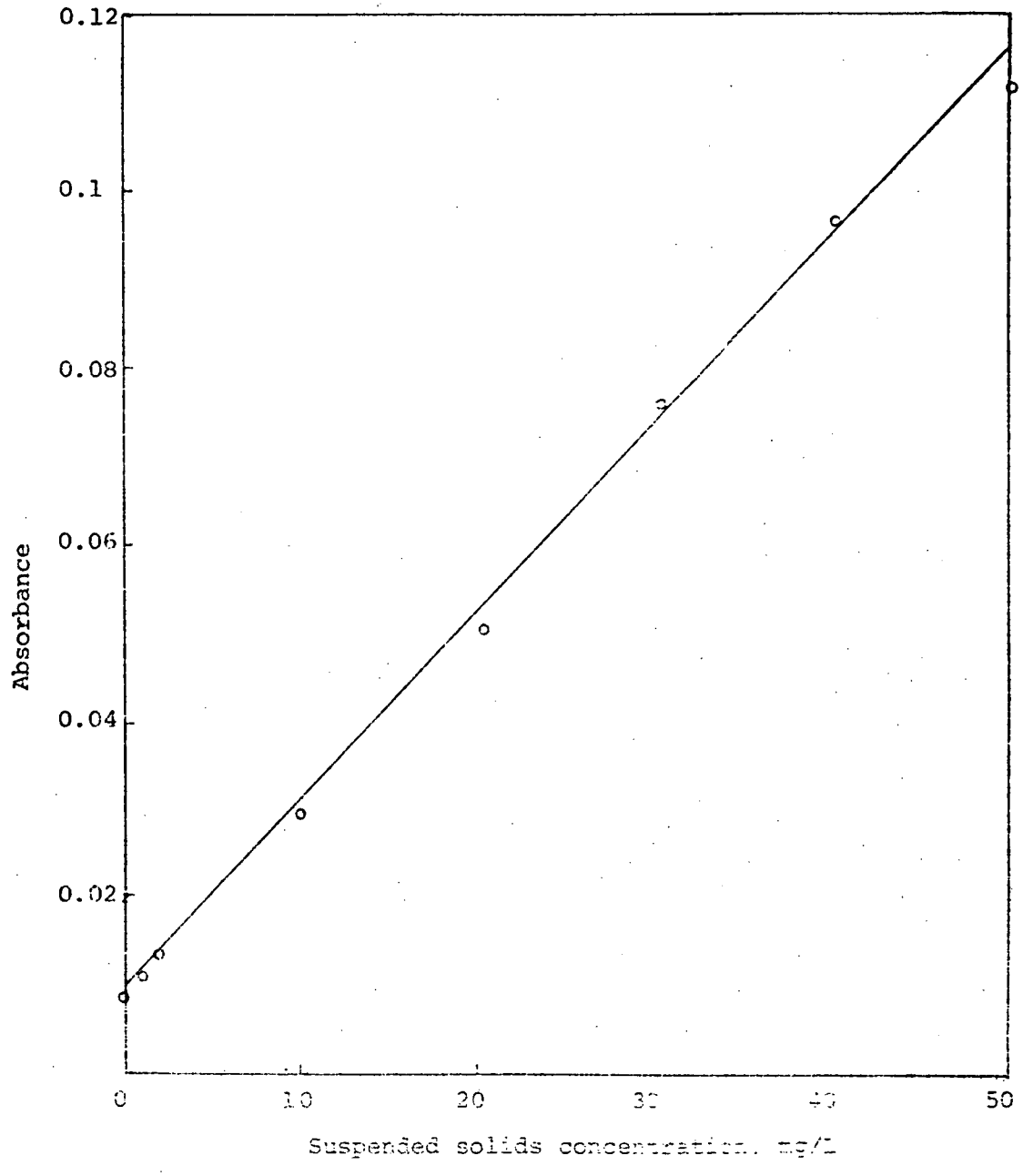
(2) The sample having the lower optical density (comparison liquid - usually distilled water) was now placed in position within the beam. The spot galvanometer showed a deflection due to the difference in optical densities of the two samples.

(3) The calibrated variable aperture diaphragm was adjusted (using the drum) until the galvanometer returned to zero and the reading on the drum was recorded.

Preparation of the Calibration Curve

As the turbidity of a suspension is related to its optical density, the above method was used for the measurement of the turbidity. The instrument was calibrated according to the method given above using standard formazin suspensions and distilled water (as the comparison liquid). The calibration curve is shown in Figure A5.2.

FIG. A5.3 Calibration curve for Spectrophotometer



APPENDIX 6

PREPARATION OF CULTURE MEDIA FOR BACTERIOLOGICAL STUDIES

(a) Peptone - Water Medium

10 g of neutralized bacteriological peptone (Oxiod L_{34}) and 5 g of sodium chloride was added to 1 L of distilled water and the medium was allowed to soak for 15 min. Selected volumes of this medium were sterilized by autoclaving for 15 min at 121°C.

(b) Nutrient Agar Medium

15 g of Agar No. 3 (Oxoid L_{13}) and 10 g of Nutrient Broth No. 2 (Oxoid CM_{67}) were added to 1 L of distilled water. The medium was allowed to soak for 15 min, before being distributed in batches of 200 mL or 400 mL. The medium was sterilized by autoclaving for 15 min at 121°C. Approximately 20 mL portions of cooled sterilized medium were poured into petri dishes and the dishes allowed to cool in a sterilized atmosphere before being stored at 4°C.

(c) MacConkey Agar Medium

51.5 g of MacConkey Agar No. 3 (Oxoid CM_{115}) was added to 1 L of distilled water and the medium allowed to soak for 15 min. 200 mL or 400 mL portions of this medium were sterilized by autoclaving for 15 min at 121°C. The plates were prepared as described in Section (b).

APPENDIX 7

RESULTS OF JAR TESTS

TABLE A7.1 Determination of optimum alum dose

Initial turbidity = 37 FTU (40 mg/L kaolin clay in tap water)

pH = 7.0

Alum dose mg/L		10	20	30	40	50	60
Time for floc to app. mins	>	20	6.5	4.5	3.75	4.25	4.75
Residual turbidity FTU		-	9.3	4.7	3.6	3.4	4.0

Time of rapid mix = 30 s (at 100 r.p.m.)

Time of slow mix = 20 mins (at 30 r.p.m.)

Time of settling = 20 mins

TABLE A7.2 Effect of adding rice hull ash activated silica on the residual turbidity

Initial turbidity = 38 FTU

pH = 7.0

Alum dose mg/L	50	50	50	50	45	45	45
App. silica dose mg/L	0	5	10	15	0	5	10
Time for floc to app. mins	-	< 1	< 1	-	-	2.5	2.25
Residual turbidity FTU	4.2	2.3	2.4	1.9	5.0	3.0	2.7

Time of rapid mix = 30 s (at 100 r.p.m.)

Time of slow mix = 20 mins (at 30 r.p.m.)

Time of settling = 20 mins

TABLE A7.3 Effect of adding activated silica on settling rate of floc

Initial turbidity = 26 FTU

pH = 7.0

Optimum coagulant dose = 30 mg/L

Sample No.	1	2	3	4	5	6	7
Coagulant dose mg/L	30	30	30	30	30	30	30
Silica dose mg/L	0	7.5	0	7.5	0	7.5	7.5
Time for floc to appear mins	5.50	4.20	5.50	4.20	5.50	4.20	4.20
Time of settling mins	15	15	20	20	25	25	10
Residual turbidity FTU	6.1	4.2	5.9	4.2	5.6	4.2	4.2

Time of rapid mix = 40 s (at 100 r.p.m.)

Slow mix at 30 r.p.m.

TABLE A7.4 Coagulation with aluminium sulphate and activated silica at pH = 6.0

Optimum alum dose = 50 mg/L

Turbidity of water sample = 40 mg/L

Alum mg/L	50	50	50	50	50	50
Silica mg/L	0	3.5	7.0	10.5	14	21
Residual turbidity FTU	2.4	1.2	1.1	0.65	0.8	0.5

Time of rapid mix = 60 s (at 100 r.p.m.)

Time of slow mix = 20 mins (at 30 r.p.m.)

Time of settling = 25 mins

TABLE A7.5 Coagulation with aluminium sulphate and activated silica at pH = 6.5

Alum dose = 50 mg/L

Turbidity water sample = 40 mg/L

Alum mg/L	50	50	50	50	50	50
Silica mg/L	0	3.5	7	10.5	14	21.0
Turbidity FTU	2.4	1.6	1.7	1.6	1.6	2.6

Time of rapid mix = 60 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Time of settling = 25 min

TABLE A7.6 Coagulation with aluminium sulphate and activated silica at pH = 7.0

Turbidity of water sample = 40 mg/L

Alum mg/L	50	50	50	50	50	50
Silica mg/L	0	3.5	7.0	10.5	14.0	21.0
Turbidity FTU	2.5	1.6	1.8	1.6	1.9	3.4

Time of rapid mix = 60 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Time of settling = 25 min

TABLE A7.7 Coagulation with aluminium sulphate and activated silica at pH = 8.0

Turbidity of water sample = 40 mg/L

Alum mg/L	50	50	50	50	50	50
Silica mg/L	0	3.5	7.0	10.5	14	21
Turbidity FTU	3.4	2.3	3.1	3.1	3.5	4.9

Time of rapid mix = 60 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Time of settling = 25 min

TABLE A7.8 Coagulation using aluminium sulphate and an anionic polyelectrolyte Magna floc 156

Turbidity of water sample = 34 FTU

pH of water sample = 7.0

Alum mg/L	50	50	50	50	50	50
Magna floc 156 mg/L	0	0.1	0.2	0.3	0.4	0.6
Residual turbidity FTU	1.65	1.4	1.8	1.75	1.45	1.45

Time of rapid mix = 90 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Settling time = 25 min

TABLE A7.9 Coagulation using aluminium sulphate and cationic polyelectrolyte Magna floc 140

Turbidity of water sample = 34 FTU

pH of water sample = 7.0

Alum mg/L	50	50	50	50	50	50
Magna floc 140 mg/L	0	0.2	0.4	0.6	0.8	1.0
Residual turbidity FTU	1.6	2.1	2.2	2.4	2.6	2.2

Time of rapid mix = 90 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Settling time = 25 min

TABLE A7.10 Coagulation with aluminium sulphate and nonionic polyelectrolyte Magna floc 351

Alum mg/L	50	50	50	50	50	50
Magna floc 351 mg/L	0	0.2	0.4	0.6	0.8	1.0
Residual turbidity FTU	2.1	2.1	3.0	2.6	2.6	2.7

pH of water sample = 7.0

Turbidity of water sample = 34 FTU

Time of rapid mix = 90 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Settling time = 25 min

TABLE A7.11 Coagulation with rice hull ash activated silica and aluminium sulphate

Turbidity of water sample = 34 FTU

pH of water sample = 7.0

Alum mg/L	50	50	50	50	50	50
Activated silica mg/L	0	3.5	7.0	10.5	14	21
Residual turbidity FTU	2.4	1.2	1.1	0.65	0.8	0.5

Time of rapid mix = 90 s (at 100 r.p.m.)

Time of slow mix = 20 min (at 30 r.p.m.)

Settling time = 25 min

APPENDIX 8

SCANNING ELECTRON MICROSCOPIC STUDIES

The electron micrographs of rice hull ash, diatomaceous earth and sand particles shown in Chapter 3 were obtained, using scanning electron microscope available in the School of Textile Technology. The operation of the microscope and the preparation of samples are described below.

(a) Principles of Operation

The major components of scanning electron microscopes are an electron optics column containing two or more magnetic lenses, an electronic gun which can be powered by voltages between 2 - 50 kV, stigmator coils, specimen chamber, scanning coils, power supplies, electron detectors, an amplification system and cathode ray tubes.

The high voltage for powering the electron gun is selected according to the type of specimen to be examined. Once the specimen is placed in the chamber, the electron beam is directed and focussed on to it. The purpose of magnetic lenses is to condense the beam to a small size, selected to be between 100 Å - 1 μm depending upon the characteristics of the specimen and the resolution desired. The stigmator coils correct the noncircularity of the final spot. The electron beam is scanned over the specimen surface in a television type raster. The electron beam when reaching the specimen surface interacts with it, producing four different types of signals that may be

detected and amplified by the appropriate detection and amplification system. These are:-

1. back-scattered electrons - possess high energy
2. secondary electrons - possess low energy
3. photons
4. the electrons which are absorbed on to the specimen and can be detected as a current out of the specimen.

The conventional scanning electron microscope uses either back-scattered or secondary electrons to form the image of the specimen. As the back-scattered electrons have high energy, they are detected by a wide angle detector, without further acceleration, whereas the secondary electrons are accelerated to a high voltage and are detected.

(b) Preparation and Examination of Specimens

The samples of rice hull ash, sand and diatomaceous earth were examined under a scanning electron microscope. The samples were mounted on stubs and held by double-sided adhesive tape. A J.S.M. 2 (Jeol Ltd., Japan) scanning electron microscope in the School of Textile Technology was used. This model had been fitted with a wide angle back-scattered electron detector and had been modified to enable insulating specimens to be examined without the distortion that may occur if a charge accumulates on the specimen (Robinson, 1975). The samples were photographed with a 50 sec exposure on 35 mm film.

The results of the microscopic examination are given in Chapter 3.

APPENDIX 9

ANALYSIS OF RESULTS USING CHI-SQUARE DISTRIBUTION ANALOGY

Figure 9.1a Variate U and time curves for filter runs 35A to 35C

Figure 9.1b Equi U plots of depth L and time for filter runs 35A to 35C

Figure 9.2a Variate U and time curves for filter runs 36A to 36C

Figure 9.2b Equi U plots of depth L and time for filter runs 36A to 36C

Figure 9.3a Variate U and head loss (H_T-H_O) curves for filter runs 36A to 36C

Figure 9.3b Equi U plots of depth L and head loss (H_T-H_O) curves for filter runs 36A to 36C

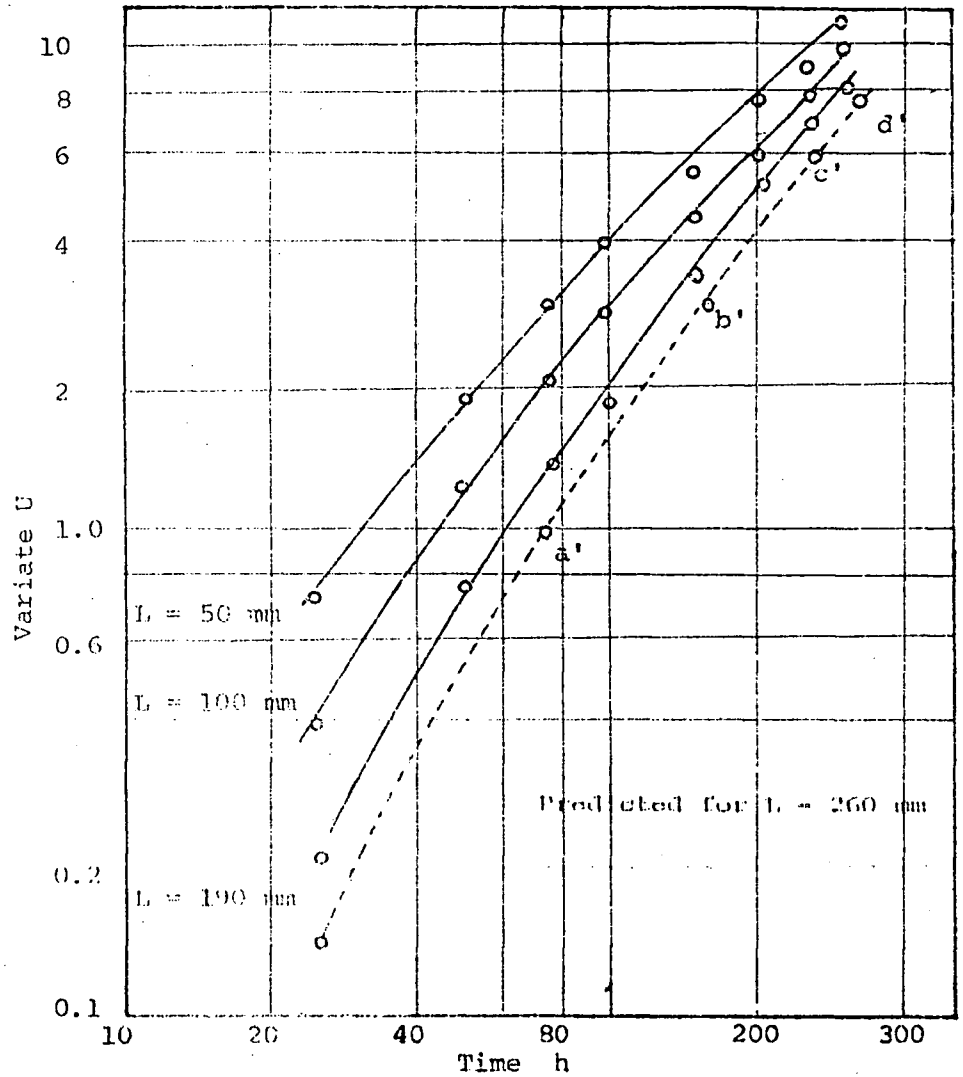


FIG. A9.1a Variate U and time curves for filter runs 35A to 35C

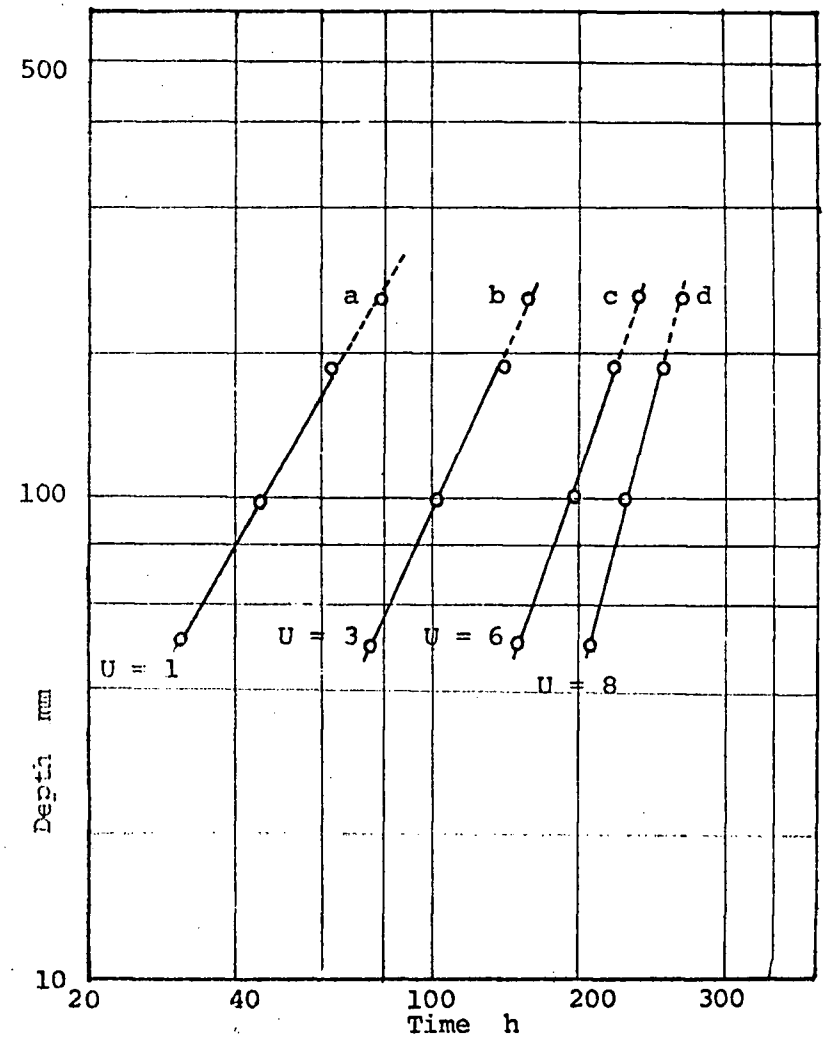


FIG. A9.1b Equi U plots of depth L and time for filter runs 35A to 35C

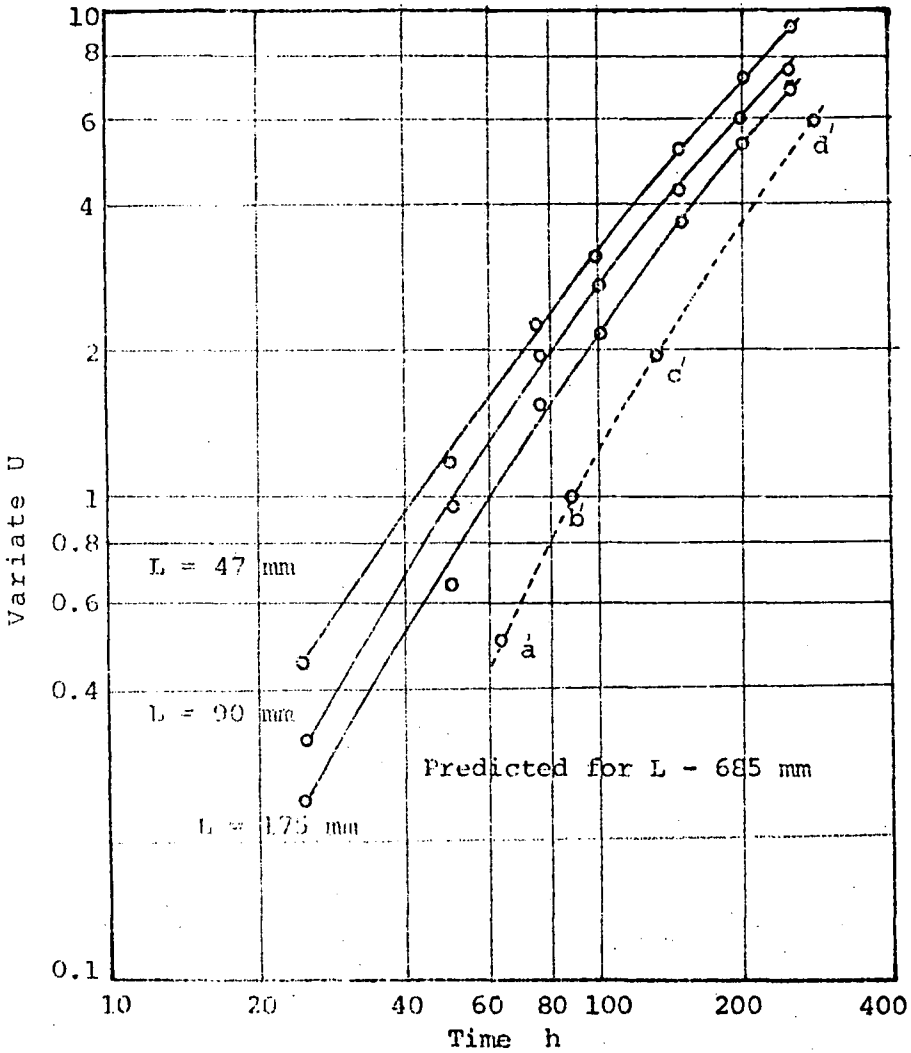


FIG. A9.2a Variate U and time curves for filter runs 36A to 36C

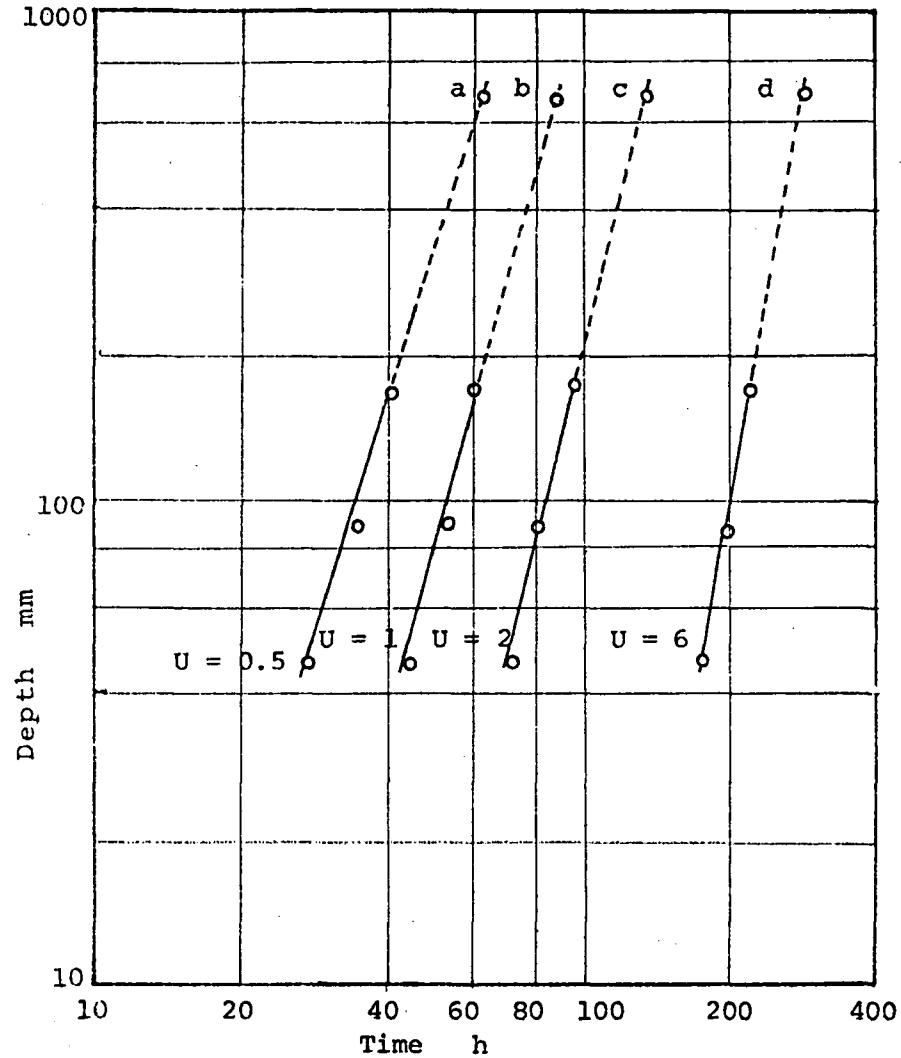


FIG. A9.2b Equi U plots of depth L and time for filter runs 36A to 36C

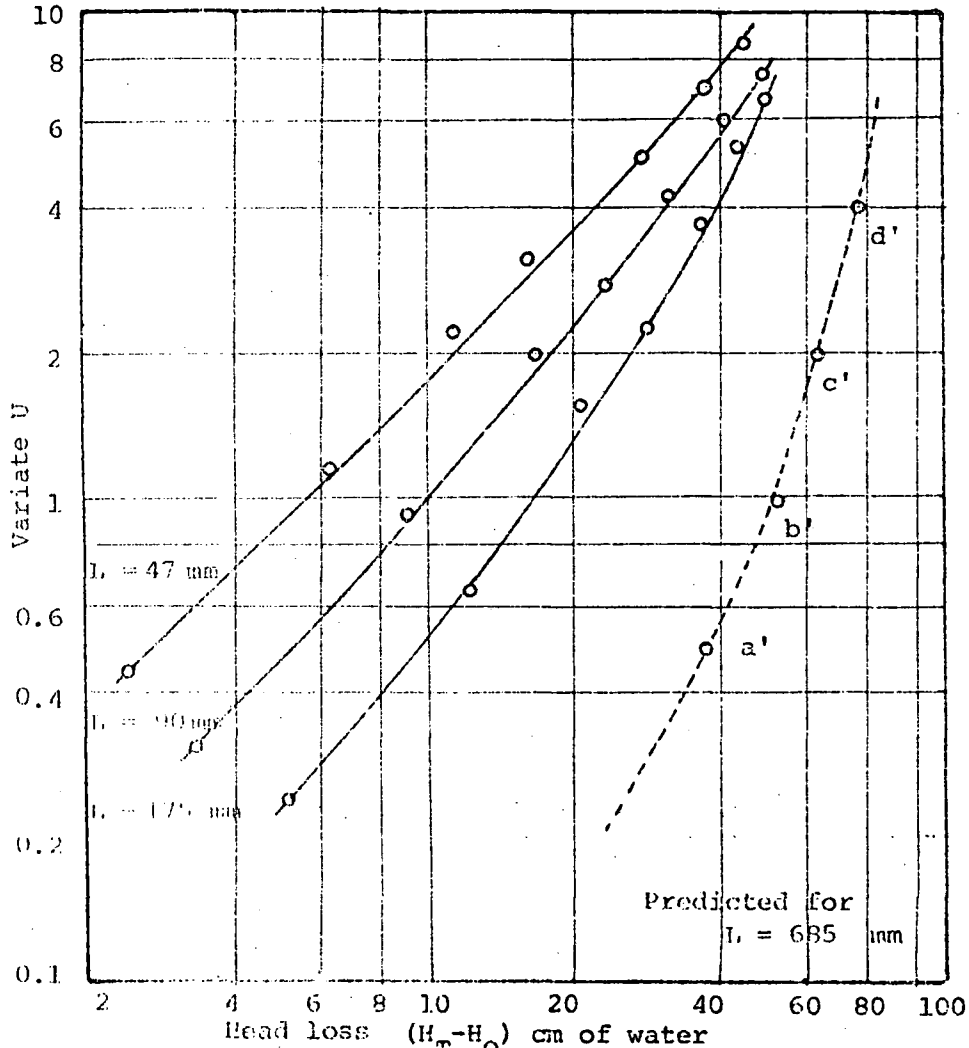


FIG. A9.3a Variate U and head loss (H_T-H_O) curves for filter runs 36A to 36C

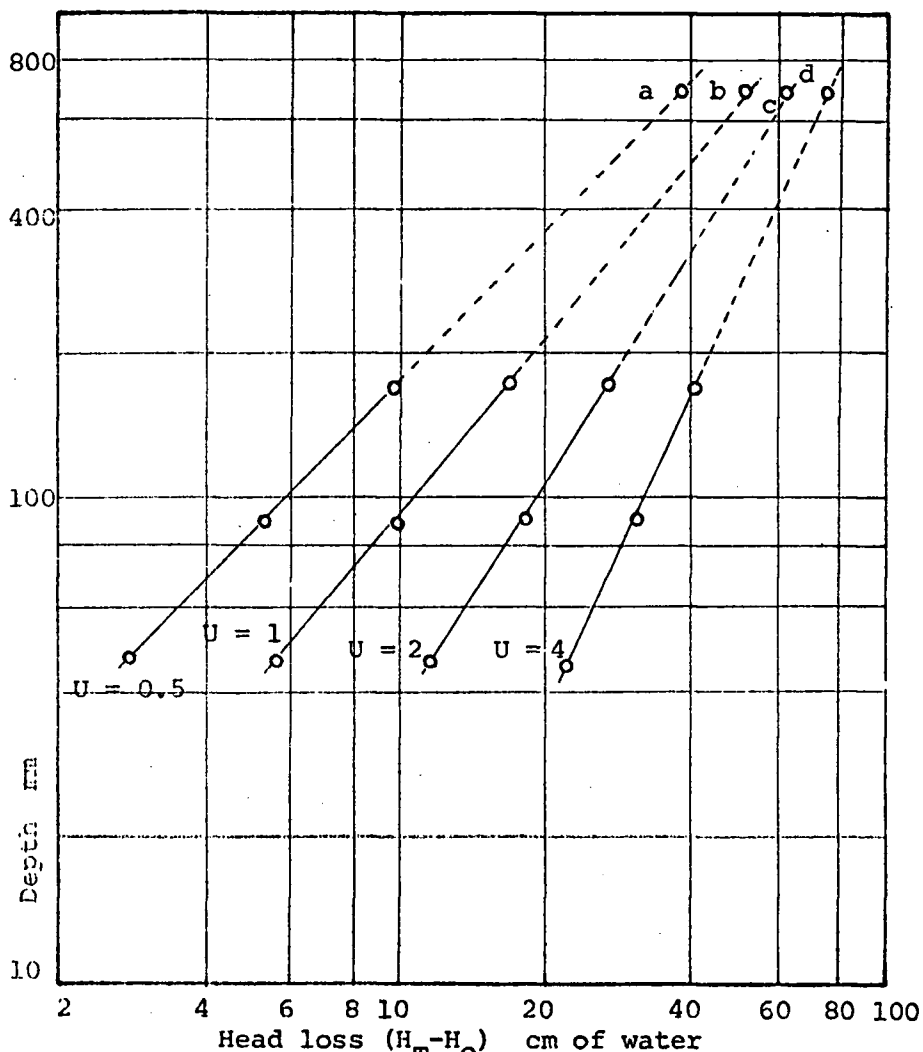


FIG. A9.3b Equi U plots of depth L and head loss (H_T-H_O) curves for filter runs 36A to 36C

APPENDIX 10

COMPUTER PROGRAM

The following symbols were used in the computer program.

A	filter constant	mm^{-1}
B	filter constant	mm^{-1}
CO	inlet suspended solids concentration	mg/L
C(N)	concentration in the Nth layer	mg/L
DL	depth increment	mm
DT	time increment	h
F	initial porosity	
LMAX	total depth of filter medium	mm
R	density of deposited particles (bulk density)	mg/L
S(N)	specific deposit in the Nth layer	vol/vol
T	time	h
TMAX	length of filter run	h
V	rate of filtration	$mm^3/(mm)^2h$
XO	initial filter coefficient	mm^{-1}
X(N)	filter coefficient in the Nth layer	mm^{-1}
Y(N)	depth of the Nth layer from the surface of the medium	

```
      PROGRAM CONC(INPUT,OUTPUT,TAPE1=INPUT,TAPE3=OUTPUT)
      DIMENSION C(400),S(400),X(400),Y(400)
   11 FORMAT(1H1,T20,'N',I25,'Y(N)',T30,'C(N)')
    7 FORMAT(1H0,T20,I3,T25,F6.2,T40,F6.2)
    8 FORMAT(T20,'T',T30,'Y(N)',T40,'C(N)')
    9 FORMAT(T20,F6.2,T30,F5.2,T40,F5.2,T40,F8.4,T70,F5.3)
      READ*,XO,SO,A,B,TMAX,TINT
      READ*,LMAX,DL,DT,V,CO,F,R
      M = LMAX/DL
      M=M+I
      TLAST = 0.0
C     CALCULATION OF THE INITIAL CONCENTRATIONS
      T = 0.0
      DO 10 N=1,M
      Y(N)=0.0
      S(N) = SO
      X(N) = XO
   10 CONTINUE
      DO 50 N=1,M
      Y(N)=(N-1)*DL
      C(N)=CO*(EXP(-XO*Y(N)))
   50 CONTINUE
      WRITE (3,11)
      DO 60 N=1,M,5
      WRITE(3,7)N,Y(N),C(N)
   60 CONTINUE
   70 DO 100 N=1,M
      S(N) = S(N) +V*X(N)*C(N)*DT/R
      X(N) =XO +A*S(N)- (B*S(N)**2)/(F-S(N))
  100 CONTINUE
      T = T+DT
      C(1) =CO
      DO 200 N=2,M
      C(N) = C(N-1)-X(N-1)*C(N-1)*DL
  200 CONTINUE
C     NOW TEST FOR THE TIME INVERVAL TO PRINT THE RESULTS
      IF ((T-TLAST).GE.TINT) GO TO 300
```

```
      IF (T.GE.TMAX) GO TO 400
      GO TO 70
  300 WRITE (3,8)
      DO 350 N=1,M,5
      WRITE(3,9)T,Y(N),C(N),S(N),X(N)
  350 CONTINUE
      TLAST =TLAST + TINT
      GO TO 70
  400 STOP
      END
```

REFERENCES

A.O.A.C. (1965) Official Methods of Analysis, Assen Agr. Chemi 10th Edition, Washington D.C., p 95.

A.S.T.M. (1977) American Society for Testing and Materials Part 19 D854.

A.W.W.A. (1973) Water quality and treatment, Amer. Wat. Wks Assen, 3rd Edition Ch. 3 and 7.

A.W.W.A. (1975) Standard Methods for the Examination of Water and Wastewater, 14th Edition, Amer. Pub. Hea. Assen, Inc, New York.

ADIN, A., BAUMANN, E.R. and CLEASBY, J.L. (1979) The application of filtration theory to pilot plant design, Jour. Amer. Wat. Wks Assen, Vol. 71, 1, pp 17-27.

ADIN, A. and REBHUN, M. (1977) A model to predict concentration and head loss profiles in filtration, Jour. Amer. Wat. Wks Assen, Vol 69, 8, pp 444-453.

ANON. (?) Manual of instructions for water treatment plant operators, New York State Department of Health, pp 127-151.

ANON. (undated) Use of coagulant-flocculant aids, Unit processes - water plant operation, Training course manual, Environmental Protection Agency.

ANON. (1965) Filter aid filtration, Johns-Manivelle celite filter aids, FA.84A-RWC2-75 Filtration and Minerals Division, U.S.A.

ARMBRUST, H.N. (1965) Diatomaceous earth filtration Jour. New England Wat. Wks Assen, Vol. 69, 9, pp 287-300.

BAILY, A.C. (1937) Anthrafilit in a slow sand filter Jour. Amer. Wat. Wks Asscn, Vol. 29, 12, pp 1900-1915.

BAYLIS, J.R. (1937) Experiences in filtration Jour. Amer. Wat. Wks Asscn, Vol. 29, 7, pp 1010-1048.

BAYLIS, J.R. (1937a) Silicates as aids to coagulation, Jour. Amer. Wat. Wks Asscn, Vol. 29, 9, pp 1355-1396.

BEAGLE, E.C. (1978) Rice husk conversion to energy, F.A.O. Agricultural Services bulletin 31, Food and Agriculture Organization, Rome.

BIRKNER, F.B. and MORGEN, J.J. (1968) Polymer flocculation kinetics of dilute colloidal suspensions, Jour. Amer. Wat. Wks Asscn, Vol. 60, 2, pp 175-191.

BLACK, A.P., BIRKNER, F.B. and MORGEN, J.J. (1965) Destabilization of dilute clay suspensions with labeled polymers. Jour. Amer. Wat. Wks Asscn, Vol. 57, 12, pp 1547-1560.

BOLTO, B.A., CROSS, K.W.V., ELDRIDGE, R.J., SWINTON, E.A. and WEISS, D.E. (1975) Magnetic filter aids Chem. Eng. Progress, Vol. 71, 12, pp 47-50.

BOYD, R.H. and GHOSH, M.M. (1974) An investigation of the influences of some physicochemical variables on porous media filtration, Jour. Amer. Wat. Wks Asscn, Vol. 66, 2, pp 94-98.

BRADLEY, D.J. (1974) Water supplies: the consequences of change in human rights in health, Ciba foundation symposium 23 (new series), Amsterdam, The Netherlands, pp 81-98.

BROMOFEILD, S.M. (1959) The effect of the siliceous component of decomposing rice hulls on the solubility of phosphate Aust. Jour. Agr. Sc., Vol. 10, pp 353.

BROWN, J.C. and OKUN, D.A. (1965) European practice in water filtration, Proceedings of the conference on water filtration. April, Rolla, Missouri, pp 55-78.

CAMP, T.R. (1964) Theory of water filtration, Jour. San. Eng. Div. (Proc. Amer. Soc. Civil Engrs) Vol 90, SA4, paper 3990, pp 1-29.

CLARK, J.W., VIESSMAN, W. and HAMMER, M.J. (1971) Water supply and pollution control, 2nd Edition, International text book company, Intent educational publishers, New York.

CLARKE, J.I. (1971) Population geography in developing countries, Oxford Pergamon Press.

CLEASBY, J.L. and BAUMANN, E.R. (1962) Selection of sand filtration rates, Jour. Amer. Wat. Wks Assen, Vol. 54, 5, pp 579.

CRAFF, T.F. (1966) Review of rapid sand filtration theory, Jour. Amer. Wat. Wks Assen, Vol. 58, 5, pp 428-439.

CULP, G.L. and CULP, R.L. (1974) New concepts in water purification, Van Nostrand Reinhold Company, New York.

CULP, R.L. (1977) Direct filtration Jour Amer. Wat. Wks Assen, Vol. 69, 7, pp 375-378.

DEB, A.K. (1969) Theory of sand filtration Jour. Sanit. Eng. Div. (Proc. Amer. Soc. Civil Engrs) Vol. 95, A4, paper 3990, pp 1-29.

DIETERICH, B.H. and HENDERSON, J.M. (1963), Urban water supply conditions and needs in seventy five developing countries, Monograph series No. 23, World Health Organization, Geneva. Chapters 1 and 2.

F.A.O. (1979) Agricultural residues quantitative survey, F.A.O. Agricultural Services bulletin Prov. Food and Agriculture Organization of the United Nations, Rome.

FAIR, G.M. (1951) The hydraulics of rapid sand filters Jour. Inst. Wat. Eng., Vol. 5, 2, pp 171-213.

FAIR, G.M., GEYER, J.C. and OKUN, D.A. (1968) Water and Wastewater Engineering, Vol. 2, John Wiley and Sons Inc, New York. Ch. 27 and 30.

FRANKEL, R.J. and SEVILLA, A.S. (1972) An Asian technological approach to water reuse: series filtration using local filter media, Advances in water pollution research, 6th Conference, Jerusalem, pp 723-731.

FREIVALOS, J. (1975) Finding the best use for rice by-products, Rice Jour., Vol. 78, part 7, pp 19-20, 22-23.

GADIEL, P.A. (1979) A review of polyelectrolyte use in water treatment in Australia, Jour. Aust. Wat. Wastewat. Asscn, Vol. 6, pp 10-12.

GRANTHAM, G.R. and WATERHOUSE, K.A. (1976) The direct filtration process and its application to Sydney's water supply, Jour. Wat. Wastewat. Assoc, Vol. 3, 2, pp 13-17.

GREGORY, J. (1978) Effects of polymers on colloid stability

Scientific basis of flocculation, Ed. K.J. Ives, Sijthoff and Noordhoff, Alphen a/d Rijn.

GRIFFIN, A.E. (1954) Preparation and use of activated silic Jour. Amer. Wat. Wks Asscn, Vol. 46, 6, pp 571-574.

HAAN, C.T. (1977) Statistical Methods in Hydrology Iowa State University Press.

HARRIS, H.S., KAUFMAN, W.J. and KRONE, R.B. (1966) Ortho-kinetic flocculation in water purification Jour. San. Eng. Div. (Proc. Amer. Soc. Civil Engrs), Vol. 92, n12, SA6, pp 95-111.

HAXO, H.E. and MEHTA, P.K. (1975) Ground rice hull ash as a filler for rubber, Rubber Chem. Tech. Vol. 48, 2, pp 271-288.

HAZEN, A. (1904) On Sedimentation Tran. Amer. Soc. Civ. Engrs., Vol. 53, pp 45-48.

HEERTJES, P.M. and LERK, C.F. (1967) The functioning of deep bed filters Trans. Amer. Inst. Chem. Engrs, Vol. 45, pp 129-145.

HEIPLE, L.R. (1959) Effectiveness of coarse grained media for filtration Jour. Amer. Wat. Wks Asscn, Vol. 51, 6, pp 749-760.

HENRY, R.C. (1949) Characteristics of activated silica solutions, Jour. Amer. Wat. Wks Assen, Vol. 41, 6, pp 551-558.

HERZIG, J.P., LECLERC, D.M. and GOFF, P. Le (1970) Flow of suspensions through porous media - Application to direct filtration Ind. Eng. Chem., Vol. 62, 5, pp 8-35.

HOLDEN, W.S. (1970) Water treatment and examination, London Churchill, Ch. 31.

HOUSTEN, D.F. (1967) Utilization of rice husks, Agricultural Engineering Services Bulletin, No. 30. Food and Agriculture Organization, Rome, pp 7-12.

HOUSTEN, D.F. (1972) Rice Chemistry and Technology, Amer. Asscn Cereal Chem., Monograph Series V-4, pp 301-352.

HSUING, K. and CLEASBY, J.L. (1968) Prediction of filter performances Jour. San. Eng. Div. (Proc. Amer. Soc. Civ. Engrs), Vol. 94, SA6, pp 1043-1067.

HUDSON, H.E. Jr. (1963) Functional design of rapid sand filters. Jour. San. Eng. Div. (Proc. Amer. Soc. Civ. Engrs), Vol. SA1, pp 17-28.

HUISMANN, L. and Wood, W.E. (1974) Slow sand filtration, World Health Organization, Geneva. Ch. 2 and 3.

HUNTER, J.V., BELL, G.R. and HENDERSON, C.N. (1966) Coliform Organism Removal by Diatomite Filtration, Jour. Amer. Wat. Wks Assen., Vol. 58, 9, pp 1160-1169.

ISON, C.R. and IVES, K.J. (1969) Removal mechanism in deep bed filtration, Chem. Eng. Sc., Vol. 24, pp 717-729.

IVES, K.J. (1960) Rational design of filters, Jour. Inst. Civ. Engrs, Vol. 16, n6, pap. No. 6414, pp 189-193.

IVES, K.J. (1961) New concepts in filtration, Parts I and II, Wat. Wat. Eng., Vol. 63, n7, 9, pp 307-309, 385-388.

IVES, K.J. (1961a) Filtration using radioactive algae, Jour. San. Eng. Div. (Proc. Amer. Soc. Civ. Engrs), Vol. 87, SA3, pp 23-37.

IVES, K.J. (1963) Simplified rational analysis of filter behaviour. Proc. Inst. Civ. Engrs, Vol. 25, n5, pp 345-362.

IVES, K.J. (1969) Theory of filtration special subject , n7, International Water Supply Congress, International Water Supply Association, London.

IVES, K.J. (1970) Review Paper Rapid filtration, Water Res. Vol. 4, pp 201-223.

IVES, K.J. (1975) The scientific basis of filtration, Noordhoff International, Leyden.

IVES, K.J. (1978) The scientific basis of flocculation Sijthoff and Noordhoff, Alphen a/d Rijn.

IVES, K.J., ATKIN, J.R. and THOMPSON, R.P. (1968) Measurement of turbidity Part I and II, Eff. Wat. Treat. Journ, Vol. 8, n8, pp 406-409.

IVES, K.J. and GREGORY, J. (1967) Basic concepts of filtration, Soc. Wat. Treat. Exam., Vol. 16, Part 3, pp 147-160.

IWASAKI, T. (1937) Some notes on sand filtration, Jour. Amer. Wat. Wks Assocn, Vol. 29, n10, pp 1591-1602.

JAKSIRINONT, N. (1972) Development of a series filtration water treatment method for small communities of Asia, MS thesis, Asian Institute of Technology, Bangkok.

JORDAN, T.A., GHOSH, M.M. and BOYD, R.H. (1974) Physico chemical aspects of deep filtration, Jour. Wat. Pol. Con. Fed., Vol. 46, n12, pp 2745-2754.

KARDILE, J.N. (1972) Crushed coconut shell as a new filter media for dual and multilayer filters, Indian Wat. Wks Asscn, Vol. iv, n 1.

KENT, N.L. (1975) Technology of cereals, 2nd Edition, Oxford Pergamon Press.

LaMER, V.K. and HEALY, T.W. (1963) Adsorption flocculation reactions of macromolecules at the solid liquid interface, Rev. Pure Appl. Chem., Vol. 13, pp 112-132.

LANGE, K.R. and SPENCER, R.W. (1968) On the mechanism of activated silica solution formation, Env. Sc. Tech., Vol. 2, n 3, pp 212-216.

LANNING, F.C. (1963) Silicon in rice, Jour. Agr. Fd. Chem. Vol. 11, n 5, pp 435-437.

LATHROP, E.C. (1952) Industrial utilization of rice hulls, Rice Jour., Annual Issue, pp 13.

LETTERMAN, R.D., SAMA, R.R. and DiDOMENICA, E.J. (1979), Direct filtration using polyelectrolyte coagulant, Jour. Amer. Wat. Wks Asscn, Vol. 71, n 6, pp 332-337.

LING, J.T. (1955) A study of filtration through uniform sand filters, Proc. Amer. Soc. Civ. Engrs, Vol. 81, n 7, paper 751, pp 1-35.

LOGEN, J. (1960) The international municipal water supply system, Amer. Jour. Trop. Med. Hyg., Vol. 9, pp 469.

MACKRLE, V., DRACKA, O., SVEC, J. (1965) Hydrodynamics of the disposal of low level liquid radioactive wastes in soil, Inst. At. Energy Ag., contract rep. 93, Reported by Herzig et al. (1970).

MACKRLE, V. and MACKRLE, S. (1961) Adhesian in filters, Jour. San. Eng. Div. (Proc. Amer. Soc. Civ. Engrs.) Vol. 87, SA5, pp 17-32.

MAMPITIYARACHCHI, T.R. (1977) Suitability of rice hull ash as a medium for slow filters M.Eng.Sc. Project report University N.S.W. Australia.

MAROUDAS, A. and EISENKLAM, P. (1965) Clarification of suspensions; a study of particles deposition in granular media, Chem. Eng. Sc., Vol. 20, pp 867-888.

McCLUNEY, W.R. (1975) Radiometry of water turbidity measurements, Jour. Wat. Pol. Con. Fed., Vol. 57, n2, pp 252-265.

MCGARRY, M.G., NG KIS, LEUNG, N.H. and LEE, T.L. (1974) Waste water reclamation under tropical conditions, Jour. Process Biochem., Vol. 9, n9, pp 14-24.

MCMANUS, W.R. and CHOUNG, C.C. (1976) Studies of forage cell walls: conditions for alkali treatment of rice straw and rice hulls, Jour. Agr. Sci., Camb., Vol. 86, pp 453-470.

MCMANUS, W.R., ROBINSON, V.N.E. and GROUT, L.L. (1977) The physical distribution of mineral material on forage cell walls, Aust. Jour. Agr. Res., Vol. 28, 651-662.

MEHTA, P.K. and PITT, N. (1974) A new process for rice husk utilisation, Proceedings of fourth international conference on rice by-products utilization, Valencia, Spain.

MEHTA, P.K. and PITT, N. (1976) Energy and industrial materials from crop residues, Resource Rec. Consv., Vol. 2, pp 23-38.

MINTZ, D.M. (1966) Modern theory of filtration, Inst. Wat. Sup. Asscn Seventh Congress, Vol. I, London.

O'MELIA, C.R. (1969) A review of the coagulation process, Jour. Pub. Wks, Vol. 100, n5, pp 87-98.

O'MELIA, C.R. and CRAPPS, D.K. (1964) Some chemical aspects of rapid sand filtration, Jour. Amer. Wat. Wks Asscn, Vol. 56, pp 1326-1344.

O'MELIA, C.R. and STUMM, W. (1967) Theory of water filtration, Jour. Amer. Wat. Wks Asscn, Vol. 59, n 11, pp 1393-1410.

O'NATSKII, N.V., SERGEEV, E.M., SHEKHTMAN, Y.M. (1955) Theory of clogging of a sand bed when a clay suspension is filtered through it. Izv. Mosk Univ., Ch. III, pg 49-80, Reported by Herzig et al., 1970.

PACKHAM, R.F. and SAUNDERS, M. (1966a) Laboratory studies of activated silica - Effect on the coagulation of a clay suspension with aluminium sulphate. Proc. Soc. Wat. Treat. Exam., Vol. 15, pp 245-254.

PACKHAM, R.F. and SAUNDERS, M. (1966b) Laboratory studies of activated silica - some variables involved in preparation. Proc. Soc. Wat. Treat. Exam, Vol. 15, p 255-270.

PATWARDHAN, S.V. (1975) Low cost water treatment for developing countries. Water Waste and Health in Hot Countries, Second International Conf. on environmental health eng.

in hot climates and developing countries. Loughborough Univ. of Tech. Sept. 1975, Ed. J. Pickford.

PAXTON, J. (1979) The Statesman's Year Book 1978/1980.

PERRIN, F.H. and SMITH, F. (1973) Development of a new silicate based coagulant aid, Jour. Wat. Treat. Exam., Vol. 22, Part 2, pp 81-99.

ROBINSON, V.N.E. (1975) The elimination of charging artefacts in the scanning electron microscope. Jour. Phy.-E., Vol. 8, pp 638-640.

ROSE, H.E. and RIZK, A.M.A. (1949) Further researches in fluid flow through beds of granular material. Proc. Inst. Mech. Engrs., Vol. 160, pp 493-551.

SEN, A.K. and BULUSU, K.R. (1962) The effectiveness of Nirmali seed as coagulant and coagulant aid. Env. Hea., CPHRI, Nagpur, India, Vol. IV, pp 233.

SEVILLA, A.S. (1971) A study of filtration methods for providing inexpensive portable water to rural communities in Asia, M.A. Thesis, Asian Institute of Technology, Bangkok, Thailand.

SOSMAN, R.B. (1965) The phases of silica, New Brunswick, N.J.

STERLING, C. (1967) Crystalline silica in plants. Amer. Jour. Bot., Vol. 54, pp 840.

STUMM, W., HUPER, H. and CHAMPLIN, R.L. (1967) Formation of polysilicates as determined by coagulation effects, Jour. Env. Sc. Tech., Vol. 1, n 3, pp 221-227.

STUMM, W. and O'MELIA, C.R. (1968) Stoichiometry of coagulation, Jour. Amer. Wat. Wks Assen, Vol. 100, n 5, pp 514-539.

THANH, N.C. and PESCOD, M.B. (1976) Application of slow filtration for surface water treatment in tropical developing countries. Final report No. 65, Asian Institute Technology, Thailand.

TRIPATHI, P. N., CHAUDHURI, M. and BOKIL, S.D. (1976) Nirmali seed - a naturally occurring coagulant. Indian Jour. Env. Health, Vol. 18, n4, pp 272-281.

TWORF, A.C., HOATHER, R.C. and LAW, F.M. (1974) A text book of water supply, second edition, Edward Arnold (Publishers) Ltd., London, Ch. 7.

VAN DE VLOED, A. (1955) Comparison between slow sand and rapid filters, Subject No. 7, International Wat. Sup. Assen, Third Congress, July, London.

VIMAL, O.P. (1975) Utilization of agro-industrial byproducts: Part I Paddy husk, Res. Ind., Vol. 20, n 3, pp 113-120.

WEBER, W.J. Jr. (1972) Physicochemical process for water quality control, Wiley Interscience, New York.

W.H.O. (1976) Community water supply and excreta disposal in developing countries - review of progress. World Health Statistics, Vol. 29, n 10, pp 544-603.

YAO, K.M. (1967) Particle aggregation in water pretreatment Part 1 and 2, Jour. Wat. Sew. Wks, Vol. 114, n7, 8, pp 261-264, 295-298.

YAO, K.M., HAIBIBIAN, M.T. and O'MELIA, C.R. (1971) Water and wastewater filtration: Concepts and applications, Env. Sc. Tech., Vol. 5, n 11, pp 1105-1112.