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Appendix A

Production activity

The factory working week is Monday to Saturday, Sunday is a holiday and no killing takes place on Buddha days. From 8.00 am. to 5.00 pm. all procedures are in operation following the schedule below.

Time	Operation
8:00 - 8:20 a.m.	Start hog/cattle killing, meat processing
8:30 - 8:50	Start hog offal processing
9:00 - 9:30	Start cattle offal processing
10:00 - 10:15	Tea break
12:00	Finish cattle killing and hog killing if number of hogs about 300
12:00 - 1:00 p.m.	Lunch Break
1:00 - 2:00	Finish hog killing if number of hogs about 400-500
2:30 - 3:00	Finish hog offal processing
3:00 - 3:15	Tea Break
3:15 - 4:00	Washing in hog line
4:00 - 4:30	Finish cattle offal processing
4:00 - 5:00	Washing in cattle line

At night, slaughtering begins at 7.00 p.m. and all procedures continue until finish around 9.00 p.m.

After killing, 5-10% of meat productivity was used for processing. Hogs were regularly killed, approximately 300 in the day time and 50 at night but only around 40 cattle were killed weekly so 1500-3000 kg. pork was daily processed while 500-700 kg. beef was weekly processed.

Appendix B

COD Raw Data

COD of Anaerobic Fixed-Bed Reactor

DATE	DAY-NR	INF.COD (mg/l) Total	INF.COD (mg/l) Filter	EFF.COD (mg/l) Total	EFF.COD (mg/l) Filter	%EFF.(T)	%EFF.(F)
FLOWRATE = 0.3 m3/h							
16-AUG.	1	466	193	258	109	45	44
17-AUG.	2	339	162	121	67	64	59
19-AUG.	4	225	181	54	38	76	79
22-AUG.	7	806	264	178	27	78	90
24-AUG.	9	566	397	166	64	71	84
26-AUG.	11	194	121	87	74	55	39
29-AUG.	14	768	288	176	120	77	58
31-AUG.	16	237	126	87	59	63	53
02-SEP.	18	894	466	345	105	61	77
05-SEP.	21	185	54	61	28	67	48
07-SEP.	23	225	122	92	23	59	81
09-SEP.	25	240	118	88	34	63	71
12-SEP.	28	142	32	68	20	52	38
Avg.		407	194	137	59	64	63
FLOWRATE = 0.5 m3/h							
14-SEP.	30	177	73	108	60	39	18
16-SEP.	32	164	71	86	56	48	21
19-SEP.	35	296	164	124	78	58	52
20-SEP.	36	729	368	201	103	72	72
21-SEP.	37	354	178	138	67	61	62
23-SEP.	39	245	96	79	27	68	72
26-SEP.	42	268	145	123	69	54	52
27-SEP.	43	569	253	154	92	73	64
28-SEP.	44	265	167	97	45	63	73
29-SEP.	45	111	86	39	24	65	72
30-SEP.	46	487	193	172	147	65	24
02-OCT.	49	107	62	52	46	51	26
04-OCT.	52	355	157	132	104	63	34
06-OCT.	53	302	108	101	62	67	43
Avg.		316	152	115	70	60	49
FLOWRATE = 0.7 m3/h							
07-OCT.	54	176	66	109	8	38	88
09-OCT.	56	447	204	290	161	35	21
11-OCT.	58	256	89	145	60	43	33
13-OCT.	60	287	128	175	63	39	51
16-OCT.	63	152	71	105	46	31	35
18-OCT.	65	360	104	225	53	38	49
20-OCT.	67	237	125	131	79	45	37
23-OCT.	70	249	162	79	27	68	83
25-OCT.	72	306	151	123	69	60	54
27-OCT.	74	348	127	181	92	48	28
30-OCT.	77	360	104	97	45	73	57
Avg.		289	121	151	64	47	49

COD of Anaerobic Fixed-Bed Reactor
(Continued)

DATE	DAY-NR	INF.COD (mg/l) Total	INF.COD (mg/l) Filter	EFF.COD (mg/l) Total	EFF.COD (mg/l) Filter	%EFF.(T)	%EFF.(F)
FLOWRATE = 1.0 m3/h							
01-NOV.	78	137	105	88	61	36	42
02-NOV.	79	365	109	390	79	0	28
04-NOV.	81	549	138	326	94	41	32
07-NOV.	84	294	105	204	83	31	21
09-NOV.	86	487	193	376	98	23	49
11-NOV.	88	360	104	243	48	33	54
14-NOV.	91	302	96	209	67	31	30
15-NOV.	92	385	218	215	80	44	63
16-NOV.	93	161	89	103	66	36	26
Avg.		338	129	239	75	30	38
FLOWRATE = 2.0 m3/h							
06-JAN.	94	68	35	91	61	0	0
07-JAN.	95	392	384	208	233	47	39
09-JAN.	97	428	170	819	162	0	5
11-JAN.	99	714	221	418	263	41	0
13-JAN.	101	355	99	216	103	39	0
16-JAN.	104	877	206	517	162	41	21
18-JAN.	106	348	90	198	108	43	0
20-JAN.	108	210	83	140	62	33	25
Avg.		424	161	326	144	31	11
FLOWRATE = 4.0 m3/h							
21-JAN.	109	208	83	158	48	24	42
23-JAN.	111	212	30	154	33	27	0
24-JAN.	112	215	30	257	46	0	0
Avg.		212	48	190	42	17	14

COD of Anaerobic Upflow System Reactors

DATE	DAY-NR	INF.COD(mg/l) TOTAL	INF.COD(mg/l) FILTER	EFF.COD (mg/l) TOTAL	EFF.COD (mg/l) FILTER	%EFF.(T)	%EFF.(F)
FLOWRATE = 0.3 m3/h							
29-SEP.	1	111	20	94	15	15	25
02-OCT.	4	107	62	101	28	6	55
04-OCT.	6	355	157	225	104	37	34
06-OCT.	8	302	108	201	96	33	11
09-OCT.	11	447	204	174	106	61	48
11-OCT.	13	256	89	113	61	56	31
13-OCT.	15	287	128	71	43	75	66
16-OCT.	18	152	71	63	26	59	63
18-OCT.	20	360	104	119	68	67	35
20-OCT.	22	237	125	104	63	56	50
23-OCT.	25	249	162	98	28	61	83
25-OCT.	27	306	151	102	90	67	40
27-OCT.	29	348	127	131	54	62	57
30-OCT.	32	360	104	130	63	64	39
02-NOV.	34	365	109	127	82	65	25
04-NOV.	36	549	138	196	49	64	64
07-NOV.	39	294	105	76	31	74	70
09-NOV.	41	487	193	361	163	26	16
11-NOV.	43	360	104	130	63	64	39
12-NOV.	44	302	96	101	62	67	35
Avg.		312	118	136	65	54	44
FLOWRATE = 0.5 m3/h							
13-NOV.	45	308	127	141	74	54	42
15-NOV.	47	385	218	162	98	58	55
16-NOV.	48	161	89	65	40	60	55
18-NOV.	50	473	246	258	196	45	20
21-NOV.	53	291	129	86	39	70	70
23-NOV.	55	156	110	59	48	62	56
25-NOV.	57	538	188	261	113	51	40
28-NOV.	60	272	149	138	76	49	49
30-NOV.	62	201	79	116	57	42	28
01-DEC.	63	496	254	192	145	61	43
04-DEC.	66	385	218	139	116	64	47
06-DEC.	68	174	86	72	51	59	41
08-DEC.	70	389	157	113	94	71	40
11-DEC.	73	269	155	107	79	60	49
Avg.		321	158	136	88	58	45

COD of Anaerobic Upflow System Reactors
(Continued)

DATE	DAY-NR	INF.COD(mg/l) TOTAL	INF.COD(mg/l) FILTER	EFF.COD (mg/l) TOTAL	EFF.COD (mg/l) FILTER	%EFF.(T)	%EFF.(F)
FLOWRATE = 0.7 m3/h							
12-DEC.	74	185	118	109	96	41	19
14-DEC.	76	471	200	174	104	63	48
16-DEC.	78	204	75	104	39	49	48
18-DEC.	80	472	104	184	64	61	38
20-DEC.	82	305	143	213	62	30	57
22-DEC.	84	392	164	121	88	69	46
25-DEC.	86	272	149	116	76	57	49
27-DEC.	89	678	113	144	73	79	35
29-DEC.	91	316	205	142	89	55	57
30-DEC.	93	180	115	74	59	59	49
02-JAN.	94	196	104	96	61	51	41
03-JAN.	97	225	142	103	87	54	39
Avg.		325	136	132	75	56	44
FLOWRATE = 1.0 m3/h							
06-JAN.	100	68	35	45	49	34	0
07-JAN.	101	392	384	177	49	55	87
09-JAN.	103	428	170	517	248	0	0
11-JAN.	105	714	221	164	44	77	80
13-JAN.	107	355	99	435	150	0	0
16-JAN.	110	877	206	308	206	65	0
18-JAN.	112	348	90	234	117	33	0
20-JAN.	114	210	83	145	56	31	33
22-JAN.	116	208	81	107	45	49	44
24-JAN.	118	215	30	111	26	48	13
26-JAN.	120	212	30	104	29	51	3
Avg.		366	130	213	93	40	24
FLOWRATE = 2.0 m3/h							
27-JAN.	121	196	74	205	69	0	7
28-JAN.	122	235	137	245	125	0	9
29-JAN.	123	298	108	386	120	0	0
31-JAN.	125	276	97	213	99	23	0
02-FEB.	127	321	105	309	106	4	0
04-FEB.	129	278	89	294	98	0	0
05-FEB.	130	265	76	229	65	14	14
Avg.		267	98	269	97	6	4

Appendix C

Suspended Solids and Settleable Solids

Suspended Solids and Settleable Solids of Fixed-bed Reactor

DATE	DAY-NR	SUSPENDED SOLIDS INF.	SUSPENDED SOLIDS EFF.	SUSPENDED SOLIDS %EFF.	SETTLEABLE SOLIDS EFFLUENT
FLOWRATE = 0.3 m3/h					
16-AUG.	1	196	72	63	0.2
17-AUG.	2	87	23	74	0.2
19-AUG.	4	60	8	87	0.2
22-AUG.	7	108	49	55	0.1
24-AUG.	9	128	40	69	0.1
26-AUG.	11	89	19	79	0.1
29-AUG.	14	245	49	80	0.2
31-AUG.	16	99	21	79	0.1
02-SEP.	18	226	85	62	0.2
05-SEP.	21	76	13	83	0.1
07-SEP.	23	114	8	93	0.1
09-SEP.	25	106	63	41	0.2
12-SEP.	28	94	47	50	0.1
Avg.		125	38	70	0.1
FLOWRATE = 0.5 m3/h					
14-SEP.	30	99	54	45	0.0
16-SEP.	32	68	56	18	0.0
19-SEP.	35	112	39	65	0.1
20-SEP.	36	247	92	63	0.2
21-SEP.	37	114	69	39	0.1
23-SEP.	39	129	58	55	0.0
26-SEP.	42	103	62	40	0.1
27-SEP.	43	195	54	72	0.1
28-SEP.	44	136	66	51	0.1
29-SEP.	45	52	26	50	0.0
30-SEP.	46	228	34	85	0.0
02-OCT.	49	59	8	86	0.0
04-OCT.	52	201	28	86	0.1
06-OCT.	53	217	36	83	0.1
Avg.		140	49	60	0.1
FLOWRATE = 0.7 m3/h					
07-OCT.	54	81	69	15	0.2
09-OCT.	56	165	112	32	0.6
11-OCT.	58	143	87	39	0.3
13-OCT.	60	168	140	17	0.4
16-OCT.	63	86	73	15	0.2
18-OCT.	65	219	130	41	1.2
20-OCT.	67	80	66	18	0.3
23-OCT.	70	79	52	34	0.1
25-OCT.	72	109	46	58	0.2
27-OCT.	74	171	68	60	0.3
30-OCT.	77	196	55	72	0.1
Avg.		136	82	36	0.4

Suspended Solids and Settleable Solids of Fixed-bed Reactor
(Continued)

DATE	DAY-NR	SUSPENDED SOLIDS INF.	SUSPENDED SOLIDS EFF.	SUSPENDED SOLIDS %EFF.	SETTLEABLE SOLIDS EFFLUENT
FLOWRATE = 1.0 m3/h					
01-NOV.	78	26	64	0	4.1
02-NOV.	79	209	283	0	17.0
04-NOV.	81	311	246	21	14.2
07-NOV.	84	186	174	6	10.3
09-NOV.	86	188	240	0	12.2
11-NOV.	88	127	139	0	6.9
14-NOV.	91	114	121	0	6.1
15-NOV.	92	99	116	0	4.9
16-NOV.	93	86	75	13	1.4
Avg.		150	162	4	8.6
FLOWRATE = 2.0 m3/h					
06-JAN.	94	60	96	0	0.1
07-JAN.	95	476	180	62	0.2
09-JAN.	97	504	244	52	1
11-JAN.	99	640	208	68	1.2
13-JAN.	101	492	176	64	0.5
16-JAN.	104	1452	200	86	0.1
18-JAN.	106	322	216	33	0.2
20-JAN.	108	1868	148	92	0.3
Avg.		727	184	57	0.5
FLOWRATE = 4.0 m3/h					
21-JAN.	109	208	64	69	8.6
23-JAN.	111	225	192	15	0.3
24-JAN.	112	217	128	42	0.1
Avg.		216.5	128	42	3

Suspended Solids and Settleable Solids of RAUS Reactor

DATE	DAY-NR	SUSPENDED SOLIDS INF.	EFF.	%EFF.	SETTLEABLE SOLIDS EFFLUENT
FLOWRATE = 0.3 m3/h					
29-SEP.	1	52	48	7.69	0.0
02-OCT.	4	59	45	23.73	0.0
04-OCT.	6	201	69	65.67	0.1
06-OCT.	8	217	65	70.05	0.1
09-OCT.	11	165	47	71.52	0.1
11-OCT.	13	143	38	73.43	0.0
13-OCT.	15	168	64	61.90	0.1
16-OCT.	18	86	41	52.33	0.0
18-OCT.	20	219	52	76.26	0.1
20-OCT.	22	80	29	63.75	0.0
23-OCT.	25	79	46	41.77	0.0
25-OCT.	27	109	20	81.65	0.0
27-OCT.	29	171	44	74.27	0.0
30-OCT.	32	196	28	85.71	0.0
02-NOV.	34	209	36	82.78	0.0
04-NOV.	36	311	58	81.35	0.1
07-NOV.	39	186	18	90.32	0.0
09-NOV.	41	188	72	61.70	0.2
11-NOV.	43	127	31	75.59	0.0
12-NOV.	44	114	24	78.95	0.0
Avg.		154	44	66	0.04
FLOWRATE = 0.5 m3/h					
13-NOV.	45	99	56	43.43	0.2
15-NOV.	47	86	42	51.16	0.2
16-NOV.	48	103	57	44.66	0.2
18-NOV.	50	83	47	43.37	0.3
21-NOV.	53	54	33	38.89	0.2
23-NOV.	55	368	128	65.22	3.1
25-NOV.	57	82	47	42.68	0.2
28-NOV.	60	280	88	68.57	0.3
30-NOV.	62	219	67	69.41	0.4
01-DEC.	63	86	39	54.65	0.3
04-DEC.	66	65	29	55.38	0.2
06-DEC.	68	96	55	42.71	0.2
08-DEC.	70	89	23	74.16	0.5
11-DEC.	73	208	89	57.21	0.3
Avg.		137	57	54	0.5

Suspended Solids and Settleable Solids of RAUS Reactor
(Continued)

DATE	DAY-NR	SUSPENDED SOLIDS INF.	SUSPENDED SOLIDS EFF.	SUSPENDED SOLIDS %EFF.	SETTLEABLE SOLIDS EFFLUENT
FLOWRATE = 0.7 m3/h					
12-DEC.	74	174	60	65.52	3.7
14-DEC.	76	484	112	76.86	12.1
16-DEC.	78	109	164	0.00	11.3
18-DEC.	80	152	49	67.76	3.3
20-DEC.	82	106	38	64.15	2.9
22-DEC.	84	496	57	88.51	4.2
25-DEC.	86	81	46	43.21	3.1
27-DEC.	89	543	193	64.46	2.8
29-DEC.	91	355	146	58.87	2.2
30-DEC.	93	201	104	48.26	0.7
02-JAN.	94	187	83	55.61	0.5
03-JAN.	97	69	28	59.42	0.3
Avg.		246	90	57.72	3.9
FLOWRATE = 1.0 m3/h					
06-JAN.	100	60	29	51.67	0.2
07-JAN.	101	476	253	46.85	0.3
09-JAN.	103	504	287	43.06	0.2
11-JAN.	105	640	160	75.00	0.1
13-JAN.	107	492	152	69.11	5.5
16-JAN.	110	1452	364	74.93	0.3
18-JAN.	112	322	304	5.59	2.0
20-JAN.	114	1868	403	78.43	0.3
22-JAN.	116	868	216	75.12	1.2
24-JAN.	118	208	64	69.23	0.2
26-JAN.	120	225	148	34.22	0.5
Avg.		647	216	56.66	1.0
FLOWRATE = 2.0 m3/h					
27-JAN.	121	137	77	43.80	0.2
28-JAN.	122	503	205	59.24	0.1
29-JAN.	123	809	487	39.80	0.1
31-JAN.	125	533	204	61.73	0.3
02-FEB.	127	665	321	51.73	0.1
04-FEB.	129	541	245	54.71	0.2
05-FEB.	130	741	349	52.90	0.1
Avg.		561	270	51.99	0.16

pH and Temperature of Fixed-bed Reactor

DATE	DAY-NR	pH		TEMPERATURE	
		INF.	EFF.	INF.	EFF.
FLOWRATE = 0.3 m3/h					
16-AUG.	1	7.82	6.98	29.8	30.0
17-AUG.	2	7.64	7.08	29.6	29.9
19-AUG.	4	7.80	7.09	29.4	30.2
22-AUG.	7	7.54	6.86	29.8	30.6
24-AUG.	9	7.63	6.98	31.1	30.6
26-AUG.	11	7.72	6.99	31.9	30.5
29-AUG.	14	7.57	6.94	32.6	30.6
31-AUG.	16	7.69	7.08	32.2	30.2
02-SEP.	18	7.54	6.85	31.2	29.9
05-SEP.	21	7.72	6.88	30.1	30.2
07-SEP.	23	7.58	6.83	32.4	30.0
09-SEP.	25	7.64	7.08	29.6	29.9
12-SEP.	28	7.54	6.88	31.2	30.0
Avg.		7.65	6.96	30.8	30.2
FLOWRATE = 0.5 m3/h					
14-SEP.	30	7.57	7.20	32.6	30.2
16-SEP.	32	7.65	7.15	31.8	29.7
19-SEP.	35	7.69	6.98	32.1	30.0
20-SEP.	36	7.55	7.10	31.0	29.4
21-SEP.	37	7.68	7.03	31.6	30.0
23-SEP.	39	7.95	7.15	31.3	29.4
26-SEP.	42	7.73	7.09	31.4	29.8
27-SEP.	43	7.41	7.11	31.2	29.4
28-SEP.	44	7.94	6.90	30.8	29.1
29-SEP.	45	7.66	7.15	29.7	29.1
30-SEP.	46	7.53	7.25	29.8	29.6
02-OCT.	49	7.92	7.05	31.2	30.1
04-OCT.	52	7.43	6.91	31.3	30.2
06-OCT.	53	7.65	7.15	30.6	29.3
Avg.		7.67	7.09	31.2	29.7
FLOWRATE = 0.7 m3/h					
07-OCT.	54	7.93	7.05	31.2	29.4
09-OCT.	56	7.96	7.09	32.8	29.5
11-OCT.	58	7.56	7.11	30.9	29.8
13-OCT.	60	7.72	7.06	33.7	29.9
16-OCT.	63	7.75	7.07	31	29.6
18-OCT.	65	7.59	7.09	30.7	29.3
20-OCT.	67	7.61	6.98	31.3	29.7
23-OCT.	70	7.74	7.14	32.4	30
25-OCT.	72	7.53	7.12	32.1	29.7
27-OCT.	74	7.58	7.1	31.8	29.6
30-OCT.	77	7.66	7.06	30.7	29.6
Avg.		7.69	7.08	31.7	29.6

pH and Temperature of Fixed-bed Reactor
(Continued)

DATE	DAY-NR	pH		TEMPERATURE	
		INF.	EFF.	INF.	EFF.
FLOWRATE = 1.0 m3/h					
01-NOV.	78	7.49	7.05	29.9	29.3
02-NOV.	79	7.86	7.07	30.7	29.6
04-NOV.	81	7.96	7.09	31.2	29.7
07-NOV.	84	7.52	7.01	31.9	29.9
09-NOV.	86	7.59	7	31.3	29.0
11-NOV.	88	7.65	6.98	32.1	30.1
14-NOV.	91	7.63	6.95	31.6	29.4
15-NOV.	92	7.59	7.12	31.7	29.8
16-NOV.	93	7.72	7.2	32.1	29.9
Avg.		7.67	7.05	31.4	29.6
FLOWRATE = 2.0 m3/h					
06-JAN.	94	7.73	7.13	31.1	30.2
07-JAN.	95	7.69	7.18	30.6	29.9
09-JAN.	97	7.64	7.25	30.7	30.4
11-JAN.	99	7.73	7.26	31.7	31
13-JAN.	101	7.71	7.16	30.5	30.2
16-JAN.	104	7.76	7.18	30	29.8
18-JAN.	106	7.72	7.09	30.6	30.5
20-JAN.	108	7.69	7.1	30.8	30.3
Avg.		7.71	7.17	30.8	30.3
FLOWRATE = 4.0 m3/h					
21-JAN.	109	7.78	7.18	31.3	30.8
23-JAN.	111	7.73	7.11	30.7	30.4
24-JAN.	112	7.65	7.06	30.9	30.6
		7.72	7.12	31.0	30.6

pH and Temperature of RAUS Reactors

DATE	DAY-NR	pH		TEMPERATURE	
		INF.	EFF.	INF.	EFF.
FLOWRATE = 0.3 m3/h					
29-SEP.	1	7.66	6.96	29.7	29.1
02-OCT.	4	7.92	7.01	31.2	29.4
04-OCT.	6	7.43	7.00	31.3	29.9
06-OCT.	8	7.65	7.01	30.6	29.2
09-OCT.	11	7.96	7.03	32.5	29.6
11-OCT.	13	7.56	7.14	31.2	29.4
13-OCT.	15	7.72	7.12	33.7	29.9
16-OCT.	18	7.75	7.01	32.6	29.8
18-OCT.	20	7.59	7.04	30.9	29.5
20-OCT.	22	7.61	7.02	31.6	29.8
23-OCT.	25	7.74	7.01	32.4	29.9
25-OCT.	27	7.53	7.13	31.9	29.8
27-OCT.	29	7.58	7.20	30.7	29.7
30-OCT.	32	7.66	7.05	29.8	29.1
02-NOV.	34	7.86	7.03	29.6	29.2
04-NOV.	36	7.96	7.01	29.7	29.0
07-NOV.	39	7.52	7.15	29.9	29.3
09-NOV.	41	7.59	7.20	29.0	29.0
11-NOV.	43	7.65	7.03	30.1	29.4
12-NOV.	44	7.91	7.05	29.4	29.0
Avg.		7.69	7.06	30.9	29.5
FLOWRATE = 0.5 m3/h					
13-NOV.	45	7.46	6.96	31.7	29.7
15-NOV.	47	7.59	7.01	31.4	29.4
16-NOV.	48	7.72	7.03	30.8	29.6
18-NOV.	50	7.85	7.17	31.3	29.8
21-NOV.	53	7.66	7.14	30.2	29.6
23-NOV.	55	7.59	7.01	30.1	29.1
25-NOV.	57	7.57	6.99	29.9	29.1
28-NOV.	60	7.62	7.03	30.4	29.2
30-NOV.	62	7.68	7.05	30.5	29.3
01-DEC.	63	7.93	7.18	32.1	30.0
04-DEC.	66	7.82	7.09	30.9	29.5
06-DEC.	68	7.88	7.15	31.1	29.7
08-DEC.	70	7.80	6.96	30.8	29.9
11-DEC.	73	7.64	7.01	31.4	29.8
Avg.		7.70	7.06	30.9	29.6

pH and Temperature of RAUS Reactors
(Continued)

DATE	DAY-NR	pH		TEMPERATURE	
		INF.	EFF.	INF.	EFF.
FLOWRATE = 0.7 m3/h					
12-DEC.	74	7.49	7.04	30.9	29.9
14-DEC.	76	7.76	7.18	32.1	29.9
16-DEC.	78	7.69	7.09	31.5	29.8
18-DEC.	80	7.55	7.06	31.0	29.3
20-DEC.	82	7.62	7.13	31.2	29.8
22-DEC.	84	7.83	7.19	29.9	29.4
25-DEC.	86	7.61	7.05	31.3	29.6
27-DEC.	89	7.58	7.01	31.8	29.9
29-DEC.	91	7.86	7.03	31.1	29
30-DEC.	93	7.83	7.05	30.6	28.9
02-JAN.	94	7.79	7.1	30.7	28.8
03-JAN.	97	7.86	7.11	31.7	29
Avg.		7.71	7.09	31.2	29.4
FLOWRATE = 1.0 m3/h					
06-JAN.	100	7.71	7.08	30.5	28.9
07-JAN.	101	7.76	7.24	30	29.1
09-JAN.	103	7.72	6.94	30.6	29.3
11-JAN.	105	7.69	7.23	30.8	29.5
13-JAN.	107	7.59	7.22	31.3	29.4
16-JAN.	110	7.72	7.09	30.7	29
18-JAN.	112	7.64	7.13	30.9	29.3
20-JAN.	114	7.73	7.15	30.8	29.1
22-JAN.	116	7.74	7.19	30.6	29.2
24-JAN.	118	7.65	7.15	30.7	29
26-JAN.	120	7.83	7.2	30.5	29.4
Avg.		7.71	7.15	30.7	29.2
FLOWRATE = 2.0 m3/h					
27-JAN.	121	7.71	7.26	30.3	29.1
28-JAN.	122	7.78	7.25	30.2	28.9
29-JAN.	123	7.73	7.28	30	29
31-JAN.	125	7.65	7.35	31.1	29.5
02-FEB.	127	7.7	7.24	30.8	29.4
04-FEB.	129	7.81	7.18	30.4	29.2
05-FEB.	130	7.69	7.16	30.3	29.4
Avg.		7.72	7.25	30.4	29.2

Appendix D

Characteristics of Methanogenic Bacteria

Summary of characteristics of methanogenic archaebacteria, order *Methanobacteriales*[a]

Archaebacteria	Morphology	Substrates	G+C (mol%)	Temp optimum (°C)	pH optimum	Cell envelope composition	Major membrane isoprenoid	Reference(s)
Family *Methanobacteriaceae*								
Methanobacterium formicicum	Rod	H_2, formate	40.7	37	7.0	Pseudomurein	$C_{20} + C_{40}$	12
M. bryantii	Rod	H_2	32.7	38	7.0	Pseudomurein	$C_{20} + C_{40}$	12
M. thermoautotrophicum	Rod	H_2	49.7	65–70	7.2–7.6	Pseudomurein	$C_{20} + C_{40}$	546
M. wolfei	Rod	H_2	61	55–65	7.0–7.5	Pseudomurein	ND[b]	517
M. thermoaggregans	Rod	H_2	42	65	7.0–7.5	ND	ND	32
M. thermocalcaliphilum	Rod	H_2	38.8	60	7.5–8.5	ND	ND	33
Methanobrevibacter ruminantium	Rod	H_2, formate	30.6	38	7.2	Pseudomurein	$C_{20} + C_{40}$	431
M. smithii	Rod	H_2, formate	31	38	6.9–7.4	Pseudomurein	$C_{20} + C_{40}$	325
M. arboriphilus	Rod	H_2	29	30–37	7.5–8.0	Pseudomurein	$C_{20} + C_{40}$	544
Methanosphaera stadtmaniae	Coccus	H_2 + methanol	25.8	36–40	6.5–6.9	Pseudomurein	ND	323, 324
Family *Methanothermaceae*								
Methanothermus fervidus	Rod	H_2	33	83	6.5	Pseudomurein + protein	C_{20}	446

Summary of characteristics of methanogenic archaebacteria, order *Methanococcales*, family *Methanococcaceae*[a]

Archaebacteria	Morphology	Substrates	G+C (mol%)	Temp optimum (°C)	pH optimum	Cell envelope composition	Major membrane isoprenoid	Reference(s)
Methanococcus vannielii	Coccus	H_2, formate	32.5	36–40	7.0–9.0	Protein	C_{20}, tr C_{40}	12
M. voltae	Coccus	H_2, formate	29.6	32–40	6.7–7.4	Protein	C_{20}	505
M. muripaludis	Coccus	H_2, formate	33.4	38	6.8–7.2	Protein	ND[b]	208
M. deltae	Coccus	H_2, formate	33.6	37	ND	ND	ND	56
M. thermolithotrophicus	Coccus	H_2, formate	33.6	65	6.5–7.5	Protein	C_{20}	179
M. jannaschii	Coccus	H_2	31	85	6.0	Protein	Cyclic diether, $C_{20} + C_{40}$	55, 207

Summary of characteristics of methanogenic archaebacteria, order *Methanomicrobiales*[a]

Archaebacteria	Morphology	Substrates	G+C (mol%)	Temp optimum (°C)	pH optimum	Cell envelope composition	Major membrane isoprenoid	Reference
Family *Methanomicrobiaceae*								
Methanomicrobium mobile	Rod	H_2, formate	48.8	40	6.1–6.9	Protein	$C_{20} + C_{40}$	337
M. paynteri	Rod	H_2	44.9	40	6.5–7.0	ND	ND	375
Methanogenium cariaci	Coccus	H_2, formate	51.6	20–25	6.8–7.3	Protein	$C_{20} + C_{40}$	382
M. marisnigri	Coccus	H_2, formate	61.2	20–25	6.2–6.6	Glycoprotein	$C_{20} + C_{40}$	382
M. olentangyi	Coccus	H_2	54.4	37	ND	ND	ND	56
M. tatii	Coccus	H_2, formate	54	40	7.0	Glycoprotein	ND	539
M. limicola	Planes	H_2, formate	47.5	40	7.0	Glycoprotein	$C_{20} + C_{40}$	513
M. thermophilicum	Coccus	H_2, formate	59	55	7.0	ND	$C_{20} + C_{40}$	376
M. frittonii	Coccus	H_2, formate	49.2	57	7.0–7.5	Protein	ND	157
Methanospirillum hungatei	Curved rod	H_2, formate	45	30–37	6.6–7.4	Protein, sheath	$C_{20} + C_{40}$	122
Family *Methanosarcinaceae*								
Methanosarcina barkeri	Coccus, packets	H_2, Me, $MeNH_2$, Ac	39	35	7.0	HPS + protein	$C_{20} + C_{25}$	13, 168
M. mazei	Coccus	H_2, Me, $MeNH_2$, Ac	42	40	6.0–7.0	HPS	$C_{20} + C_{25}$	301
M. thermophila	Coccus	H_2, Me, $MeNH_2$, Ac	42	50	6.0–7.0	HPS	ND	559, 560
M. acetivorans	Coccus	Me, $MeNH_2$, Ac	42	40	6.5–7.0	Protein	ND	433
Methanococcoides methylutens	Coccus	Me, $MeNH_2$	42	35	7.0–7.5	Protein	C_{20}	434
Methanolobus tindarius	Coccus	Me, $MeNH_2$	40	25	6.5	Glycoprotein	$C_{20} + C_{25}$	259
Methanococcus halophilus	Coccus	Me, $MeNH_2$	ND	26–36	6.5–7.4	ND	ND	548
Halomethanococcus mahii	Coccus	Me, $MeNH_2$	48.5	35	7.5	ND	ND	334
Methanothrix soehngenii	Rod	Ac	51.9	37	7.4–7.8	Protein; sheath	C_{20}	183
Methanothrix sp.	Rod	H_2, Ac	ND	60	ND	ND	ND	557

[a] Also refer to references 12, 436, 504, and 514 and consult text. Abbreviations: ND, Not determined; Me, methanol; $MeNH_2$, methylamines; Ac, acetate; HPS, heteropolysaccharide.

VITA

The author, Miss Araya Surin, was born on December 23, 1962 in Lampang province, Thailand. She graduated with a bachelor's degree of Environmental Engineering from Chiang Mai University in 1985. She then worked with the Public Works Department, Ministry of Interior. After one year of being an engineer for sewage network she changed her career to become a lecturer at the Institute of Technical and Vocational Education, Chiang Mai campus. After teaching for almost 2 years, she left her job to further her postgraduate study in Environmental Engineering at Graduate School, Chulalongkorn University. She also had a few years experience with a private company, Envirtech Consultants, Co.Ltd, during her first year of study at Chulalongkorn University.