JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

USAID CONTRACT # 278-C-00-94-0026-09
DAI PROJECT NUMBER: 3114

OPERATION & MAINTENANCE OF THE WASTEWATER TREATMENT DEMONSTRATION FACILITY AT THE JORDAN YEAST Co. Ltd (YIC)

DRAFT EVALUATION REPORT

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1 0 Project objective

As a part of the Water Quality Improvement and Conservation (WQIC) project funded by United States Agency for International Development (USAID), a demonstration pilot scale treatment facility at the Jordan Yeast Industries Corporation (YIC)has been constructed and installed to treat part of the YIC effluent wastewater The treatment facility consists of two parts Anaerobic Pretreatment and Land Application The objective of the pilot works for both treatment parts is to get all necessary information and design parameters required for future design works of a scaled-up treatment plant

This draft evaluation report is issued according to the contract between Development Alternative Inc (DAI) and Middle East Environment Technology (MEET) for the operation and maintenance of the wastewater demonstration facility at Jordan Yeast Industries Corporation (YIC) Only pretreatment plant is evaluated within this report The Land application system will be evaluated separately by the soil and water consultant

This draft evaluation will depend on data collected up-to the 30th of November, 1997 as shown in Table-1 to 7

Table Analysis results and monitoring data for pretreatment part during june 199

Date	INFLUENT RAW WASTEWATER VF (mg/l)	Alk (mg/l)	pH	COD (mg/l)	SCOD (mg/l)	TBOD5 (mg/l)	SBOD5 (mg/l)	TN (mg/l)	NH4 (mg/l)	NO3 (mg/l)	TSS (mg/l)	VS (mg/l)	PO4 (mg/l)	(mg/l)	TDS (mg/l)	Cond. pH (SU)	C (mg/l)		UASB REACTOR EFFLUENT (l/day)	pH		VF (meq/l)	Alk (mg/l)	SCOD (mg/l)	COD (mg/l)	TSS (mg/l)	VSS (mg/l)	TC (mg/l)	N (mg/l)	NH (mg/l)	(mg/l)	(mg/l)	PO4 (mg/l)	TP (mg/l)	SBOD5 (mg/l)	Date
1																7.2		3?	9.0			3.40	3850													1
3	—		—	—	—	—						— —			— —			7	1	—	—	3.61	4 ?		—	—							—	—		2
																		4 7																		
5				15 90												7.59		35.1	310			8.69	3950													4
6																7.87		34.3	300			4.65	3950		3997					114					71E	5
7				5789												7.85		34.3	300			4.57	3790													6
8			5.4													7.89		—	0																	7
9			5.54	16422												8.03		34	3.0			4.57	3815													8
	83 3		4													7.61		34.4	3.0			5.9	3770		5693											9
1																7.49		3 8	3			5.52	3020													10
																2		6	3			5.9	3775													11
13																7.4		34.8	209			8.17	3883													12
14																7.4		3 7	393	7 ?																13
5			5.86	6298	2 53											7.2		3 6	600			8.27	392?													1
16															9602	7 1		[illegible]	500	7.6?		5.7	397	4302	6 60											15
17				21705	178 5	10880										7.29		3 6	340	7.68		5.6?	4090													16
8	22 76	8C	5.78													7.64		35.1	600	7.6				4846												17
19				18389	14550											7.2		3 8	600	7.68		6.82	4175													18
20															8260	7.3		35.1	800					5221	7248											19
2																7.29		36.2	600	7.87		5.71	4155													20
22																7.33		34.2	900	7.7?		6.58	380													21
23				16 48	139?6	7508					692	1438			5534	7.4		34.5	250	7.72		5.89	4245	5073	7143	360										22
24				9103	17434											7.48		34.3	900																	23
25																7.5		32.7	190	7.83		6.38	4 85	4749	6837										.8?	24
26																7.01		31.9	1100	7.58		8.1	3095													25
27																6.93		35	785		34.9															26
28																7		30.9	066	7.35	30.9	5.92	3125													27
29				18562	7 3											6.98		35.5	1130	7.36	33.6	5.83	3350													28
30											50	1134			11 0	6.84		35.2	1707	7.4	34.7	5.3	3700	3823	6995	30?	1262									29
AV	2 895	8C	6?E	17177	15620	9194										6.85		38	1482	7.37	34.1	5.78	3825													30
												1296			9959	7 395		34 8	725 333	7.610714	33.64	5.578542	3880.833	4659	6368.429	333	262			11 5					641	

Date	BIOGAS flow (m3/day)	Conc H2	UASB SP#1 TS (mg/l)	UASB SP#1 VSS (mg/l)	UASB SP#2 TSS (mg/l)	UASB SP#2 VSS (mg/l)	UASB SP#3 TSS (mg/l)	UASB SP#3 VSS (mg/l)	UASB SP#4 TSS (mg/l)	UASB SP#4 VSS (mg/l)	AERATION pH (SU)	S (ml/l)	CLARIFIER EFFLUENT Flow (m3/day)	TSS (mg/l)	NH4 (mg/l)	TBOD5 (mg/l)	COD (mg/l)	H2S TSS (mg/l)	SAND FILT pH (SU)	TSS (mg/l)	pH TANK #1 pH (SU)	T (°C)	pH TANK #2 pH (SU)	(°C)	FINAL EFFLUENT flow (m3/day)	pH (SU)	SCOD (mg/l)	COD (mg/l)	TSS (mg/l)	TKN (mg/l)	NH4 (mg/l)	TP (mg/l)	TBOD5 (mg/l)	TDS (mg/l)		Date
2																					11.21		6.87													1
																					22		6.9?													2
																					1 15		7.0					28.4			83		8			3
																					11.22		7.17													
																					10		6.5					.025	?		82		5588			5
																					33		7.0													6
7	0.023																																			7
8	0.084																				1 22		8.29													8
9	0.104																				11.17		8.5?													9
	0.138																				1?		8.49													10
1	0.1 9																				12		8.56													11
	0.335																																	7850		12
13	0.?04																																	93 5		13
	) 8																																			
	0.5 5																																	9435		5
16	0.5?																																			16
	3?																																			
8	0.93																																			18
?	0 8																																	6.?82		19
	0.97																																			?0
	1.??5																																			1
2?	0.??																																			22
	0																																			3
	3.54																																			?4
	2.04																																			5
																																				26
	78																																			7
	7																																			?8
	5.118																																			5
	6.35																																			3
	7																				1?							2? 5	?					8C.?		

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Table 2 Analysis results and monitoring data for pretreatment plant during July 1997

	INFLUENT WASTEWATER															Cond			UASB REACTOR EFFLUENT																	
	Vf	Alkal	pH	EC	SS	TBOD	SCOD	TKN	NH4	NO3	TS	VS	PO4	P	TDS	pH	TCOD		Flow	pH		VF	Alkal	SCOD	TCOD	TSS	VSS	TDS	N	NH	N		PO4	TP	TBOD	day
				734	13		1 271		C					1 09		6 85		3 85	484	7 2		4 7	000	4 .62	8 .3										°C	1
2																f 79		37 25	14	7 79		5 69	4125													2
																		5																		
5																6 8		35 9	1286	7 52		3	3828													
6											948	854				6 68		35 16	290	7 45		2 48	3958													5
7				11125	854				241					15 8	6226	6 8		35 6	1311	7 25		5 08	3488	3787	7395	2874	1794	7034								6
8																6 89		35 9	1833	7 39		2 88	3225													7
9				1 373	307		7540									6 83		35 97	1763	7 34		2 37	3250	3048	8095										2900	8
																6 83		35 57	1700	7 38		3 28	3575													9
11				2 56	1 3											6 83		36 22	16 7	7 51		6 35	180	5574	7849											10
2																6 81		35 88	206																	1
13																6 79		35 83	355	7		5 77	387													2
14																6 79		36 03	16 0	7 48		7 28	4000													13
5																6 79		35 38	1732			8 73	4175													14
16				22 5	803		5004		9	1 2	79	1435				6 77		35 72	1515	7 5		9 76	4075		11789	32 8	949			5						5
17																6 81		35 71	1300	7 39		9 77	4012													16
											016	766				6 68		35 63	5 0	7 25		8 58	3762			4683	2826									17
19																6 66		35 87	1375	7 27		6 45	3000													18
20											000	808				6 67		35 63	1527	7 2		6 45	3000			3840	2342									19
21				22855	14				507	10 7	520	1300		3 7	10450	6 67		34	1408	7 2		7 94	3125		11290	370	2290			54						20
22											016	766				6 69		35 3	1402	7 05		9 98	2975			4683	2826									21
23																6 69		35 94	1460	7 0		8 53	2575													22
24											972	583				6 74		36 11	2 17	7 01		11 58	2550													23
25				2786												6 7		35 21	271	7 25		13 07	2850		10881	2940	704									24
26																6 7		35 68	1367	7 13		12 8	2475													25
											990	1525				6 82		35 4	866	7 2		13 12	2425													26
28				19842	95				582					1 2	10873	6 73		35 2	976	7 25		12 56	2675		10347	27	973			.38						27
29											2886					6 71		35	600	7 08		15 13	2475													28
30				10 97												6 71		34 87	730	7 09		13 82	2425		9581											29
3																6 71		33 9	645	7 08		13 135	2325													30
																		33 3	559	6 9		16 225	1975													
				734 3	3,30		7938 333		631 8	10 9	84 667	010 875		17 9475	8216 333	6 7 7		35 02 94	355 323	7 262759		84 6667	3293 167	4759 6	9372 2	576 37	7213	7084		54 3333					2189	

	BIOGAS		UASB SP#1		UASB SP#3		UASB SP#4		UASB SP#5		AER ANF		CLARIFIER EFFLUENT						SAND FILT		pH ANF		pH ANK #2		FINAL EFFLUENT											
date	Flow	Comp	TSS	SS	TSS	VSS	TSS	VSS	TSS	VSS	pH	TSS	Flow	TSS	NH4	TBOD	DO	TSS	pH	TSS	pH		pH		Flow	pH	SCOD	TCOD	SS	TKN	NH4	TP	TBOD	TDS		date
	m³/day	CH4 %	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	SU	mg/l	m³/day	mg/l	mg/l	mg/l	mg/l	mg/l	SU	mg/l	SU	°C	SU	°C	m³/day	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
1	5 217																																			1
2	5 073																																			2
3	3 C																																			
4	2 327																																			4
	1 722																																			
6	2 45																																			6
7	3 72																																			7
8	6 527																																			8
9	5 328																																			9
10	5 9 3		46	2567	1 62	70718	77782	4017	14 3	2440																										10
	06																																			1
	5 775																																			12
3	6 414																																			13
	7 788																																			
5	5 49																																			15
	5 4																																			16
7	6 9 3		49	2 19	[illegible]	7 5	12294	[illegible]	672 C	377 5																										7
8	8 504																																			1
	9 2		3C	.05	450	77320	5721	3483	16	2779																										9
	7 9 2																																			20
21	6 99		306	2309	1 40	1 0	[illegible]	6628	6 EC	37715																										21
	7 716																																			2
	6 5 7																																			3
	1 3																																			24
/	1 4																																			25
	2 8																																			26
	7 3		7 C	.61	2 4	3 6	6183	3.C	8 0	4907																										2
6	3 944																																			28
7	3 353																																			29
	3 364																																			30
3	2 19																																			
	97 3		4	2 3	0	6078	2194 8	7082	3 33	7																										

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…re 3 Analysis results and monitoring data for pretreatment plant during august 199

Day	Influent raw waste: VF (meq/l)	Alk (mg/l)	pH	CL (mg/l)	SCOD (mg/l)	TBOD (mg/l)	SBOD5 (mg/l)	TN (mg/l)	NH4 (mg/l)	N (mg/l)	TSS (mg/l)	VSS (mg/l)	PO4 (mg/l)	T-P (mg/l)	TDS (mg/l)
1															
2															
3				[illegible]	[illegible]									[illegible]	
4															
5				8078		2392									
6															
7															
8															
9															
10															
11															
12				6764	15,?07	785			570	30	5.4	1176		47	9567
13															
14															
15															
16															
17															
18															
19				9008	?80	?820			0	0	983	432		42.5	
20															
21															
22															
23															
24															
25															
26				23704	9737		4356		588	0	878	812		16	9.00
27															
28															
29															
30															
31															

Day	Cond. anal: pH (SU)	TCOD (mg/l)	T (°C)	flow	pH		UASB reactor effluent: VF (meq/l)	Alk (mg/l)	SCOD	TCOD	TS (mg/l)	VS (mg/l)	TDS (mg/l)	NO3 (mg/l)	NH4 (mg/l)	TN (mg/l)	(mg/l)	PO4 (mg/l)	TP	TBOD5 (mg/l)
1	[illegible]		30.3		[illegible]		16	97												
2	6.7		33.1	.4	6.99		13.7	2050												
3	3	[illegible]	[illegible]		7.0		10	9.5				[illegible]			C					
4	6				[illegible]			1												
5	6.7	8028	33.2	568	6.76		11.8	00		7988	900	50			150			512		
6	6.83		33.1	600	6.75		12.8	1600												
7	6.8	9725	33.4	629	6.80		12.8	1675		7000	45?	3000			500			97		
8	6.9		33.5	618	5.78		11	1450												
9	6.8		33	6	6.8?		6.2	182?												
10	6.1	9498	33.8	879	6.98		8.7	1825		9731	2432	1600			742			292		
11	6.8		36	919	6.9		11.78	1550												
12	6.8	7?59	32.5	9.8	6.8?		10.73	1.50		6733	2.52	868			690			3.05		
13	6.82		32	976	5.8		1.77	1500												
14	6.82	92?3	32.4	830						7524	3.27	169?			E 3			150		
15	6.81		33.5	669	5.89		16.28	62?												
16	6.83		32.9	959	5.83		16.78	1775												
17	6.82	10 40	32.5	07	5.83		9.83	1600		9.70	400?	?333			62			336 E		
18	6.81		32.8	914	5.87		15.52	1763												
19	8.82	7878	33	92?						7244	?65	1384			?60			5.8		
20	6.8		32.8	835	6.88		14.03	1650												
21	6.8	9538	33	872	6.75		18.84	537		9094	3362	1958			258			529		
22	6.8		33.6	900	6.92		16.05	1637												
23	6.82		33.3	935	6.84		2.2?	750												
24	6.86		33.8	920						13287	098	700			465			503		
25	6.82		32.8	1032	6.82		16.8?	1676												
26	6.81	16641	33.4	946	6.76		17.31	1612		116.0	3148	1866			675			372		
27	6.81		33	92																
28	6.8		34.5	935	6.78		1.6	1625		9520	4053	2417			800			342		
29	6.8		33.8	860																
30	6.82		33.6	870																
31	6.8	10305	33.8	860	6.8		8.08	588		9450	1880	22.0			900			?2		

Day	Biogas: flow (l/day)	Conc. CH4	UASB SP#2: TSS (mg/l)	VSS (mg/l)	UASB SP#3: TSS (g/l)	VSS (mg/l)	UASB SP#4: TSS (mg/l)	VSS (mg/l)	UASB SP#5: TSS (mg/l)	VSS (mg/l)	AER. ANK: pH (SU)	TSS (mg/l)	Clarifier effluent: flow (day)	TSS (mg/l)	NH4-N (mg/l)	TBOD5 (mg/l)	TCOD (mg/l)	W.S.: TSS (mg/l)	S.C.: pH	TSS (mg/l)
1	2.49																			
2	2.1																			
3	2.13		?5304		48.4		10.65		609?											
4																				
5	1.5																			
6	2.2																			
7	2.9																			
8	2																			
9	2.5																			
10	2.4		8E.20	72989	0.?	2100	8.7	.6	7393	38?9										
11	2.5																			
12	3.1																			
13	3.6																			
14	2.6																			
15	3.1																			
16	2.7																			
17	1			53306	[illegible]	5.33	?1		6??8	3.5										
18																				
19	2.3																			
20	5																			
21	3.6																			
22	3																			
23	3.5																			
24	3		7.3	2.481	13.?	7570	6?	+	6?	[illegible]										
25	3.5																			
26	3																			
27	7																			
28	3.9																			
29	3.6																			
30	3.6																			
31			9.?	5.84	[illegible]	?9008	733		??3	79										

Day	pH ANK #1: pH (SU)	T (°C)	pH ANK #2: pH (SU)	T (°C)	Final effluent: pH (SU)	SCOD (mg/l)	COD (mg/l)	TSS (mg/l)	VSS	TKN (mg/l)	NO3 (mg/l)	NH4 (mg/l)	TP (mg/l)	TBOD5 (mg/l)	TDS (mg/l)
1															
2															
3															
4		24.7	10.7	82											
5	11.3	7.71	7.8	?0		150	7964	732	9	146.8	4.5		6	1330	[illegible]
6	11.15	30.15	7.2	29.1											
7	1.0	25.8	04	24											
8	1.8	29.3	7.1	27											
9	11.24	30.1	7.9	27.8											
10	0.8	29	7.1	27.4											
11	10.9	30.1	7.23	29.5											
12	10.93	30.17	7	?8.4		353	6	938	7?2		2	3		9.8	9?.3
13	10.92	28.7	7.23	?8.3											
14	1.04	29	7.?8	34.8											
15	11.16	?8.7	7	2?.7											
16	1.04	26	7.05	26.9											
17	11.0?	26.3													
18		2?	7.0	?5.5											
19		?9.3	7	6		[illegible]	6.7	73	3		0	?9?	8	?8	
20	1.2	28	7.04												
21	1.1	3.8	7	?0											
22	[illegible]	28.4	7.04	?3.7											
23	1.4	3	6	??.8											
24	11.0?	29	7.27	?5.5											
25	9	27		3.?											
26	1.9	27	7.3	2		6	69	7?	63		(	39?	62	9	100?C
27	11.0?	7	7.3?	[illegible]											
28	1.0?	27	7.4												
29	11.2	?6.6													
30	1.04	29.6	7	5											
31	?3	29		[illegible]											

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Table Analysis results and monitoring data of pretreatment plant during september 1997

INFLUENT RAW WASTEWATER

Date	VF	Alk	pH	TCOD mg/l	SCOD mg/l	TBOD5 mg/l	SBOD5 mg/l	TKN mg/l	NH4 mg/l	NO3 mg/l	TSS mg/l	VS mg/l	PO4 mg/l		TDS mg/l
1															
2				33	14.3		6233		91		2Y	7.4			10452
4															
5															
6															
7															
8															
9				14.05	1.404		4..0		7.0	0	0.0	853		40	10233
10															
1															
12															
13				1.895	134.1										
1															
15															
16				8.02	.83		1305		70	0	938	886	109		
17															
18															
19															
20															
21															
22															
23				62	4.5		784		125	0	1847	1037	46		5464
24															
25															
26															
27															
28															
29															
30				3694							1073	953		5.2	9463
31															

Cond.

Date	pH	TCOD mg/l	
1	6.8		33.3
2	6.8	9.43	32.8
4	6.9	9.47	32.6
5	6.92		33.2
6	6.88		32.8
7	6.83	8009	33.21
8	6.84		33.5
9	6.85	7748	34.5
10	6.86		33.2
1	6.85	73.8	33
12	6.85		32.6
13	6.85		32.7
1	6.85	6432	33.8
15	6.86		33.7
16	6.85	17.85	32.9
17	6.86		32.9
18	6.85	5912	32.9
19	6.85		32.8
20	6.85		32.6
21	6.85	6675	33.1
22	6.85		33.5
23	6.85	8371	33.2
24	6.86		33.3
25	6.85		32.9
26	6.85		32.7
27	6.8		33.1
28	6.5	62	32.8
29	6.86		32.8
30		6475	
31			

UASB REACTOR EFFLUENT

Date	Flow m3/day	pH SU		VF mg/l	Alk mg/l	SCOD	COD	TSS	VSS mg/l	TDS mg/l	NO3 mg/l	NH4 mg/l	TKN mg/l		PO4-P mg/l	TP mg/l	TBOD5 mg/l
1	832	7		6.88	450												
2	907	6.92		15.77	17.0		8000	--	880	0.76		1000					
4	828						85.4	2.34									
5	900																
6	1053																
7	1339	5.85		13.78	1750		7.0	19	2143	39.3		645			467		
8	1400	5.88		15.73	1950												
9	1488	6.82		17.22	2050		7709	2905	557			920					
10	925																
1	408						61.6	[illegible]	1467			60			388		
12	419																
13	1419	7.04		13.69	2075												
1	09	7		0.84	2200		64.3	.64	798			125			327		
15	1458			8.62	2750												
16	69	7		11.87	2200		.4 7	902	744			355			176		
17	1454																
18	1435	7.06		11.61	2400		5028	090	682			685			120		
19	1 80																
20	1361	7.12		12.6	2450												
21	1458						5599	350	2017						196		
22	1394	7.2		6.01	2550												
23	1465	7.11		10.56	2500		19	084	016			1075			90		
24	3	7		9.58	2500												
25	1450																
26	1 7																
27	145_																
28	70						4913	3034	1463			673			20		
29	1474																
30	1431						8226	944	1763	5920		703					
31																	

BIOGAS / UASB SLUDGE / AE TANK / CLARIFIER EFFLUENT / SAND FILT.

Date	BIOGAS Vol. m3/day	BIOGAS Conc. %	UASB SP#2 TSS mg/l	UASB SP#2 VSS mg/l	UASB SP#3 TSS mg/l	UASB SP#3 VSS mg/l	UASB P## TSS mg/l	UASB P## VSS mg/l	..2 ... TSS %	..2 ... VSS mg/l	AE TANK pH SU	AE TANK TSS mg/l	CLARIFIER EFFLUENT Flow m3/day	CLARIFIER EFFLUENT TSS mg/l	CLARIFIER EFFLUENT NH4-N mg/l	CLARIFIER EFFLUENT TBOD5 mg/l	CLARIFIER EFFLUENT COD mg/l	W TSS mg/l	SAND FILT pH SU	SAND FILT TSS mg/l
1	2																			
2	3.8																			
3																				
4	3.4																			
5	3.7																			
6	2.9																			
7	4.8		7.0	78100	1606	78990	429	2443	828	2383										
8	4.5																			
9	5.6																			
10	4.1																			
11	4.2																			
12	3.5																			
13	5																			
14	4.7		17?447	87200	0.785	6323	357	900	3.5	1915										
15	8																			
16																				
17	6																			
18	8																			
19	6.2																			
20	5.9																			
21	5		77.43	47580	79?.4	5.350	44	79.3	7	378										
22	(																			
23																				
24	6.5																			
25	9																			
26	6.5																			
27	6.1																			
28	5		347.0	5802	1?..	7?785	3.0	1	3467	433										
29	5.6																			
30	5																			
31																				

pH ANF / pH TANK #2 / FINAL EFFLUENT

Date	pH ANF pH SU	pH ANF °C	pH TANK #2 pH SU	pH TANK #2 °C	FINAL EFFLUENT pH SU	SCOD mg/l	TCOD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	NO3 mg/l	NH4 mg/l	TP mg/l	TBOD5 mg/l	TDS mg/l
1	1	28	9.52	26.1											
2	11.2	28	08	25.4		334	6708	2690	146_			413		_50	4406
3	1		9	25.4											
4	1.04		6.86	26.3											
5	10.95		7.1	25.6											
6	10.66	28	6.62	23.8											
7	1.08	28.9	7.22	2											
8	10.73	25.6	7.12	24.3											
9	3	29	5	24.8		768	6894	2363	393		0	.0.	300	819	1 1.3
10	11.14	26.6	7.5	3											
11	11.3	26.5	7.1	24											
12	11.15	27	7.23	2											
13	11.18	28.3	7.24	3.65											
14	1	30.5	7.16	24.6											
15	11.32	26.7	5	8									T PO4	SBOD	
16	11.1	?8	7.16	24		~	6.4	~C	/	—	—	—	13_	670	31?C
17	9?	28	7.08	3.6											
1	1.2	26.8	7.27	?6.3											
19	11.72	28	7.6	3.8											
20	1.05	28	7.13	22.8											
21	10.81	27	7.17	23.2											
22	11.06	29	7.79	2											
23	10.94	26	7.24	21			[illegible]	0					1	46?	[illegible]
2	1.0	20	7.06	20.3											
25	10.9	?5.7	7.16	3.7											
6	11.1	25	0	22											
27	1	27	7	??.7											
28	2	?5	7.11	3.4											
?9	1	4	6.94												
0						1	.4 2	?0	9			3	2		4?C
3															

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Table 5 Analysis results and monitoring data for pretreatment plant during october 1997

Date	INFLUENT RAW WASTEWATER VF	Alkal	pH	COD	SCOD	TBOD	SBOD	TS	NH4	NO3	TSS	VSS	PO4-P	P	TVS	Cond. pH	Cond. COD	T
	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	g/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	SU	mg/l	°C
																6.85		32
2																6.83	6253	32.7
4																6.85		32.7
5																6.85	5222	32.8
6																6.85		32.5
7				16312	12065		1953		6.0	0	905	816			8530	6.86	6262	32.5
8																6.88		32.7
9																6.85	6395	32.5
10																6.85		32.3
1																6.85		32.8
12																6.85	5353	33
13																6.85		32.2
14				17495	13253				745	0	034	848		21	94.2	6.8	1 490	32.8
15																6.8		33.1
16																6.8	8895	32.3
17																6.8		33.7
18																6.8		32.7
19																6.8	329	33.5
20																6.8		33.2
21				94.3	7836		3348		652	0	188	934		32	5877	6.81	5751	33.4
22																6.8		33.5
23																6.8	11613	33.3
24																6.8		33.4
25																6.8		33.3
25																6.8	9064	33.4
27																6.8		32.3
28				4522	11 40		5343		655		804	413		5.2		6.8	5388	33.4
29																6.8		33.2
30																6.8	5971	
31																6.8		33

Date	Flow	pH		UASB PEAK OF EFFLUENT VF	Alkal	SCOD	TCOD	TSS	VSS	TDS	NO3-N	NH4	TKN		PO4	TP	TBOD
	m3/day	SU		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	141																
2	133						8234	3090	1700			610			358		
4	1447																
5	1474						8029	15368	5470			750			328		
6	1377																
7	1498						7058	1876	5472			782			392		
8	1442	7.03		0.7	75												
9	490						58.3	3207	1647			630			384		
10	1435																
1	1420	6.99		2[illegible]	[illegible]5												
12	1485						000	627	267			675			371		
13	1474	0		9.2	875												
14	1459	5.94		9.2	925		8549	3920	1820			695			330		
15	1492																
16	1550						7.23	34.0	804			715			394		
17	1096																
18	1000																
19	135	6.8		6.78	375		5029	2142	414			707			428		
20	1367																
21	1440						4707	3000	1497			610			438		
22	1,00																
23	1459						8129	2274	1269			645			284		
24	484																
25	1459																
25	1474						8219	1148	340			573			378		
27	1435																
28	1475						5768	3956	2383			638			438		
29	1460																
30	[illegible]						6049	3044	1937			708			578		
31	7																

Date	BIOGAS Flow	Conc	UASB SP#2 TSS	VSS	UASB SP#3 TSS	VSS	UASB SP#4 TSS	VSS	UASB SP#5 TSS	VSS	AER TANK pH	TSS	CLARIFIER EFFLUENT Flow	TSS	NH4	TBOD	TCOD	W.S. TSS	SAND FILT pH	TSS
	m3/day	CH4	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	SU	mg/l	m3/day	mg/l	mg/l	mg/l	mg/l	mg/l	SU	mg/l
1	5.8																			
2	5.8																			
4	6																			
5	5.5		253780	70565	95094	54	4317	[illegible]	4077	1983										
6	5.6																			
7	6.3																			
8	5.9																			
9	6																			
10	5.5																			
11	4.9																			
12	5		11750	6547	7 010	45225	539[illegible]	[illegible]	2220	93										
13	5																			
	5.9																			
15	5																			
16	4.9																			
	4.7																			
8	5																			
19	3		07 8	1163 1	55290	208 0	622	4	7417	[illegible]										
20	3.3																			
2	6																			
22	3																			
23	6																			
2	6																			
5	6																			
26	6		817 0	40113	190210	87730	3.84	96	3824	[illegible]012										
27	6.7																			
28	7																			
29																				
30																				
	6.4																			

Date	pH TANK pH	°C	pH TANK #2 pH	°C	FINAL EFFLUENT pH	SCOD	TCOD	TSS	VSS	TKN	NO3	NH4	TP	SBOD	TDS
	SU	°C	SU	°C	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	1	23.7	7.02	22.5											
2	11.09	23	7.32	22											
	0.96	24.4	7.36	22.4											
4	0.9	23	94	24											
5	11.13	2	7	22.7											
6	11.24	2[illegible]	7.1	23.2											
7	1	24	7.5	24		3535	323	109[illegible]				307.5	297	349	1,403
8	11.3[illegible]	24.4	7.[illegible]9	23.8											
9	1 23	25.7	7.72	23.7											
10	1 5[illegible]	[illegible]5.2	7	23.9											
11	11.6	25	7.96	23											
12	11.2	25.2	7.5	24.1											
13	1.55	[illegible]3	7.95	22.5											
	11.72	27.4	8	25.6		9.1	416	10.8	468			388		02	8460
15	2	27	8	25.2											
16	11.14	2[illegible].5	7.[illegible]	[illegible]8.8											
	1 24	[illegible]8	7	27.2											
8	0[illegible]	2[illegible]	7	2 7											
19	11 7	4	7	22											
20	11 8	38.4	7.5	2 9											
2	03	51.7	3	20.8		333		20[illegible]	7		C	383	[illegible]C3	3	17540
22	11.07	[illegible]	7.07	1.7											
23	11.09	50	7.5	6											
2	6	0	7	2.5											
5	11.01	51	7.07	3.6											
[illegible]	11.1	8	7	4.1											
27	1 b	02	1	3.9											
28	11.9[illegible]	3	03	3.9		7644	[illegible].0	1.1	13.C			4.[illegible]3	291	34	
29	2.2	3.5	7.05	5.7											
30	2.27	[illegible]	0[illegible]	7											
	12.27	1	0[illegible]	5											

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Table 6 Analysis results and monitoring data for pretreatment plant during november 1997

Date	INFLUENT RAW WASTEWATER VF (m3/day)	Alkal (mg/l)	pH (SU)	COD (mg/l)	SCOD (mg/l)	TBOD5 (mg/l)	SBOD5 (mg/l)	TKN (mg/l)	NH4 (mg/l)	NO3 (mg/l)	TSS (mg/l)	VSS (mg/l)	PO4-P (mg/l)	T-P (mg/l)	TDS (mg/l)	Cond tank pH	TCOD (mg/l)	T (°C)	Flow (m3/day)	pH (SU)	~	UASB REACTOR EFFLUENT VFA (mg/l)	Alkal (mg/l)	SCOD (mg/l)	TCOD (mg/l)	TSS (mg/l)	VSS (mg/l)	TDS (mg/l)	NO3 (mg/l)	NH4 (mg/l)	TKN (mg/l)		PO4 (mg/l)	TP (mg/l)	TBOD5 (mg/l)
1																6.8		33.5	1430																
2																6.8	6275	33	1419						64.2	07	2444			46			1050		
3																																			
4																6.81		33	1423																
5																6.8		33.5	1426																
6																6.8	14949	31.2	1480						11415	2293	1400			00			1040		
7																6.8		31.7	1480																
8																6.8		33.3	1441																
9																6.8	9435	33.1	1175						5893	340	2940			380			1000		
10																6.8		33.3	1378																
11				183.2	14045		7.36		560	0	2650	1800		3.9	14140	6.8	9539	33.1	1476						7805	3493	1800			420			870		
12																6.8		33.6	1315																
13																6.8		33.6	1222																
14																																			
15																6.82		31.5	709																
16																6.8		31.8	1180																
17																6.81		31.2	1100																
18				17536	12022		5901		534	0	2120	1400		4	129.6	6.81	7219	33.1	1440						5265	10300	6810			626			163.4		
19																6.8		33	1469																
20																6.8		32.6	1420																
21																6.8		32.4	1400																
22																6.8		19.33	1419																
23																6.81	7.78	18.1	1467						7.98	762	1100			800			690		
24																6.81		16.9	1400																
25				8443	739		4851		575	0	1150	680		13.7	11830	6.81	9165	16.7	1393						7500	28.7	1742			770			872		
26																6.8		32.2	1429																
27																6.8		33.1	1322																
28																6.81		32.8	14 9																
29																6.8		32.9	1400																
30																6.81	6852	33	1420						7781	2727	600			803			235		
31																																			

Date	BIOGAS Flow (m3/day)	Conc CH4	UASB SP#2 TSS (mg/l)	UASB SP#2 VSS (mg/l)	UASB SP#3 TSS (mg/l)	UASB SP#3 VSS (mg/l)	UASB SP#4 TSS (mg/l)	UASB SP#4 VSS (mg/l)	UASB SP#5 TSS (mg/l)	UASB SP#5 VSS (mg/l)	AER TANK pH (SU)	AER TANK TSS (mg/l)	CLARIFIER EFFLUENT Flow (m3/day)	TSS (mg/l)	NH4 (mg/l)	TBOD5 (mg/l)	TCOD (mg/l)	W TSS (mg/l)	SAND FILT pH (SU)	SAND FILT TSS (mg/l)	pH TANK# pH (SU)	°C	Anaerobic #2 pH	°C	FINAL EFFLUENT pH (SU)	SCOD (mg/l)	TCOD (mg/l)	TSS (mg/l)	VSS (mg/l)	TKN (mg/l)	NO3 (mg/l)	NH4 (mg/l)	TP (mg/l)	SBOD5 (mg/l)	TDS (mg/l)
1	5.8																																		
2	5.7		293300	140240	9700	78700	5400	784	300	3300																									
3	5.9																																		
4	5.6																																		
5	6.6																																		
6	5.9																																		
7	6																																		
8	5.9																																		
9	5		21.1	9889	49560	29060	5000	3530	5000	3880																									
10	6.3																																		
11	6.8																																		
12	6.3																				0.3	50.5	7	9.1		3.2	5.8	809			0	400	6.6	147	10E10
13	6																				11	56.1	8	21.6											
14																					22	58.5	7.08	9.79											
15	1.1																				11.09	58	7	21.7											
16	5																				11.23	33	2	19.2											
17																					1	36.6	7	19.8											
18	4.2																				1	32	1	19.4											
19	7																				11	19	7.2	8.7		40.6	6.8	0	[illegible]		0	34	70	7.26	[illegible]
20	5.9																				1.17	16.7		16.8											
21	6.1																				11.07	15.7	7.05	17.2											
22	4.2																				11.03	18.9	7.06	19.4											
23	4.7		61429	162000	2045	2774	5.39	[illegible]	494	2700											1.0	17	7.0	16.9											
24	4.5																				11	17.7	[illegible]	7.6											
25	4.3																				1.2	16.2		6.5											
26																					04	6.7	1	6.2		7275	8190	1670	[illegible]		0	3.5	1.0	849	[illegible]
27	4.3																					15	80	18.4											
28	4.3																				7.22	18	7.57	17.9											
29	3.1																				7.2	8	7.23	6.9											
30	4		468333	280000	[illegible]	269	4740	[illegible]	370	2400											7.38	31	3	16.7											
31																					7	1.4	7.3	6											

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Table 7 Raw wastewater quality during june up to end of november

Date	Day	pH	TCOD	SCOD	$TBOD_5$	$SBOD_5$	TKN	NH N	NO_3-N	TSS	VSS	PO_4 P	T P	EC	TDS
		SU	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mS/cm	mg/lt
03 06 97	1		15765												
05 06 97	3		15590												
07 06 97	5		15789												
08 06 97	6	5 4													
09 06 97	7	5 54	16422												
10 06 97	8	5 49													
15 06 97	13	5 89	16298	12453											9602
17 06 97	15		21705	17879	10880										
18 06 97	16	5 76													
19 06 97	17		16389	14550											8260
22 06 97	20		16148	13976	7508					1692	1438				10534
24 06 97	22		19103	17434											
29 06 97	27		18562	17431						1450	1134				11440
01 07 97	29		17294	13725		11271		410					1 09		
03 07 97	31		18275	12610											
06 07 97	34		11125	8647				241					15 8		6226
08 07 97	36		17373	13072	-	7540									
10 07 97	38		21561	14361											
15 07 97	43		22145	14803		5004		439	11 2	2914	1485				
17 07 97	45									1016	766				
19 07 97	47									1000	808				
20 07 97	48		22855	14441				507	10 7	1520	1300		13 7		10550
21 07 97	49									1016	766				
23 07 97	51									972	583				
24 07 97	52		12766												
26 07 97	54									1990	1525				
27 07 97	55		19842	14983				1562					41 2		10873
28 07 97	56									2886					
29 07 97	57		10197												
03 08 97	62		8367	8318			456 6	448		587			16		4708
04 08 97	63														
05 08 97	65		8078		2392										
12 08 97	71		16264	15502	7857			570	30	1524	1176		470		9567
19 08 97	78		9008	7582	2820			410	0	983	492		42 5		
26 08 97	85		23704	19737		4356		588	0	878	812		1 6		9700
02 09 97	92		14033	11635		6233		900		826	754			7	10452
09 09 97	99		14106	11404		4550		710	0	1070	853		40	9 5	10233
13 09 97	103		14895	13451										7 5	
16 09 97	106		8502	5816		1305		430	0	1938	886	109		8 55	
23 09 97	113		6244	4293		784		1125	0	1847	1037	46		8 99	5464
30 09 97	120		13694					803		1073	963		5 2	8 3	9463
07 10 97	127		16312	12065		1953		630	0	966	816			8	8530
14 10 97	134		17495	13253				745	0	1034	848		21	9	9452
21 10 97	141		9413	7636		3348		652	0	1188	934		32	6 5	5877
28 10 97	148		14522	11140		5343		655		804	413		5 2	9 3	
11 11 97	162		16312	14049		7436		560	0	2650	1800		3 9	8 06	14140
18 11 97	169		17536	12022		5901		534	0	2120	1400		4	8 97	12916
25 11 97	176		8483	7391		4851		575	0	1150	680		13 7	9 95	11830
	No Samp	5	38	30	5	14	1	21	14	26	24	2	16	13	20
	Avg	5 6	15320 3	12522 0	6291 4	4991 1	456 6	642 6	3 7	1426 7	986 2	77 5	45 4	8 4	9490 9

Table 8 Comparison between actual raw wastewater quality and design figures

Parameter	Unit	Design	Actual		Actual / Design
			No of samples	Average value	%
pH		6 5	5	5 6	0 86
TCOD	mg/L	8230	38	15320	1 86
SCOD	mg/L	7557	30	12522	1 66
$TBOD_5$	mg/L	5400	5	6291	1 17
$SBOD_5$	mg/L	**	14	4991	
TKN	mg/L	871	1	457	0 52
NH_4 N	mg/L	290	21	643	2 22
NO_3 N	mg/L	**	14	3 7	
TSS	mg/L	660	26	1427	2 16
T P	mg/L	36	16	45	1 25
EC	mS/cm	**	13	8 4	
TDS	mg/L	**	20	9491	

* Design value is given in NH_3-N

** No value is given in design parameters presented in O&M manual

2 0 Introduction

2 1 Objective of pretreatment plant

The pilot-scale wastewater treatment plant constructed at the facilities of Jordan Yeast Industries Corporation (YIC), is used for technology demonstration as part of the Jordan Water Quality Improvement and Conservation (WQIC) project, under the United States Agency for international Development (USAID) contract Effluent from the pilot-scale treatment plant will be used for crop irrigation The pre-treatment system consists of anaerobic treatment, aerobic solids removal step, sand filtration, and ammonia stripping

The pilot-scale wastewater treatment system is intended to remove organic matter (5-day biochemical oxygen demand, BOD_5 or chemical oxygen demand, COD), suspended solids (SS) and ammonia nitrogen (NH_3-N) from process wastewater The key components of the system include raw wastewater holding tank, conditioning tank, UASB reactor, flow splitting tank, clarifier, sand filter, ammonia stripping tower, pH adjusting tanks, waste sludge holding tank, blowers, compressor, biogas handling system, nutrient feed system, and several pumps

2 2 Anaerobic treatment in UASB reactor

UASB technology is proven and widely used in several types of industries for BOD removal from wastewater's Anaerobic processes (in the absence of oxygen) such as the UASB are the most cost-effective technology used for BOD reduction of high strength wastes because they require less nutrients (chemicals), space, and energy to operate Anaerobic processes also produce usable energy in the form of methane gas Anaerobic processes also produces less sludge than aerobic processes thus reducing the quantity of sludge to be land applied Anaerobic systems also better withstand frequent as well as extended shutdowns compared to aerobic processes The anaerobic process involves degradation of high strength wastewater which is mediated by two main groups of bacteria acid formers (acetogens) and methane formers (methanogens) When wastewater passes up through a bed of active granular biomass in the UASB reactor, the organic (BOD) are quickly converted mainly into biogas The biogas and biomass are separated from the treated wastewater in a settler built into the reactor The treated wastewater exits the UASB reactor near the top The anaerobic process is designed to achieve about 90 percent BOD_5 removal and 70 percent chemical oxygen demand (COD) removal under the design average conditions The anaerobically treated wastewater undergoes further polishing before discharge

2 3 Aerobic process

Anaerobic treatment effluent contains a high concentration of suspended solids Further processing of the anaerobic effluent is required to meet effluent solids and ammonia nitrogen limits High solids in the anaerobic effluent would have a tendency to plug the media in the ammonia stripping tower The aerobic process provides a treatment step for changing the characteristics of the solids in the anaerobic effluent in the clarifier Solids separated in the clarifier are wasted

2 4 Sand filter

Clarifier effluent may still contain some solids that could affect the performance of the ammonia stripping tower The sand filter aids in removing additional solids prior to ammonia stripping The multimedia sand filter consists of four types of media and a staging timer for operation of the backwash system As the clarifier effluent flows across the media from top to bottom , the solids are trapped in the media Filtered effluent is forced out through a pipe at the center of the filter When the system is backwashed, liquid is forced through the effluent pipe and flows upwards carrying the trapped solids to the top and out of the filter through the backwash pipe

2 5 Ammonia stripping

Raw wastewater contains a high concentration of ammonia nitrogen in addition to organic nitrogen The ammonia stripping tower aids in stripping ammonia from the anaerobic effluent It should be noted that only nitrogen in the ammonia form can be stripped off in the tower Optimum stripping requires that the influent pH be maintained around 11 0 S U The tower influent and effluent pH are adjusted in pH adjustment tanks The sand filter effluent is sprayed at the top of the random media in the ammonia stripping tower A blower forces air from bottom to top. As liquid trickles down over the media, ammonia is stripped off from the liquid and transferred into the air flowing upwards

3 0 Treatment process description

3 1 Feed preconditioning

Process wastewater is conveyed to the raw wastewater holding tank from storage tanks From the raw wastewater holding tank, the wastewater metering pump transfers the wastewater to the conditioning tank In the conditioning tank, the pH the wastewater is adjusted, required nutrients are added and the temperature is raised to 32°C The heated and conditioned wastewater is then pumped to the UASB The operational goals for conditioning the raw wastewater include maintaining wastewater temperature in the 30 to 34°C range, maintaining reactor influent pH at a suitable value which ensures an optimal reactor effluent pH of 6 8 to 7 2 S U, and supplying adequate macro- and micro-nutrients The temperature of the incoming wastewater is raised to the required range by an electric heater installed in the conditioning tank The operation of the heater is controlled by a thermocouple The wastewater pH is controlled by adjusting the amount of potassium hydroxide or other hydroxides other than calcium hydroxide added by one of the two caustic metering pumps Macro nutrients, nitrogen and phosphorus should be maintained at a COD N P ratio of 500 7 5 1 in the UASB influent for optimum treatment Based on the available data sufficient nitrogen is present in the Jordan YIC wastewater Micronutrients should be added in adequate quantities The wastewater should be analyzed to determine those nutrients that are adequately present in the wastewater Chlorides of the required cations are generally used to prepare a micronutrient solution that is pumped by a metering pump

3 2 Upflow anaerobic sludge blanket reactor

In the Upflow Anaerobic Sludge Blanket Reactor (UASB) reactor, the waste stream flows upward through a blanket of biological sludge granules Treatment occurs during biomass and organic matter contact as the wastewater flows upward through the suspended sludge blanket Gas production causes internal circulation, aiding the formation and maintenance of the biomass blanket As the gas rises, it attaches to some sludge granules, causing them to rise up through the liquid When the granules collide with biogas collection assemblies biogas is released from the granules, and the separated granules typically fall back to the top of the sludge blanket Residual solids are separated in the internal clarification zone, and also fall back on top of the sludge blanket The UASB process is susceptible to high levels of difficult to degrade oil and grease (FOG) (maximum allowed 75 mg/L) and TSS (maximum allowed is 15 percent of influent COD concentration) which can hinder biological contact and decrease the efficiency of the reactor However, the FOG and TSS concentrations below the stated maximum limits generally do not pose problems One advantage of the UASB is that its hydraulic retention time is typically half that of an anaerobic filter, and therefore the reactor is smaller Another advantage is that the internal clarification zone eliminates the need for downstream clarifier for solids separation as in the anaerobic contact process The treated effluent exits the reactor near the top and flows into a flow splitting tank The flow splitting tank allows for some of the UASB effluent to be recycled back to the conditioning tank Biogas produced during anaerobic treatment will be measured and vented Excess biomass generated in the UASB is periodically pumped to the sludge holding tank

3 3 Aerobic process

The aerobic treatment step consists of an aeration tank and a clarifier and is designed for gross separation of solids from the anaerobic effluent The process is designed to change the characteristics of the solids such that they can be separated in the clarifier The process is not designed for additional carbonaceous matter removal or for nitrification In fact , it is designed for a very short detention time to prevent nitrification so that ammonia can be effectively stripped off in the ammonia stripping tower

3 4 Sand filtration

The sand filter is designed to remove solids in the clarifier effluent that may other wise plug the ammonia stripping tower The multimedia sand filter include a backwash system and a staging timer for backwashing the unit on a set schedule

3 5 Ammonia stripping

The ammonia stripping tower is designed to strip ammonia present in the tower influent The amount of ammonia stripped increases with pH and the amount of air supplied The tower is designed for 90% ammonia removal at a pH of 11 S U The pH of the wastewater before and after ammonia stripping is adjusted in separate pH adjustment tanks The pH before the ammonia stripping tower should be maintained in 11 to 11 20 S U range Above this pH ammonia stripped remains fairly constant But below 11 S U the rate of ammonia stripped decreases and hence to maintain optimum conditions it is necessary to maintain the pH in the required range

4.0 General operating conditions maintained throughout period of operation

4 1 Conditioning tank and UASB reactor

The following operating conditions and parameters have been maintained during the initial start-up and operation of the UASB reactor

• pH range of conditioning tank	6 8 - 7 2
• Temperature of conditioning tank	33 - 37 °C
• Total feed rate to the reactor	7 0-7 5 lit /min
• VFA range of UASB effluent	< 1 meq/lit
• Temperature of UASB	35 ± 2 °C
• UASB pH	Neutral
• Fe as micro nutrient	5 mg/lit

Unfortunately the above figures were not quite the correct ones After several discussions, the following parameters were modified to become

• Temperature of conditioning tank	30 - 34 °C
• Fe as micro nutrient	100 mg/lit
• Optimum VFA range	5 - 10 meq/lit
• Normal operation range	5-15 meq/lit
• Alkalinity	Consistent
• UASB effluent Residual P as Ortho Phosphate	10-15 mg/lit

Above conditions have been maintained through out the whole operating period after modification took place Because of the conditioning tank heater failure, the temperature fluctuates in some operation days before it has been finally fixed

The maximum hydraulic load to the reactor could not exceeded 1 5 m^3/day for reason discussed in another part of this report

4 2 Ammonia pH adjustment tanks and stripping tower

Stripping of ammonia took place at ambient temperature during the initial stage of experiment At later stages the temperature has been raised to above than 60° ahead of the stripping tower to examine ammonia stripping efficiency versus temperature of wastewater

5 0 Operational problems and corrective actions

5 1 Raw wastewater conditioning

As it is explained in the process description of pretreatment plant, raw wastewater is pumped from holding tank to a conditioning tank where it is mixed with part of the UASB effluent Before the mixture is pumped back to the UASB for treatment anaerobically, it should be conditioned in terms of pH, temperature and macro and micro nutrients

5 1 1 pH adjustment

Neutral conditions should be maintained in the UASB reactor Thus pH in the conditioning tank should be maintained to keep the UASB effluent pH 7 0 to 7 2 The earlier design expected that the UASB effluent pH will be acidic and less than 6 8, thus the system has been provided by caustic dosing pump to maintain the pH as recommended but at steady state conditions of the reactor the effluent pH was above 7 2 Thus it was recommended to use the nutrient pump to inject phosphoric acid into the conditioning tank to prevent the UASB pH from reaching elevated levels that might effect the performance of the reactor Actually this point was the reason behind the loss of almost half the amount of the initial biomass content of UASB reactor before the pH was forced down to neutral conditions by acid injection

5 1 2 Heating

As required by design, it is recommended to maintain the UASB reactor temperature at the mesophylic range or 33 - 37°C and later on 30 - 34°C , thus a 15 kW electrical heater is installed in the conditioning tank to heat its contents to the required temperature range The material of the heater could not stand the very corrosive environment of the conditioning and for this reason the heater failed in the last week of October This should be considered in any future design works Locally fabricated heater has been installed in the conditioning tank to replace the failed heater But it failed also so many times The material of the locally fabricated heater was copper Finally it has been decided to install a steam line between the YIC boilers and the pretreatment plant and permanent duplex St St heaters were installed in both conditioning tank and ammonia stripper

5 1 3 Nutrients addition

As it was explained earlier, ferric chloride addition has been found necessary Thus and other than macro nutrient dosing system that is already provided with the system, it is recommended to have another dosing 'system for micronutrient addition such as ferric chloride which has been found to be of great benefit in maintaining the biomass in the reactor for extended periods of times through minimizing disintegration of biomass granules

5 2 UASB reactor

Since the start-up of the UASB reactor in June up-to end of august the performance of the reactor fluctuates due to many reasons The most important one is the continuos loss of the biomass from the reactor due to disintegration This loss of biomass has been minimized by controlling pH of the UASB and by addition of ferric chloride Thus within the first week of September, the UASB reactor started to show steady state conditions with maximum hydraulic load of 1500 L/day The performance of the UASB reactor since July 1st up-to end of November, 1997 is shown in Table-11 In Table-12, the biomass content of the reactor is presented The maximum biomass content of the reactor did not exceed 50 to 60 kg Thus, the hydraulic load applied to the reactor will not exceed 1500 to 1800 L/day

5 3 Aeration

Before the wastewater is pumped to the clarifier, it is aerated to enhance the settlement of the anaerobic sludge It has been noticed that precipitation of a hard material is taking place within the aeration tank This precipitate is most likely ferric phosphate but it has not analyzed yet to confirm this

5 4 Sand filtration

Sand filter' is intended to remove suspended solids ahead of the ammonia tower Since the date of ferric chloride addition and the appearance of the previously mentioned hard precipitate, the filter feed centrifugal pumps started to loose its efficiency before it completely failed and failed The pump has been repaired and the impeller has been replaced A decision has been made not to use centrifugal pump and to replace it with an air operated diaphragm pump which was already available on site Another problem that has been faced was the failure of the automatic head of the filter which has been replaced with a manual one with isolation ball valves

5 5 Ammonia stripping

Under ambient temperature and without preheating the ammonia overall removal efficiency of the tower did not exceed 46% After a heater has been installed prior to the tower to preneat the wastewater up-to 60°C, the removal efficiency may increase This may be discussed in the final evaluation report when data for December, 97 and January, 98 are included

6 0 Theoretical process design.

6 1 Design characteristics

The UASB reactor has been initially designed to treat influent wastewater with the following characteristics

Table - 9 INFLUENT WASTEWATER CHARACTERISTICS UASB REACTOR		
Parameter		**Design Average**
Flow	lpd	6000
	lpm	4 2
BOD	mg/L	5400
	kg/d	32 4
TCOD	mg/L	8230
	kg/d	49.4
SCOD	mg/L	7557
	kg/d	45 3
TSS	mg/L	660
	kg/d	4
TKN	mg/L	871
	kg/d	5 2
NH3-N	mg/L	280
	kg/d	1 7
Phosphorus	mg/L	36
	kg/d	0 22

6 2 Effluent Requirements

The design effluent quality for the entire pilot-scale treatment system is as below

Table - 10 EFFLUENT REQUIREMENTS	
Parameter	**Removal (%)**
BOD	90
TCOD	70
SCOD	75
TSS	90
Ammonia-N	90 in Tower

6 3 Design Parameters

The Design basis for the treatment processes is presented in the following subsection

6 3 1 UASB Reactor

Table - 11 DESIGN PARAMETERS - UASB REACTOR	
Parameter	**Design value**
Digester volume, m^3	3 5
Recycle flow, % of plant influent flow	200-500
Hydraulic retention time, hrs	14
Total COD load capacity , kg/m^3 d	12-15
Influent soluble COD, % of influent Total COD	92
Total COD reduction, % of influent	70
Soluble COD reduction, % of influent	75
BOD reduction, % of influent	90
TSS reduction, % of influent	10-15
Total gas flow, m^3/d	9 2
Methane content, % by volume	70-80
Sludge produced, kg/d	2-3
VSS content in sludge, %	80
Solids concentration of sludge, % TSS	6-10

6 3 2 Aerobic Process

The aerobic process is designed for an influent flow rate of 6 cubic meters per day

6 3 3 Sand Filter

The sand filter is designed for an influent flow rate of 6 cubic meters per day

6 3 4 Ammonia Stripping Tower

The ammonia stripping tower is designed for an influent ammonia concentration of 600 mg/L Minimum conversion of organic nitrogen is expected in the anaerobic stage

7 0 Discussion of process design.

7 1 Quality of raw wastewater during experiment period as compared to design figures

All data presented in Table-7 represent quality of raw wastewater during the period of experiment up-to end of November 1997 From this table and from the design parameters presented earlier, quality of raw wastewater against design figures can be compared as shown in Table-8 Total dissolved solids is the most important parameter that was not mentioned in the design parameters

7.1 1 Total chemical oxygen demand and soluble chemical oxygen demand (TCOD & SCOD)

As shown in Table-8, the actual average TCOD value of raw wastewater is almost 1 9 times the design figure This fact was noticed in the earlier stages of the operation of the plant The pretreatment system was designed to remove almost 50 kg TCOD per day at the design concentration value of TCOD However this amount of TCOD can still be treated by the system but the volume that is possible to be treated shall be reduced to almost the half The design hydraulic load for the pretreatment system was 6 m^3/day, thus the maximum hydraulic load that can be treated shall not exceed 3 m^3/day. Actually, the maximum hydraulic load that the system was able to treat was only 1 5 m^3/day. The reason behind this reduced treated hydraulic load was the fact that the system was designed at F/M ratio of 0.5 (50 Kg TCOD for 100 kg of active biomass) assuming that the UASB reactor will contain 100 kg of biomass (VSS) but unfortunately only 50 kg of biomass were maintained during the experiment The reduced biomass content of the UASB is discussed in another part of this report Actual average value of soluble chemical oxygen demand (SCOD) is almost 1 7 times the design figure The ratio between actual values of SCOD/TCOD is 0.82 or almost 80% of total chemical oxygen demand is soluble

7 1 2 Total biochemical oxygen demand and soluble biochemical oxygen demand ($TBOD_5$ & $SBOD_5$)

Actual average value for $TBOD_5$ is very close to the design figure Nothing is mentioned about $SBOD_5$ in the design parameters The ratio between actual values of $SBOD_5/TBOD_5$ is 0 79 or almost 80% of total biochemical oxygen demand is soluble. The ratio between $SBOD_5$/SCOD is 0.4 or 40% of soluble chemical oxygen demand is biodegradable, also ratio between $TBOD_5$/TCOD is 0.4 or 40% of total chemical oxygen demand is biodegradable.

7 1 3 Macronutrients (NH_4-N & T-P)

The required ratio between TCOD N P as recommended in the initial design shall be 500 7 5 1 The actual ratio of raw wastewater and based on the actual average values for TCOD, NH_4-N and T-P is 500 21 1 5 during the experiment period subject to evaluation Thus micronutrients are present in sufficient amounts in raw wastewater based on average figures

7 1 4 Micronutrients

As shown in Table-12, analysis of UASB reactor effluent indicated presence of sufficient amounts of micronutrients such as K, Fe, Mg, Ca, Zn, Cu, Mn, Ni, Al, Co, Mo, S & Se

7 2 Recommended raw wastewater quality for future design works

Based on the data collected during the period of the experiment, the recommended raw wastewater quality that could be used for any future design works is presented in Table-13

7 3 UASB actual operating characteristics

The UASB reactor has been initially designed to treat influent wastewater with the characteristics shown in Table - 8 Table - 14 illustrates the actual operating parameters during the experiment period as compared to design ones

Table - 14 INFLUENT WASTEWATER DESIGN AND OPERATING AVERAGE CHARACTERISTICS - UASB REACTOR

Parameter		Design Average	Operating Average
Flow	lpd	6000	1500
	lpm	4 2	1 1
BOD	mg/L	5400	6291
	kg/d	32 4	9 4
TCOD	mg/L	8230	15320
	kg/d	49 4	23
SCOD	mg/L	7557	12522
	kg/d	45 3	18 8
TSS	mg/L	660	1427
	kg/d	4	2 1
TKN	mg/L	871	-
	kg/d	5 2	-
NH3-N	mg/L	290	643
	kg/d	1 7	0 96
Phosphorus	mg/L	36	45
	kg/d	0 22	0 07

Table 12 Micronutrients analysis and required amounts in UASB effluent

Parameter	Unit	09 08 97	23 09 97	Requried
K	mg/L	921 9	815 2	10 00
Fe	mg/L	21 5	53	5 00
Mg	mg/L	94 1	66 1	5 00
Ca	mg/L	517 2	228 6	10 00
Zn	mg/L	1 2	2 45	0 10
Cu	mg/L	1 1	2 1	0 05
Mn	mg/L	0 78	0 62	0 05
Ni	mg/L	0 01	0 009	0 04
Al	mg/L	50	88 2	0 05
Co	mg/L	0 01	0 008	0 01
Mo	mg/L			0 00
S	mg/L			10 00
Se	mg/L	3	2	0 05

Table 13 Recommended raw wastewater quality for future design works

Parameter	Unit	Average value
pH		5 6
TCOD	mg/L	15320
SCOD	mg/L	12522
$TBOD_5$	mg/L	6291
$SBOD_5$	mg/L	4991
TKN	mg/L	457
NH_4 N*	mg/L	643
NO_3 N	mg/L	3 7
TSS	mg/L	1427
T P	mg/L	45
EC	mS/cm	8 4
TDS	mg/L	9491

As shown above the reactor could not treat more than 50% of the TCOD load and almost 25% of the designed hydraulic load The reason behind this as it has been explained earlier is the following

1 The operating TCOD concentration is almost 200% of the design one
The actual operating biomass (VSS) is only 50% of the design one

7 4 Operating Parameters

7 4 1 UASB Reactor

The following table describes the design parameters as compared to the operating parameters of the UASB reactor

Table - 15 DESIGN AND OPERATING PARAMETERS UASB REACTOR

Parameter	Design value	Operating value
Digester volume, m^3	3 5	3 5
Recycle flow, % of plant influent flow	200-500	580
Hydraulic rete- -ion time, hrs	14	56
Total COD load capacity , kg/m^3 d	12-15	2 7
Influent soluble COD, % of influent Total COD	92	82
Total COD reduction, % of influent	70	62 5
Soluble COD reduction, % of influent	75	66 3
BOD reduction, % of influent	90	87
TSS reduction, % of influent	10-15	0
Total gas flow, m^3/d	9 2	4 8

7 4 2 Other treatment units

The actual hydraulic operating load of all other treatment units such as aeration tank, clarifier, sand filter and ammonia tower was limited to a maximum of 1500 L/day due to the limited hydraulic load to the UASB reactor Also the ammonia tower was designed to treat raw wastewater with less than 300 mg/L ammonia nitrogen content, but the actual operating ammonia concentration was average of 643 mg/L

8 0 Overall performance of pretreatment system

Pretreated wastewater quality is presented in Table-18 and system performance during September, October and November are shown in Table-19 The removal efficiencies of TCOD, SCOD and BOD_5 are very close to design figures The overall removal efficiency of the pretreatment system during the whole period of operation as compared to design removal figures is shown in Table-20. The ammonia removal efficiency shall be discussed in the final evaluation report upon examining the stripping at temperatures above ambient temperature

Table-16 UASB reactor performance monitoring data

DESIGN	3000	17000	5100	35 7	10 2	100	0 36	17 9	0 5	70
	FLOW	TCOD IN	TCOD OUT	TCOD REMOVED	TCOD REMOVED	VSS REACTOR	F/M	GAS FLOW	G/F	TCOD REMOVAL
Date	lit/day	mg/lit	mg/lit	kg/d (F)	kg/d/m^3	kg (M)		m3/d		EFFICIENCY
01 07 97	1484	17294	8235	13 44	3 84	50 00	0 27	5 22	0 39	52 38
03 07 97	1300	18275	8769	12 36	3 53	50 00	0 25	3 41	0 28	52 02
06 07 97	1311	11125	7395	4 89	1 40	50 00	0 10	2 45	0 50	33 53
08 07 97	1763	17373	8086	16 37	4 68	50 00	0 33	6 63	0 40	53 46
10 07 97	1677	21561	7849	23 00	6 57	34 00	0 68	5 97	0 26	63 60
15 07 97	1515	22145	11289	16 45	4 70	34 00	0 48	5 53	0 34	49 02
20 07 97	1408	22855	11290	16 28	4 65	43 00	0 38	7 96	0 49	50 60
24 07 97	1271	12766	10881	2 40	0 68	43 00	0 06	5 11	2 13	14 77
27 07 97	976	19842	10347	9 27	2 65	28 00	0 33	4 74	0 51	47 85
29 07 97	730	10197	9581	0 45	0 13	28 00	0 02	3 36	7 48	6 04
03 08 97	666	8367	7758	0 41	0 12	30 00	0 01	2 13	5 25	7 28
12 08 97	978	16264	6793	9 26	2 65	34 00	0 27	3 10	0 33	58 23
19 08 97	920	9008	7244	1 62	0 46	40 00	0 04	2 30	1 42	19 58
31 08 97	907	14033	6708	6 64	1 90	40 00	0 17	4 20	0 63	52 20
02 09 97	907	14033	8000	5 47	1 56	40 00	0 14	3 80	0 69	42 99
09 09 97	1488	14106	7709	9 52	2 72	50 00	0 19	5 60	0 59	45 35
16 09 97	1469	8502	5447	4 49	1 28	50 00	0 09	5 40	1 20	35 93
30 09 97	1431	13694	8226	7 82	2 24	50 00	0 16	5 60	0 72	39 93
07 10 97	1496	16312	7056	13 85	3 96	55 00	0 25	6 30	0 45	56 74
14 10 97	1459	17495	8594	12 99	3 71	55 00	0 24	5 90	0 45	50 88
21 10 97	1440	9413	4707	6 78	1 94	55 00	0 12	4 60	0 68	49 99
28 10 97	1475	14522	5768	12 91	3 69	55 00	0 23	5 70	0 44	60 28
11 11 97	1476	16312	7805	12 56	3 59	60 00	0 21	6 80	0 54	52 15
18 11 97	1440	17356	5265	17 41	4 97	60 00	0 29	4 20	0 24	69 66

Table 17 Active biomass content of UASB reactor

Date	VSS of UASB ports in mg/L port #2	port #3	port #4	port #5	VSS of UASB effluent, mg/L	Total VSS kg
10 07 97	2567	70718	40173	2440	0	33 90017
17 0797	2309	71250	6628	37715	2826	43 0364
19 07 97	44005	77320	3483	2776	2342	44 40404
21 07 97	2309	71250	6628	37715	2826	43 0364
27 07 97	56125	13267	3500	4907	1973	28 72552
10 08 97	72989	21007	4756	3821	1600	34 8434
17 08 97	53300	52433	3757	3525	2333	40 11538
31 08 97	53847	29008	4005	2792	2210	32 90957
07 09 97	76100	78990	2443	2383	2143	53 25908
05 10 97	70565	54136	2240	1983	5470	54 25976
02 10 97	140240	78700	2840	3300	2444	73 23022
23 11 97	162000	27745	2946	2700	1100	60 47992

Table 18 Pretreated wastewater quality

Date	Day	SCOD	TCOD	TSS	VSS	TKN	NO_3-N	NH_4-N	TP	$TBOD_5$	EC	TDS
		mg/lit	mg/lit	mg/lit	mg/lit	mg/lit	mg/lit	mg/lit	mg/lit	mg/lit	mS/cm	mg/lit
03 06 97	1		2804					89		778		
05 06 97	3		3025	663				282		1686		
12 06 97	10											7850
13 06 97	11											9315
15 06 97	13											9435
19 06 97	17											6582
05 08 97	65	2130	7984	732	439	157	4 5	147	625	1330		5468
12 08 97	71	3531	6426	968	728		21	420		1918		9973
19 08 97	78	4849	6127	1693	1310		0	280	428	568		
26 08 97	85	6579	8901	1236	630		0	390	392	468		10000
02 09 97	92	3934	6708	2690	1463			413		350	13	4406
09 09 97	99	4768	6894	2363	1393		0	500	300	819	13 4	11153
16 09 97	106	4255	6449	2096	567				134	670	12 6	3120
23 09 97	113	5184	3854	1030	573		0	425	176	466	12 88	10292
30 09 97	120	3726	5832	2033	920			300	142		13 6	9560
07 10 97	127	3635	4323	1090				307 5	297	349	12	11403
14 10 97	134	3911	4416	1068	468			388		402	13	8460
21 10 97	141	3033	4414	2090	729		0	388	503	330	13 1	10540
28 10 97	148	2884	5850	1910	1370			416	291	348	12 2	
11 11 97	162	3112	4558	809	421		0	400	6 6	142	13 03	10610
18 11 97	169	4016	6581	1140	720		0	345	420	756	13 15	10960
25 11 97	176	7995	8190	1670	1000		0	375	170	846	13 9	11825
	No Samp	16	18	17	16	1	10	17	13	15	12	18
	Avg	4221 4	5740 9	1487 1	795 7	157 0	2 6	345 0	298 8	815 1	13 0	8941 8

Table-19 Performance of pretreatment plant during september october and november

	Raw TCOD	Treated TCOD	Raw SCOD	Treated SCOD	Raw BOD_5	Treated BOD_5	Removal efficiency		
Date	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCOD	SCOD	BOD_5
02 09 97	14033	6708	11635	3934	6233	350	52 20	66 19	94 38
09 09 97	14106	6894	11404	4768	4550	818	51 13	58 19	82 02
07 10 97	16312	4323	12065	3635	1953	349	73 50	69 87	82 13
14 10 97	17495	4416	13253	3911		402	74 76	70 49	
21 10 97	9413	4414	7636	3033	3348	330	53 11	60 28	90 14
28 10 97	14522	5850	11140	2884	5343	348	59 72	74 11	93 49
11 11 97	16312	4558	14049	3112	7436	142	72 06	77 85	98 09
18 11 97	17536	6581	12022	4016	5901	756	62 47	66 59	87 19
						Average	62 4	67 9	89 6
						Design	70 00	75 00	90 00

Table-20 Overall performance of pretreatment plant during whole period of operation based on average values

	Raw TCOD	Treated TCOD	Raw SCOD	Treated SCOD	Raw BOD_5	Treated BOD_5	Removal efficiency		
Date	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCOD	SCOD	BOD_5
Actual	15320	5741	12522	4221	6291	815	62 5	66 3	87 0
Design							70 00	75 00	90 00

9 0 Conclusions and recommendation:

In brief, the following can be concluded and/or recommended

1 The anaerobic treatment is very useful process in the treatment of highly strength wastewater's such as yeast factory effluent

2 The removal efficiency of the anaerobic treatment system can reached the design figures if the active biomass is retained within the reactor and disintegration of granules is minimized

3 The disintegration of active biomass has been minimized to a certain extent through addition of ferric chloride and phosphoric acid as source of ortho phosphate But this was not enough and the UASB effluent VSS content is relatively high The high level of ammonia concentration could be the reason behind continued disintegration of granules Ammonia above 400 mg/L is considered toxic to methane formers

4 Ammonia in the UASB influent can be minimized if the treatment process is modified

5 Ammonia stripping can be installed ahead of the UASB reactor instead of having ammonia stripping behind the reactor or another ammonia tower can be installed ahead of the UASB reactor The solutions suggested earlier by Triad are not practical ones Neither raw wastewater can be practically diluted nor ammonia can be minimized from the source

6 Another solution is to have amore efficient reactor in terms of liquid/solid/gas separation zones to minimize the carry over of the VSS with the UASB effluent This is something related to the upper zone design of the UASB reactor which should be considered in full scale plant design

7 If all above solutions where not practical, having an external clarification zone ahead of the splitting tank should be considered or the splitting tank design should be modified to include a clarification zone and to have the recycle to the UASB reactor from the lowest point of this clarification/splitting tank

8 With the addition of phosphoric acid and ferric chloride, a hard precipitate of noticeable amount has been observed in the aeration tank This precipitate should be studied carefully and should be minimized as much as possible

9 The high salinity of raw wastewater and high chloride levels should be considered when selecting various materials of a full scale plant and specially the heaters

10 Salinity of effluent pretreated water has increased as compared to raw wastewater and this could affect the decision of reuse of pretreated wastewater in irrigation of various crops This shall be verified by the land application evaluation report

11 The centrifugal pumps are not recommended to be used within such type of treatment process due to the hard precipitates earlier discussed

12 Finally, the anaerobic treatment may be feasible if the goal was to recover energy through methane gas but it might not be feasible if it is to be reused in irrigation Again this assumption can be verified through land application report