Twentieth Indian Expedition to Antarctica, Scientific Report, 2006
Ministry of Earth Sciences, Technical Publication No. 18, pp 205-214

Assessment of Wastewater Treatment Scheme at Indian Antarctic Station, Maitri

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Abstract

Wastewater treatment (WWT) system adopted at Indian Antarctic Station "Maitri" for treating kitchen, urinal and bathroom wastewater was studied during the 20th Antarctica expedition. Two numbers of WWT system working on rotating biological contactor principle treats kitchen wastewater and urinal/bathroom wastewater separately. The average chemical oxygen demand (COD) of urinal/bathroom wastewater at the inlet to WWT was found to be 281 mg/1 and at the outlet it was 160 mg/1. The average COD of kitchen wastewater laden with vegetable oil at the inlet of WWT was found to be about 6626 mg/1 and at the outlet of WWT, 3607 mg/1. Observations reveal that the WWT units were never seeded with biological culture and therefore the treatment was not effective. The rotating disc in the bioreactor was stopped to make the system as a settling chamber and COD of the influent and effluent were determined. It was found that the efficiency of COD removal has gone up, as the settling process is effective after stopping the rotation of disc.

Introduction

Members of environmental group of previous scientific expeditious to Antarctica were entrusted with the task of preparing environmental impact statement for Maitri station operations in Antarctica. The report of 13th and 14th expedition contains details of various environmental components of environmental analysis comprising water characteristics of Priyadarshini lake, characterization of wastewater, biological component (Ghosh et al., 1997), oil contaminated soil analysis (Ramteke et al., 1997), noise pollution and air quality (Sushma et al, 1998. In this report, analysis of existing wastewater treatment scheme and wastewater characteristics that is generated at Maitri station is presented with the intention of providing data for wastewater system design in future.

Sources of Wastewater

In any human habitat, one of the most important wastewater of concern is sewage. At Maitri station, night soil is collected dry at 11 AM

everyday. It is burned to ash, which is then collected and shipped back to India for disposal. Therefore the major waste generation is controlled at source itself. The remaining wastewater consist of two streams (i) kitchen containing mainly vegetable oil and (ii) cloth washing, bathing and urinal wastewater. These two streams of wastewater are collected separately and treated in two separate units called Klargester's bioreactor. Figure 1 shows

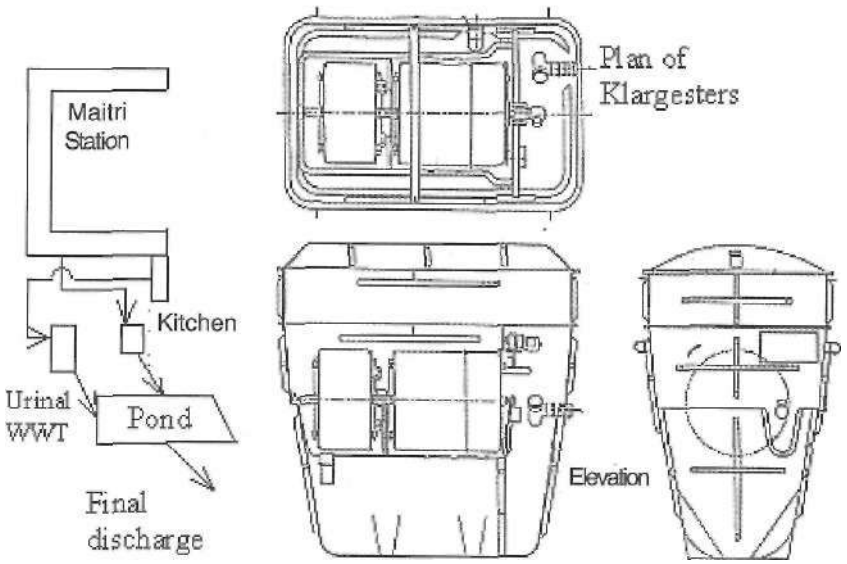

Fig. 1: Schematic diagram of wastewater treatment and plan & cross section of Klargesters WWT unit at Maitri station.

the layout of wastewater collection, treatment, disposal system and the plan and vertical cross section of Klargester's WWT unit. The quantity of wastewater generated is estimated in two ways one from the amount of water pumped to the station from the source lake i.e., Priyadarshini lake and the other is from actual measurement of wastewater from the two treatment units in one day. Table 1 shows the monthly water drawn for one-year period, which includes summer period when total number of inmates is 75. The maximum average daily water consumption is 3.6 m^3/ d during summer season. This includes water used by the summer huts also and therefore the actual amount of wastewater generation is less than this. Tables 2 and 3 show the actual amount of wastewater measured at the outlet of treatment unit. The wastewater generated from urinal/ bathroom is 1.503 m^3/d and that generated from kitchen is 1.081 m^3/d, i.e., the total amount of wastewater generated is 2.584 m^3/d during summer season when summer and winter team members are present.

Table 1: Water Intake at Maitri Station from Priyadarshini Lake (Monthly Average)

Summer	Water Intake (m^3/day)	**Winter**	Water Intake (m^3/day)
December 1999	3.050	**March 2000**	2.735
January 2000	3.606	April 2000	2.427
February 2000	3.305	May 2000	2.366
		June 2000	2.544
		July 2000	2.380
		August 2000	2.296
		September 2000	2.407
		October 2000	2.274
		November 2000	2.400

Table 2: Performance Evaluation of Wastewater Treatment Unit -Hourly variation of COD at the inlet and outlet of Urinal/Bathroom Klargester WWT Unit (14-15, February 2001)

Sl.No.	**Time**	Flow	**Influent**		Effluent	
		(1/h)	**pH**	COD	COD	PH
1	**11PM-6AM**	33	8.32	150	120	8.15
2	6-7AM	45	**8.35**	200	176	8.16
3	**7-8AM**	65	8.32	360	128	8.17
4	8-9AM	140	**8.40**	152	136	8.15
5	**9-10AM**	50	**8.46**	160	192	8.12
6	**10-11AM**	90	8.47	176	144	8.13
7	**11-12AM**	130	**8.38**	224	112	**8.16**
8	**12-1PM**	168	8.43	208	224	8.15
9	**1-2PM**	167	**8.45**	352	80	8.14
10	**2-3PM**	33	8.41	208	112	8.13
11	**3-4PM**	14	**8.39**	192	16	8.12
12	**4-5PM**	25	**8.52**	208	120	8.15
13	**5-6PM**	100	8.57	272	112	8.17
14	**6-7PM**	153	**8.43**	832	736	**8.18**
15	**7-8PM**	54	**8.38**	224	100	8.18
16	**8-9PM**	46	**8.62**	800	80	**8.16**
17	9-10PM	**110**	8.73	192	128	8.22
18	**10-11PM**	80	**8.55**	144	160	8.21
	Total	1503	Average	**281**	160	

Table 3: Hourly variation of COD at the inlet and outlet of Kitchen Klargester Unit (31, January 2001 to 1, February 2001)

Sl.No.	Time	Flow (l/h)	Influent		Effluent	
			pH	COD	COD	pH
1	11PM-6AM	10	4.16	2080	5200	4.23
2	6-7AM	32	4.18	1952	4960	4.18
3	7-8AM	100	4.18	14467	4640	4.20
4	8-9AM	70	4.18	2920	4320	4.20
5	9-10AM	60	4.18	4240	3560	4.15
6	10-11AM	18	4.36	4900	3088	4.16
7	11-12PM	38	4.33	6000	2032	4.13
8	12-1PM	78	4.33	7440	2032	4.20
9	1-2PM	130	4.34	9080	1856	4.21
10	2-3PM	55	4.33	6760	1776	4.15
11	3-4PM	80	4.37	20640	1696	4.21
12	4-5PM	46	4.33	7040	1600	4.21
13	5-6PM	44	4.34	3136	2000	4.23
14	6-7PM	36	4.32	6560	5840	4.22
15	7-8PM	67	4.31	6944	3840	4.23
16	8-9PM	92	4.25	1216	5200	4.21
17	9-10PM	105	4.23	5672	5520	4.22
18	10-11PM	20	4.17	2133	5760	4.15
	Total	1081	Average	6626	3607	

Wastewater Treatment Scheme

The wastewater treatment (WWT) scheme was procured from Klargester Inc., U.K. originally for the purpose of treating sewage. However due to adoption of daily night soil burning practice these units were surplus and therefore installed for treatment of remaining two streams of wastewater (kitchen and bathroom/cloth washing/urinal). The WWT unit is oval in cross section consisting of three chambers in series; wastewater passes through these chambers called primary settling chamber, bio-zone and secondary settling chamber. The primary settling chamber receives raw wastewater, which after the designed detention period flows to the second chamber containing partly submerged discs mounted on a shaft, which is rotated by an electrically operated motor. Rotating discs are installed in the second chamber with the intention that after some period of operation, microbes will attach themselves to the disc and then the

reactor would work as a rotating biological contactor (RBC). The rotation of the discs having microbes attached to it come in contact with the incoming waste as a result microbes in the submerged part will consume the organic matter of the wastewater while the upper half exposed part will take oxygen from air and therefore the conversion of dead organic matter to live organic will take place.

It was gathered that since the commissioning of this treatment unit, it was never seeded with biological culture. A close observation of the rotating disc of kitchen bioreactor reveals that the slime layer on this disc is of vegetable oil and ghee used in the cooking. The overflow passes to the secondary settling chamber. The supernatant from this settling chamber overflows and is discharged to an open pond which freezes during winter period. During a very short time span of summer this melts and is discharged through a pump to a place 800 m away from the Maitri station. In order to evaluate the performance of WWT unit and operating procedure, samples of wastewater were collected from different locations from its generation point to final disposal point and analyzed.

Performance Evaluation of Wastewater Treatment Unit

In order to assess the performance of Klargester's bioreactor, the parameters that could be analyzed at the environmental laboratory of Maitri station were temperature, pH, chemical oxygen demand (COD) and dissolved oxygen (DO). At the inlet and outlet of each bioreactor, COD and pH were analyzed on hourly basis. Tables 2 and 3 present the hourly values of pH and COD for both the WWT units. Average COD value of urinal/bathroom wastewater was 281 mg/1 and for kitchen wastewater the same was more than 6000 mg/1. The effluent of urinal/bathroom WWT was 160 mg/1. For a biological treatment unit this reduction cannot be considered an acceptable value. The effluent of kitchen WWT shows average COD of about 3600 mg/1, again indicating that the WWT has not served the intended purpose. Even though the WWT unit was never seeded with biological culture, it is expected that the treatment system will consume dissolved oxygen by chemical and / or biochemical oxidation and therefore the DO of the reactor was monitored at all the chambers. Table 4 shows the DO values. It is observed that the DO of all the chambers was almost zero indicating the exertion of chemical or biochemical oxygen demand.

Since the bioreactor was never seeded with biological culture, which is a must for any biological waste treatment process, it is realized that the biological reactor is in fact working as a settling chamber that too in the

Table 4 (A): Dissolved Oxygen in Kitchen Klargester WWT Unit (26, January 2001)

Sl. No.	Location	DO (mg/l)	pH	Temperature (°C)
1.	Influent (collected from the kitchen)	0	5.6	24.5
2.	Primary settling chamber	0	4.55	22.2
3.	Bio-zone	0	4.48	22
4.	Final settling chamber	0.8	4.23	20.6
5.	Effluent at pond	2.0	4.23	23.6

Table 4 (B): Dissolved Oxygen in Urinal/Bathroom Klargester WWT Unit

Sl. No.	Location	DO (mg/l)	pH	Temperature (°C)
1.	Influent (collected at the WWT Unit)	0	8.83	20.8
2.	Primary settling chamber	0	8.7	20.5
3.	Bio-zone	0	8.56	20.1
4.	Final settling chamber	0	8.52	19.0
5.	Effluent at pond	0.2	8.53	20.5
6.	Pond wastewater	0.4	7.52	9.0

first and third chamber. In the second chamber the rotating discs does not allow effective settling. In order to assess the effectiveness of this treatment unit as a settler, the bio-disc of Kitchen WWT unit was stopped by putting its motor off for a few days and samples were collected at all the chambers and analyzed for COD, pH and temperature. Table 5 shows these values

Table 5: COD of kitchen Klargester WWT Unit (Bio-disc stopped to treat it as a settling chamber)

Sl. No.	Description	2/2/01			3/2/01			4/2/01		
		Temp. (°C)	pH	COD (mg/l)	Temp. (°C)	pH	COD (mg/l)	Temp. (°C)	pH	COD (mg/l)
1.	Primary settling	24.3	4.4	1632	20.6	4.4	3648	26.8	4.9	3408
2.	Bio-zone	25.1	4.3	1888	23.1	4.5	2064	25.1	4.68	2528
3.	Secondary settling	22.4	4.3	2128	19.3	4.5	2704	21.1	4.4	1808
4.	Effluent before pond	-	4.2	1392	-	4.35	1776	-	4.35	1712

when the WWT unit is taken as a settling unit. It is observed that there is a gradual reduction in COD value from the primary settling chamber to the final settling chamber. Though the samples were not collected and analyzed on hourly basis, the three reading give an indication that the WWT unit works better as a settling chamber compared to the rotating discs as biological units.

Temperature of Wastewater in the WWT Unit

One of the very important parameters for biological treatment of wastewater is the temperature of the contents of the bioreactor. In order to study the effectiveness of the heating mechanism of bioreactor, temperatures were recorded on hourly basis for one day during summer period. Temperatures were measured for the two streams of wastewater at its source of generation, in the primary settling chamber, bio-zone, secondary settling chamber, inside the wooden hut in which the bioreactor is placed and the ambient temperature of the atmosphere. Tables 6 and 7 show the temperature values measured. It can be observed that the average temperature of bioreactor during summer season is 20° C when the ambient temperature is -7° C. This summer period persist only for three months (15th December to 15th March) and rest of the year, the ambient temperature falls below -30° C. During winter season, the efficiency of WWT unit may fall if it is working as a bioreactor.

Table 6: Temperature (° C) at Various Sections of Urine / Bathroom Klargester Wastewater Treatment Unit (24 -25, February 2001)

Sl. No.	Time	Ambient	Inside wooden hut	Influent	Primary settling	Bio-zone	Secondary settling
1	1AM	-7.3	3.1	15.7	16.2	16.3	14.4
2	2AM	-7.4	3.3	15.4	15.9	15.9	14.2
3	3 AM	-7.6	2.3	15.3	15.6	15.7	13.9
4	4AM	-7.6	3.1	14.7	15.2	15.3	13.7
5	5 AM	-7.3	2.1	14.7	15.1	15.2	13.5
6	6 AM	-7.1	1.3	14.8	14.9	15.0	13.3
7	7 AM	-7.5	3.2	16.2	14.9	14.8	13.1
8	8AM	-5.9	2.0	16.7	15.9	15.1	13.1
9	9AM	-5.5	3.0	24.2	19.3	16.2	13.9

(Contd.)

Table 6: Temperature (° C) at Various Sections of Urine / Bathroom Klargester Wastewater Treatment Unit (24 -25, February 2001) *(Contd.)*

Sl. No.	Time	Ambient	Inside wooden hut	Influent	Primary settling	Bio zone	Secondary settling
10	10 AM	-3.8	3.3	19.3	18.5	17.6	14.5
11	11AM	-2.0	3.6	19.2	18.3	17.9	14.8
12	12 AM	-1.9	5.2	19.3	18.6	18.2	15.5
13	1 PM	-2.1	2.4	20.0	19.1	18.4	16.2
14	2 PM	-2.3	4.0	19.9	19.0	18.5	16.3
15	3 PM	-3.1	2.4	18.9	18.7	18.4	16.3
16	4 PM	-4.0	2.2	18.3	18.3	18.2	16.0
17	5 PM	-4.2	3.5	18.6	18.3	18.0	15.9
18	6 PM	4.9	6.1	18.6	18.0	17.8	15.7
19	7 PM	-5.0	4.2	19.2	18.5	17.8	15.7
20	8 PM	-5.4	7.9	18.2	17.9	17.7	15.6
21	9 PM	-5.9	4.2	17.4	17.3	17.5	15.3
22	10 PM	-6.1	3.3	16.6	17.1	17.1	15.0
23	11 PM	-6.3	4.0	16.7	16.8	16.9	14.9
24	12 PM	-7.0	2.1	16.2	16.5	16.6	14.7

Table 7: Temperature (° C) at Various Sections of Kitchen Klargester Wastewater Treatment Unit (24 – 25, February 2001)

Sl.No.	Time	Ambient	Inside wooden hut	Influent	Primary settling	Bio-zone	Secondary settling
1	1 AM	-7.1	12.8	17.7	16.6	17.2	16.1
2	2 AM	-7.4	11.3	15.4	15.5	16.3	15.3
3	3 AM	-7.6	11.3	14.0	14.7	15.4	14.7
4	4 AM	-7.6	11.3	13.5	13.7	14.6	13.9
5	5 AM	-7.6	11.7	12.9	13.5	14.1	13.7
6	6 AM	-7.1	11.0	12.1	13.1	13.7	13.2
7	7 AM	-7.5	10.1	17.0	12.8	13.4	12.9
8	8 AM	-5.9	10.2	20.1	12.6	13.1	12.6
9	9 AM	-5.5	10.3	37.4*	15.7	14.5	12.8
10	10 AM	-3.8	12.4	22.5	18.5	18.2	14.3

(Contd.)

Table 7: Temperature (° C) at Various Sections of Kitchen Klargester Wastewater Treatment Unit (24 - 25, February 2001 *(Contd.)*

Sl. No.	Time	Ambient	Inside wooden hut	Influent	Primary settling	Bio-zone	Secondary settling
11	11AM	-4.0	12.5	2.0	16.0	17.0	12.5
12	12 AM	-1.9	7.5	20.8	15.5	15.1	12.7
13	1 PM	- 2.1	7.5	19.3	14.5	14.6	13.0
14	2 PM	- 2.3	7.9	25.6	15.7	15.6	13.4
15	3 PM	- 3.1	8.2	24.6	16.8	17.1	14.3
16	4 PM	- 4.0	9.2	23.4	17.5	16.9	14.8
17	5 PM	- 4.2	11.4	25.8	17.1	17.1	15.0
18	6 PM	- 4.9	10.8	32.0*	17.3	17.6	15.3
19	7 PM	- 5.0	9.3	25.8	17.12	17.6	15.6
20	8 PM	- 5.4	10.6	23.8	16.9	17.6	15.6
21	9 PM	- 5.9	10.6	28.6	18.8	17.8	16.1
22	10 PM	- 6.1	11.4	28.0	18	18.6	16.5
23	11 PM	- 6.3	10.9	30.8*	20.5	19.6	17.5
24	12 PM	- 7.0	13.1	20.2	17.9	18.3	16.7

* Occasional high temperatures are due to hot water discharge from kitchen.

Conclusion and Recommendations

The Klargester's WWT units were procured for treatment of sewage, but due to night soil burning, the sewage treatment was not required and the WWT units are used for the treatment of kitchen, urinal and bathroom wastewater. Had it been used for treatment of sewage, it would not have required biological seed as the night soil contains sufficient microbial population to carryout the task of biochemical conversion. In the treatment of two waste streams, microbial population is required to be developed by seeding and commissioning in the initial phase of its operation. The best source of seed is night soil for such wastewater treatment, however in the harsh climate of Antarctica, handling night soil is discouraged as it may put additional psychological stress on the workers associated with WWT. By stopping the rotating disc for treating the unit as a settling chamber, it was found that the treatment efficiency becomes very high and therefore it is recommended that as an interim measure, the rotating disc should be stopped and the solid be allowed to settle, The contents should be kept warm by the existing immersion rods so that it does not freeze.

The tank should be cleaned manually of its settleable part and a chemical treatment unit should be adopted for the settled wastewater. The final combined wastewater from the pond is disposed to a place about 800m away from the station to keep the stations premises clean. An observation is needed to ensure that the melting snow during summer season of this disposal site does not join the Priyadarshini Lake. If it happens, a new disposal site should be identified beyond the catchement area of Priyadarshini Lake.

Acknowledgement

Authors wish to thank Department of Ocean Development for providing an opportunity to participate in the 20th Antarctic Expedition. Our special thanks are to the EME of Indian Army who provided a very useful logistic support in the harsh weather of Antarctica. Thanks are also due to Dr. R. Sarin, Dr. M. Z. Hasan, Dr. R. N. Singh, NEERI, Nagpur for their kind consent to participate in the expedition.

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