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Studies of water and wastewater quality at Indian Scientific Base Maitri, east Antarctica during XXVIII ISEA

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ABSTRACT

Lake water sampling was carried out from Schirmacher Oasis during the XXVIIIth Indian Scientific Expedition to Antarctica for determining the various quality parameters. The aim of the studies was to know the water characteristics of area, which are likely to be influenced by ongoing human activities and scientific research programs of Indian scientific station. Water samples were collected from four lakes and analyzed for Physico-chemical parameters, microbiological and radiation contamination. Total dissolved solids were found to be maximum 14 mg/l in one of the four lakes. Few Psychrophillic bacteria were found in landlocked lake. Radiation contamination was observed well below the permissible limits in all lake water. Two wastewater samples from Inlet and Outlet of wastewater treatment unit were also collected to assess the performance of the unit and to measure quality of treated wastewater at Maitri station.

INTRODUCTION

Water is an essential element for sustainability of any form of life and its existing environment in Antarctica is influenced by natural factors viz. Wind speed, ambient temperature, ice, snow, blizzard, glacier etc. The established Indian Scientific Base Maitri requires water for its operations, pursuance of scientific research and other logistic activities in Schirmacher Oasis. Lakes are the sources of fresh water and can be used as drinking water in Antarctica. Water resources may be influenced in terms of quantity and quality depending upon the waterrequirements and wastewater discharged by scientific station. The study of water resources at Maitri Station is significant for assessing the environmental impacts.

The Schirmacher Oasis area is about 100 km inside Princes Astrid coast of Queen Maud Land between the ice shelf and the continental ice dome in Antarctica continent. The area has three types of lakes, viz. Pro-

glacial Lake, land-locked lake and Epi-shelf lake. During summer, the polar ice melts and water often flows into the lakes. The valleys are ice-free because the mountains block the flow of ice from the polar plateau and low precipitation & strong winds lead to little accumulation of snow in the area. The lakes occupy closed basins and vary in surface area, depth and ice-cover thickness.

India established first permanent station 'Dakshin Gangotri' (70°05'37"S Latitude, 12°00'00" Longitude) on ice-shelf on Princess Astrid coast in 1983. This station is now non-operational due to complete burial under ice and has been declared as a historic site (HSM44). The Second Indian Permanent Scientific Base Maitri in east Antarctica was established in the year 1989 in the Schirmacher Oasis. It is being operated throughout the year to carry out scientific research in different fields. To support the continuing scientific research and stay of scientists and logistic staff, a huge quantity of freshwater is required for daily consumption. As a result, a substantial volume of wastewater is generated at Maitri base (Tiwari et al., 2006). Monitoring and assessment was conducted to evaluate the quality characteristics of water and wastewater at Maitri station.

WWTP Unit at Maitri

A Wastewater Treatment Plant (WWTP) unit has been installed adjacent to Kitchen/Lounge of Maitri Station. The ETP unit is a BioDisc system to treat the wastewater, bath and kitchen domestic wastewater produced in Maitri station. The main body and cover of the BioDisc are constructed of Fiber Reinforced Plastic (FRP). A general outline diagram of WWTP unit is given in Fig.-1.

Wastewater from Maitri station enters in the Primary Settlement Tank (PST), through inlet pipe. All the suspended solids are settled in the bottom of the tank and retained for periodic de-sludging. The surface of the BioDiscs becomes colonized by naturally occurring microorganisms, which form a visible coating known as the Biomass. As the biodiscs rotate, the Biomass is alternately submerged in the settled waste and aerated by exposure to the atmosphere. Under these conditions the Biomass can efficiently break down the pollutants in the wastewater.

The second stage of the Biozone is hydraulically sealed from the first stage and maintains a constant liquid level. Liquid is transferred to second stage at a steady rate, by a series of buckets attached to the rotor. This controlled flow of effluent is at the heart of the specially managed flow system, which promotes healthy and balanced growth of the microorganisms essential for efficient treatment. The sludge from the final settlement

tank is separated out and the treated wasted water is discharged into the pit (Sharma et al., 2010).

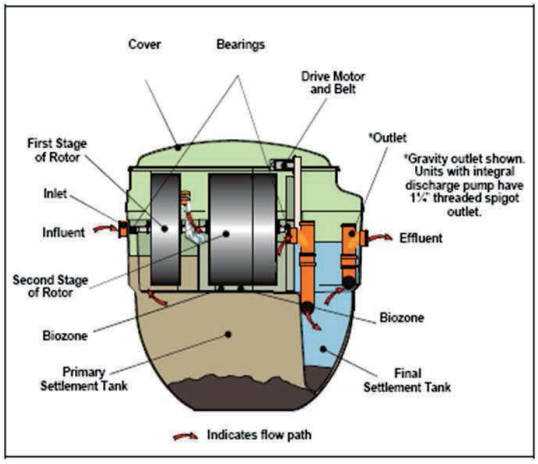

Fig-1: General view of wastewater treatment plant (WWTP) Unit (BioDisc System)

METHODOLOGY

Water and wastewater sampling and analysis was carried out as per the guidelines of protocols IS: 3025 (Relevant Parts) & APHA (2005). Results were compared with specification IS: 10500. Pesticides analysis was performed with the help of GC-MS and LS-MS. Instruments used in the testing of Radiation Contamination are: Gross Alpha Counting system with Zn(Ag) detector, Gross Beta Counting System with Geiger Muller detector and Gamma Spectrometer with NaI(Tl) detector and 1k Multi-Channel Analyzer.

RESULTS AND DISCUSSION

Lake water quality

Water samples were collected from Land-locked lake (L), Priyadarshini lake near Maitri (M), Epishelf lake (E) and Pro-glacial lake (P). Geo-coordinates of all sampling points are given in Table 1. Results of analysis of all the samples collected from in and around Maitri station, Schirmacher Oasis are summarized in Table 2.

Physical parameters like colour and odour are below the prescribed limit of standards for drinking water.Turbidity in all samples was below the prescribed limit of 5 NTU. pH values of all the samples lies between 6.5 to 7.4 and were within standard value for pH (6.5 to 8.5). Dissolved solids were observed in range of 7 mg/l to 17 mg/l. Highest concentration of 17 mg/l was found in the lake sample marked as E. This sample was drawn

from a epi-shelf lake. Verlencar et al., (1996) reported similar results in the study of freshwater lakes in Schirmacher Oasis, Antarctica.

The values of inorganic non-metallic and metallic constituents Sulfate, Fluoride, Copper, Manganese, Mercury, Cadmium, Selenium, Arsenic, Lead, Zinc, & Phosphate in all samples were below the prescribed limit of drinking water standard. High concentrations of few metals in drinking water may be harmful for human beings (Kashyap et al., 2000).

Chloride content in all selected samples was found to be varying between 2 to 4 mg/l. Calcium and Magnesium content, the major ions responsible for hardness in an aquatic ecosystem were less than 1 mg/l in all the samples. Calcium and magnesium are. Alkalinity in all samples was found to be between 2 and 6 mg/l, which is less than the prescribed limit (200 mg/l). All the other parameters were found to be below the prescribed limits.

Table 1: Collection sites of water samples in & around Maitri Station

S.No.	Particular	Location	Codes	Date of sampling	Latitude (S)	Longitude (E)
1.	Lake water	Land-locked Lake	L	25.02.09	70° 44. 389²	11° 26. 843²
		Priyadarshni Lake	M	26.02.09	70° 45. 886²	11° 43. 73.5²
		Epi-shelf Lake	E	24.02.09	70° 45. 423²	11° 34.072"
		Pro-glacial Lake	P	24.02.09	70° 45. 545²	11° 44. 018²
2.	Wastewater	WWTP- Inlet	I	05.03.09	70° 46. 040²	11° 44. 384²
		WWTP-Outlet	O	05.03.09		

Table 2: Physico - Chemical Analysis of Lake's Water Samples Maitri Station

S. No.	Parameter	IS: 10500-1991 Desirable (Permissible*)	Lake Codes			
			L	M	E	P
1	Colour, Hazen unit	5 Max.	<5	<5	<5	<5
2	Odour	Unobjectionable (UO)	UO	UO	UO	UO
3	Turbidity, NTU	5 Max. (10)	<1	2	<1	1
4	pH	6.5-8.5	6.9	7.4	6.6	6.5
5	Total hardness as CaCO3, mg/l	300 Max. (600)	2	2	5	3
6	Iron as Fe, mg/l	0.3 Max. (1.0)	<0.01	<0.01	<0.01	0.01
7	Chloride as Cl, mg/l	250 Max. (1000)	2	2	4	2

8	Fluoride as F, mg/l	1.0 Max. (1.5)	<0.1	0.2	0.1	<0.1
9	Dissolved Solids, mg/l	500 Max. (2000)	7	7	14	8
10	Magnesium as Mg, mg/l	30 Max. (100)	<1	<1	<1	<1
11	Calcium as Ca, mg/l	75 Max. (200)	<1	<1	<1	<1
12	Copper as Cu, mg/l	0.05 Max. (1.5)	<0.01	<0.01	<0.01	<0.01
13	Manganese as Mn, mg/l	0.1 Max. (0.3)	<0.01	<0.01	<0.01	<0.01
14	Sulphate as SO_4, mg/l	200 Max.	1	<1	<1	<1
15	Nitrates as NO_3, mg/l	45 Max	<1	<1	<1	<1
16	Phenolic Compounds mg/l	0.001 Max.	ND	ND	ND	ND
17	Mercury as Hg, mg/l	0.001Max.	<0.001	<0.001	<0.001	<0.001
18	Cadmium as Cd, mg/l	0.01 Max.	<0.01	<0.01	<0.01	<0.01
19	Selenium as Se, mg/l	0.01 Max.	<0.005	<0.005	<0.005	<0.005
20	Arsenic as As,mg/l	0.01 Max	<0.005	<0.005	<0.005	<0.005
21	Cyanide as CN, mg/l	45 Max	<0.01	<0.01	<0.01	<0.01
22	Lead as Pb, mg/l	0.05 Max	<0.01	<0.01	<0.01	0.01
23	Zinc as Zn, mg/l	5 Max.(15)	<0.01	<0.01	<0.01	<0.01
24	Anionic Detergents as MBAS, mg/l	0.2 Max.	ND	ND	ND	ND
25	Chromium as Cr+6, mg/l	0.05 Max.	<0.01	<0.01	<0.01	<0.01
26	Mineral Oil, mg/l	0.01 Max.	ND	ND	ND	ND
27	Alkalinity as $CaCO_3$, mg/l	200 Max.(600)	2	4	6	4
28	Aluminum as Al, mg/l	0.03 Max	<0.02	<0.02	<0.02	<0.02
29	Phosphate as PO_4, mg/l	0.05 Max.	<0.05	<0.05	<0.05	<0.05
30	Boron as B, mg/l	15 Max	<1	<1	<1	<1

* Values given in brackets are maximum permissible limits

The total bacterial count were found to be 1.5x 10^3 cells/ml in landlocked lake (L), 1.5x 10^2 cells/ml in Priyadarshni Lake (M) and 3.7x 10^3 cells/ml in the sample collected from WTP outlet (O). Psychrophillic microorganisms per ml of water were encountered in a few lakes. The highest Psychrophillic count was found to be 77 cfu in landlocked Lake (L), while it was 40 cfu in the sample collected from WTP outlet (O). MPN Coliform/100 ml was not observed in collected samples. Besides this, Yeast & Mould, Staphylococcus, Pseudomonas were also absent in collected samples. Matondkar (1986) also observed Psychrophillic organisms in freshwater Lakes in Antarctica.

Pesticide content was found below detection limits in lake water samples and radiation contamination has been found well below the permissible level in the water samples of Schirmacher Oasis area. The radiation contamination results indicated that the samples are fit for human consumption from radiological point of view.

Table-3: Microbiological Studies of Lake Water and wastewater at Maitri

S.N.	Microbial parameters	Lake codes			
		L	M	E	O
1	**Total Bacterial Count/ml** (cfu) (As per guidelines of IS : 5402-2002, Reaff 2007)	1.5 x 10^3	1.5 x 10^2	Less than 1	3.7 x 10^3
2	***Psychrophillic* Count/ml** (cfu) (As per guidelines of IS : 1479 p-3, 1977, Reaff 2003)	77	Less than 1	Less than 1	40
3	**MPN *Coliform*/100ml** (cfu) (As per guidelines of IS : 1622-1981, Reaff : 2003) Ed 2.4 (2003-05)	No growth observed	No growth observed	No growth observed	No growth observed
4	**Yeast & Mould Count/ml** (cfu) (As per guidelines of IS : 5403-1999, Reaff : 2005)	Less than 1	Less than 1	Less than 1	Less than 1
5	***Salmonella* / 25ml** (cfu) (As per guidelines of IS: 5887 (p-3) 1999 Reaff : 2005)	Absent	Absent	Absent	Absent
6	***Staphylococcus aureus*/25ml** (cfu) (As per guidelines of IS : 5887 P-2 1976 Reaff : 2005)	Absent	Absent	Absent	Absent
7	***Pseudomonas aeruginosa* /10ml** (cfu) (As per guidelines of IS:13428, Amend., 2005)	Absent	Absent	Absent	Absent

(L-Landlocked Lake, M- Priyadarshni lake, E-Epishelf lake, O- Outlet of WWTP)

Detection Limit: Two or more than two organisms.

Note: As no growth observed in MPN coliform, test for detection of E.coli was not carried out.

Table-4: Analysis of Radiation Contamination in Lake Water

Test Parameters and Protocol	Requirement	Observed value			
		L	M	E	P
1) Gross alpha (including Radium- 226) As per IS:14194 (Part 2)	< 0.5 bq / l	<MDL	<MDL	<MDL	<MDL
2) Gross beta Particle activity (As per IS: 14194 (Part 1)	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL
3) Radioactive contamination analysis: Cesium 137 content As per AERB Guidelines	< 1.9 bq / l	<MDL	<MDL	<MDL	<MDL

Minimum Detection Limit (MDL) of the instrument used:

Alpha counting system: 0.04 bq / liter and Beta counting system: 0.6 bq / liter

Minimum detection limit of the instrument used:

Gamma spectrometer with 1 k multi channel analyzer: 1.7 bq / liter

Wastewater quality at Maitri Station

pH value of wastewater sample at the outlet of wastewater treatment plant (WWTP) was within the prescribed range of 5.5 - 9.0, for the treated water to be discharged into inland surface water by Central Pollution Control Board (CPCB). Total Suspended Solids and Dissolved Solids in wastewater sample at the outlet of WWTP were found to be 40 mg/l and 610 mg/l respectively, which were below the prescribed limit for water to be discharged into inland surface water. Chemical oxygen demand (COD) was found lower than prescribed limit in treated wastewater. Connor (2008) demonstrated the processes and integrated steps of a wastewater treatment system in Antarctica.

Biological Oxygen Demand (BOD) at the outlet WWTP was below the prescribed limit of CPCB. BOD value is an indication of requirement of oxygen to disintegrate biological matter. The treatment plant is reducing the COD and BOD load significantly.

Table 5: Wastewater Quality of Maitri Station, Schirmacher Oasis

S.No.	Parameter	Disposal standards –CPCB (into inland surface water)	Sample source		Protocol
			Inlet	Outlet	
1	pH	5.5 – 9.0	7.5	7.4	IS:3025 Pt.- 11-2002
2	Total Suspended Solids, mg/l	100	58	40	IS:3025 Pt. 17-2002
3	Total Dissolved Solids, mg/l	2100	734	610	IS:3025 Pt-16-2002
4	Chemical Oxygen Demand as COD, mg/l	250	186	150	APHA 21st Ed.-5220
5	Biological Oxygen Demand as BOD, mg/l	30	65	42	APHA 21st Ed.-5210
6	Oil & Grease, mg/l	10	12	6	APHA 21st Ed.-5520
7	Iron as Fe, mg/l	-	0.7	0.5	APHA 21st Ed.-3111
8	Total Phosphate as P, mg/l	-	48	36	IS: 3025 Pt-31-2003
9	Manganese as Mn, mg/l	-	0.08	0.05	APHA 21st Ed.-3111
10	Cadmium as Cd, mg/l	2	<0.01	<0.01	APHA 21st Ed.-3111
11	Lead as Pb, mg/l	0.1	<0.01	<0.01	APHA 21st Ed.-3111
12	Zinc as Zn, mg/l	5	0.2	0.2	APHA 21st Ed.-3111
13	Mercury as Hg, mg/l	0.01	<0.001	<0.001	APHA 21st Ed.-3112
14	Anionic Detergents (MBAS), mg/l	-	0.5	0.2	APHA 21st Ed., 5540

Oil & Grease value of wastewater sample at the outlet of WWTP were below the limits prescribed by CPCB. Higher quantity of oil & grease in the wastewater retards mixing of atmospheric oxygen in wastewater. Mercury, Lead, Zinc and Cadmium were also found well below the prescribed limits of wastewater discharged into inland surface water given by CPCB. Ghosh et al., (1997) evaluated the wastewater management in Maitri station.Ansari and George (2006) also demonstrated the wastewater treatment scheme in Maitri station, Schirmacher Oasis over east Antarctica.

CONCLUSION

Antarctica has many simple and fragile lake ecosystems. Lakes are the only source of drinking water for expedition members in Antarctica. Preliminary assessment is a prime concern to evaluate the basic characteristics and pollution level of freshwater ecosystems. Primary study reveals that Schirmacher Oasis Lake water is purest and uncontaminated. Still it is not altered by the presence of anthropogenic activities at Maitri station. The environment management plan, implemented at Maitri station should be continued in future expeditions in order to maintain water quality of Schirmacher Oasis lake. Regular wastewater quality assessment is also essential to regularize and control the pollution in the pristine environment of Antarctica. Presently, wastewater from Maitri station does not seem to affect the Lake water quality.

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REFERENCES

1. Ansari, M.H. and George, K.V. (2006): Assessment of wastewater treatment scheme at Indian Antarctic station, Maitri. Twentieth Indian Expedition to Antarctica Scientific Report, Ministry of Earth Sciences, Technical Publication No.-18, pp: 205-214.

2. APHA (2005): Standard methods for the examination of water and wastewater. 21st Ed. American Public Health Association, APHA, AWWA, WEF, Washington, D. C. pp: 1170.

3. Connor, M.A. (2008): Wastewater treatment in Antarctica. Polar Record, 44(229): 165-171.

4. Ghosh, T.K.; Muley, R.; Ghode, R. and Ramteke, D.S. (1997): Water and wastewater management at Indian station Maitri in Antarctica. Thirteenth Indian Expedition to Antarctica Scientific Report, Department of Ocean Development, Technical Publication No.-11, pp: 301-311.

5. Kashyap, A.K.; A.N. Sahi; S.P. Shukla and R.K. Gupta (2000): Metal Concentrations in Water Bodies of Schirmacher Oasis, Antarctica: An Assessment. Seventeenth Indian Expedition to Antarctica, Scientific Report 2000, Department of Ocean Development, Technical Publication No. 15, pp: 211-219

6. Matondkar, S.G.P. (1986): Microbiological studies in Schirmacher Oasis, Antarctica: Effect of temperature on bacterial population. Third Indian Expedition to Antarctica Scientific Report, Department of Ocean Development, Technical Publication No.-3, pp: 133-147.

7. Sharma, B.;Bharti, P. K.; Pal, N.; Singh, R.K.; Niyogi, U. K. and Khandal, R.K. (2010): Waste management practices at Indian station Maitri. Proceeding of Brainstorming on Polar Science, IMD, Govt. of India, pp: 67-76.

8. SIIR (2010): Long Term Environmental Monitoring and Impact Assessment Study at New Up-Coming Scientific Base at Larsemann Hills, 27th, 28th, 29th ISEA combined report to NCAOR, submitted by Shriram Institute for Industrial Research, New Delhi.

9. Tiwari, A.K.; Sunil Kulkarni; D. S. Ramteke And G. N. Nayak (2006): Environment Quality at Maitri Station in Antarctica, Journal of Environ. Science & Engg. 48(3):191-198.