Twenty Seventh Indian Antarctic Expedition 2007-2009
Ministry of Earth Sciences. Technical Publication No. 25, pp 241-248

Physico-Chemical Analysis of Waste Materials Produced at Indian Scientific Base Maitri in Antarctica

Narendra Pal, Bhupesh Sharma, Pawan K. Bharti,
R.K. Singh, V. K. Verma and U. K. Niyogi
Shriram Institute for Industrial Research, Delhi

ABSTRACT

Activities which can have an effect on the environment at Maitri station are mainly: operation of generator, snow vehicle movement, disposal and treatment of waste, workshop activity, fuel storage and oil spill, station activity, new construction activity, executing science projects etc. Physico-chemical analysis of waste materials *viz.* wastewater, ash and waste oil samples collected during the 27th expedition under the Environmental Management Plan was carried out. The most important parameter for wastewater, biological oxygen demand (BOD) at inlet to WWTP was found as 397 mg/l and at outlet (after treatment) was 107 mg/l. Food Ash sample was found to have higher iron and magnesium contents 23.2 and 10.4 mg/l respectively. Considerable quantity of zinc was found in waste oil samples. The aim of the study was to carry out a monitoring and assessment study of the waste materials at Indian Scientific Base Maitri and to have their physico-chemical characterizations.

Keywords: Antarctica, Maitri Station, Waste Management, Assessment.

1.0 INTRODUCTION

Schirmacher Oasis is situated at about 100 km inside Princess Astrid coast of Queen Maud Land, between the ice shelf and the continental ice sheet of Antarctic continent. It is about 2.5 km in width and 17 km in length and covers about 35 sq. km. area of low-lying hills, with an average elevation of 100 m above the sea level. The geographical co-ordinates lie between Latitudes from 70 44.21 S to 70 46.04 S and Longitudes from 11 26.03 E to 11 49.54 E. The average annual temperature is -10°C and mean wind speed is about 10 m/s. The average snow precipitation ranges between 2 to 3 cm and relative humidity is 15-20%. Air temperature ranges between -5°C and +9.2°C during summer months and between -12°C and -40°C during winter months (Richter, 1984).

Indian Scientific Base Maitri in East Antarctica was established long back in the year 1988 in the Schirmacher Oasis. Since then, it has been a permanent Indian scientific base at Antarctica and is being operated throughout the year to carry out purposeful research in different scientific fields, comprising of Atmospheric Sciences, Earth Sciences, Geomagnetism, Biological and Environmental Sciences, Human Physiology and Medicines, Meteorology, Ecology, Glaciology *etc*. It has facilities to conduct scientific research in several fields (Tiwari *et al*., 2006).

Storage of food materials, cooking of food, maintenance of generators, cranes, snow scooters, piston bully vehicles, supply of drinking water, te.wastewater discharge etc. are the regular and supportive activities. These activities, to some extent, have an impact on surrounding environment (SIIR, 2010).

2.0 METHODOLOGY

2.1 Sampling and Analysis of Wastewater

Wastewater sampling and analysis was carried out as per the guidelines of IS: 3025 (Relevant Parts) and APHA (2005).

2.2 Sampling and Analysis of Ash Samples

Ash residue left after burning of solid waste may contain hazardous substance and needs to be disposed of as per the standard guidelines. Analysis of collected ash samples was carried out using the methodologies given in relevant parts as specified in IS: 1727. Chemical, titrimetric, gravametric and instrumental methods were used for various analyses. HPLC grade water was used for reagent preparation and blank corrections. Analytical grade reagents were used in analysis of the samples.

2.3 Sampling and Analysis of Waste Oil

Two samples of used oil were collected from Maitri station. First sample was collected from a drum containing stored used-oil and the second sample was collected from the workshop area, where used oil was stored.

Analysis of collected oils samples were carried out using the methodologies given in various relevant protocols as specified. Chemical and instrumental methods were used for various analyses. HPLC grade water was used for reagent preparation and blank corrections. Analytical grade reagents or pure quality reagents were used in analysis. Used oil samples were analyzed as per guidelines of ASTM D 5184 & IS 1448.

3.0 RESULTS AND DISCUSSION

3.1 Wastewater

Results of analysis of wastewater are presented in **Table 1.** These are compared with prescribed limit for effluent discharged into inland surface waters Indian Standards: 2490 (1974) given by Central Pollution Control Board (CPCB).

Table 1– Wastewater quality at Maitri Station

S.N.	Parameter	Disposal standards –CPCB (into inland surface water)	Sample marked as	
			INLET	OUTLET
1	pH	5.5 – 9.0	6.2	7
2	Total Suspended Solids, mg/l	100	1380	34
3	Dissolved Solids, mg/l	2100	338	853
4	Chemical Oxygen Demand as COD, mg/l	250	976	323
5	Biological Oxygen Demand as BOD, mg/l	30	397	107
6	Oil & Grease, mg/l	10	53	16
7	Iron as Fe, mg/l	-	0.8	0.5
8	Phosphate as P mg/l	-	28	1.7
9	Copper as Cu, mg/l	3	0.6	0.02
10	Manganese as Mn, mg/l	-	0.02	0.02
11	Cadmium as Cd, mg/l	2	<0.01	<0.01
12	Lead as Pb, mg/l	0.1	0.02	0.02
13	Zinc as Zn, mg/l	5	<0.01	<0.01

The pH value of wastewater sample at the outlet of WWTP is within the limits of 5.5 - 9.0, for the discharge of treated water into inland surface water. Total Suspended Solids and Dissolved Solids in wastewater sample at the outlet of WWTP are below the prescribed limit of CPCB (100 mg/l and 2100 mg/l respectively) for water to be discharged into inland surface water. Chemical oxygen demand (COD) was found higher than prescribed limit in treated wastewater. Biological Oxygen Demand (BOD) at the outlet of WWTP is higher, when it is compared with limit for BOD prescribed limit by CPCB. BOD value is an indication of requirement of oxygen to disintegrate biological matter. Oil & Grease content of waste-water sample at the outlet of WWTP is higher than prescribed limit of 10 mg/l for the treated water to be discharged into inland surface water. Higher quantity of oil & grease in the wastewater retards mixing of atmospheric oxygen in wastewater (Cannor, 2008). Copper, 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) also explained the various quality characteristics of wastewater and wastewater treatment status at Maitri station.

3.2 Ash

Ash is the residue left after combustion and if combustion is proper, the ash will be entirely inorganic. The ash produced from the combustion of food-waste contains primarily inorganic constituents viz. calcium, chlorine, iodine, iron, phosphorus, potassium, sodium, and sulfate. There are two major sources of ash generation at Maitri Station viz. incineration of toilet waste and incineration of food waste. Accurate measurement of quality of ash is relevant from the point of view of different environmental regulations. Two samples of ash were collected from food waste incinerator and toilet incinerators.

Analytical results of ash samples presented in **Table- 2.** Loss on ignition (LOI) at 950 ± 25°C was found to be varying from 5.0 to 21.9 % by mass. The maximum and minimum LOI were obtained in toilet incinerator ash & in food incinerator ash respectively. Silica (as SiO_2) and Calcium (as CaO) were found high in toilet waste ash and low in food incinerator ash. Magnesium (as MgO) and Iron (as Fe_2O_3) were found to be high in food incinerator ash and low in toilet incinerator ash.

Loss on ignition was observed as 21.9 % and 5.0% by mass in toilet ash and food ash, respectively. Silica (as SiO_2) was found to be 24.1 % and 16.9% by mass in toilet ash and food ash, respectively. Calcium (as CaO) was found to be 10.9 % and 8.7% by mass in toilet ash and food ash, respectively.

Magnesium (as MgO) was found to be 3.9% and 10.4% by mass in toilet ash and food ash, respectively. Iron (as Fe_2O_3) was found to be 3.2 % and 23.2% by mass in toilet ash and food ash, respectively.

Table 2 – Test results of Ash of Maitri Station

Sr N.	Parameters	Ash samples		Method of Test
		Toilet Ash	Food Ash	
1	Loss on Ignition, % by mass at 950±25°C	21.9	5	IS 1727 Guidelines
2	Silica as (SiO_2), % by mass	24.1	16.9	IS 1727 Guidelines
3	Calcium (as CaO) % by mass	10.9	8.7	IS 1727 Guidelines
4	Magnesium (as MgO) % by mass	3.9	10.4	IS 1727 Guidelines
5	Iron (as Fe_2O_3) % by mass	3.2	23.2	IS 1727 Guidelines

3.3 Waste Oil

Oil becomes unsuitable for its originally intended use due the presence of impurities or loss of original properties. After use, the oil is labeled as used-oil or waste-oil, which is mixture of large group of fluids like Contaminated ATF, Hydraulic machinery/Engine Oil, Motor oil, Lubrication Oil, Crankcase oil, Gearbox oil, *etc* (Sharma *et al.*, 2010).

These oils may contain heavy metal impurities of arsenic, cadmium, chromium, lead, nickel and their improper disposal may cause environmental pollution in the region.

ATF is used to run Electricity generators, Incinerators, Piston Bully vehicles, Cranes etc. Engine oil is used for lubrication of various internal parts of engine, lubrication of moving parts and also cleans and inhibits corrosion, improves sealing and cools the engine by removing heat from the moving parts. This oil remains active and does all its functions for a specified period depending upon the use of generator and after its use, it is taken out and again fresh engine oil is filled. Hydraulic & lubricating oils are used in machinery and equipment ranging from brakes, power steering systems, excavators, garbage trucks and industrial shredders. It may contain a wide range of chemicals, including oils, butanol, esters, polyalkylene glycols, phosphate esters. Results of analysis of waste oils are presented in **Table 3**.

Table 3 – Oil quality used in power generator

SN	Parameters	Generator Oil	Workshop Oil	Method of Test
1	Colour, ASTM	<8.0	<8.0	ASTM D 1500
2	Kinematic Viscosity (at 40°C) cSt	46.2	71	IS: 1448(pt-25),Reaff-2002
3	Density at 15°C, g/cm^3	0.886	0.874	IS: 1448(pt-32),Reaff-2003
4	Flash Point °C (COC)	213	202	IS: 1448(pt-69),Reaff-2003
5	Ash Content, %by mass	1.24	0.89	IS: 1448(pt-04),Reaff-2002
6	Gross Calorific Value, cals/g	10600	10360	IS: 1448(pt-06),Reaff-2002
7	Lead (Pb), ppm	1.5	6.5	ASTM D 5184 guidelines and ICP
8	Cadmium (Cd), ppm	<0.1	< 0.1	ASTM D 5184 guidelines and ICP
9	Chromium (Cr), ppm	0.6	0.9	ASTM D 5184 guidelines and ICP
10	Zinc (Zn), ppm	463.7	382.6	ASTM D 5184 guidelines and ICP
11	Mercury (Hg), ppm	0.3	0.3	ASTM D 129 guidelines and AAS
12	Arsenic (As), ppm	1.3	1.3	ASTM D 129 guidelines and AAS

Kinematic viscosity of generator oil sample and workshop oil sample were observed to be 46.2 cSt and 71.0 cSt, respectively. Ash content in generator oil sample and workshop oil sample were found to be 1.24 % and 0.89 % respectively. Density, flash point and gross calorific values were observed almost similar in both oil samples. Few metals like lead, cadmium, chromium, mercury and arsenic were observed in very low quantity in both waste oil samples. Zinc content in generator oil sample and workshop oil sample were found to be 463.7 ppm and 382.6 ppm, respectively.

4.0 CONCLUSION

Wastes can pose adverse impacts on the environmental health. Waste generation cannot be stopped in any working area, but it can be managed and minimized. Besides this, regular monitoring of waste quality and quantity is a basic requirement of good environmental management practices (Ansari and George, 2006). Regular monitoring and assessment of wastewater quality can evaluate the performance and efficiency of WWTP. So, continuous monitoring of ambient air quality, lake water quality, waste generation and waste disposal practices should be carried out in and around Maitri station in future expeditions also.

Acknowledgement

The authors are grateful to MOES and NCAOR for providing opportunity to participate in Indian Antarctic Expedition and to the Leader of the 27th expedition for continuous support and guidance, while at work. Thanks are due to all the expedition members for their help. Authors are also thankful to the management of Shriram Institute for Industrial Research for motivating the team members to participate in the expedition.

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. Richter, W. (1984): On the physical geography of the Schirmacher Oasis (East Antarctica, Dronning Maud Land), *ZFI - Mitteilungen*, 89:23-29.

6. Sharma, B.; P. K. Bharti; 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.

7. 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.

8. 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.