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Environmental Status at Maitri, Indian Permanent Station in Antarctica : Preliminary Studies

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Abstract

A Set of procedural guidelines have been developed in 1991 for evaluating the environmental impact of scientific research programmes and their associated logistic support facilitiesin Antarctica. In view of this, Environmental Impact Assessment (EIA) studies were initiated during thirteenth Indian Antarctic expedition in 1993-94 for the Indian station Maitri which started functioning in 1988. Studies covered different components of the environment, viz, air, noise, water, wastewater, land and solid waste. Different sources of pollution were identified and the samples were analysed to generate existing status of the environment. Preliminary studies reveal that air and noise pollutions were not at alarming stages. Wastewaters generated by the station are treated in two biodiscs and collected for about 10 days in ponds before discharging further in a portion of land located at higher contour. A seepage water channel has been identified to join the 0.35 sq.km. Zub lake which caters water supply to the inmates of the station. This needs to be attended to prior to deterioration of Zub lake water. While analytical details of air, noise and solid wastes have been delineated in the present- communication, the same for waters, wastewaters, soil, sediment and laboratory studies have been documented in four subsequent supplementary papers. Finally, guidelines towards Environmental Management Plan based on environmental protocol to Antarctic Treaty and present status of the environment have been suggested as urgent preliminary steps to look into.

Introduction

The Indian scientific expeditions to Antarctica have been launched since 1981. The first two expeditions were only during austral summer months and from third expedition onward the Indian Antarctic stations have been manned round the year. The first Indian Antarctic station 'Dakshin Gangotri' (DG) which is rarely used for scientific activities in recent years, is on die shelf, whereas the second station named 'Maitri' is on Schirmacher Oasis at latitude 70°45'53"S and longitude 11°44'03"E (elevation 117 m). While the former was constructed in 1984, the latter was built during 1988-89. None of the sites was

Infra Structure of Maitri Station

Site

The site of the station has been selected on ice free mountainous terrain where the problem of snow drift accumulation does not exist and the station can be used for a longer period.

Engineering support

The indigenous station Maitri was designed and constructed during seventh and eighth expeditions by Defence Research Development Organisation (DRDO), Pune. Additional facilities in the form of a green house with environmental control systems for plant growth, walk-in-type cold storage system, a dome like structure as another green house, a generator house named Aditya and a vehicle repairing hut have been established in succeeding years. The station consists of four blocks. The main block houses living accommodation, medical facilities, communication control system and laboratory. Block A accommodates power supply system and workshop. While Block B accommodates control heating system, water storage tanks, kitchen, dining hall & bath room, Block C provides incinerator type of toilets. Adequate storage facility has been provided in the loft above the main block.

The panels of the modular construction are made of timber framework, marine plywood and sandwiched PU foam as insulating material. The panels are interconnected by wooden connectors. The models have been lined internally by a fire retardant material 'Gypsum Board' and externally by plastisol coated GI sheet.

Water supply to station

Water supply to the Maitri station is catered by pumping water from Zub lake, also referred as Priyadarshini lake by Indians, about 255 m away toward northern side of the station. Pumping of water is mostly undertaken by a centrifugal pump having a capacity of 3000 1 per hour. Additionally one submersible pump, enclosed in two concentric stainless steel/jackets for electrical heating, has been lowered in lake water at a distance of 80 m from the edge of the lake. Heating is necessary to ensure a continuous flow of water even at a low temperature of -40^{o}C. To further ensure a continuous flow from the pump to the boiler room in the main station, the entire copper pipe line has been enclosed in air tight insulated ducts supported on a steel structure. Besides the main water pipe, the duct houses two additional tubes, carrying aqueous monoethylene glycol, connected to the main boilers of the duct to prevent

subjected to detailed Environmental Impact Assessment (EIA) studies prior to establishment.

EIA was first adopted by the Antarctic Treaty Consultative Parties (ATCPs) in 1987, when recommendation XIV-2 was agreed at the XIV Antarctic Treaty Consultative Meetings (ATCM). This developed a set of procedural guidelines to be used by national Antarctic organisations in evaluating the environmental impact of scientific research programmes and their associated logistic support facilities in Antarctica. The protocol on environmental protection to the Antarctic Treaty which has been agreed by 26 ATCPs (including India) in 1991, requires EIA to be applied in the planning and operation of all activities undertaken in Antarctica. The EIA procedures, based on reef mmendation XIV-2 as referred above, are delineated in three stages.

***Preliminary Stag* : Each activity must be assessed according to national procedure. If an activity has less than a minor or transitory impact it can proceed.**

***Initial Environmental Evaluation (1EE)* : If an activity is considered as having a minor or transitory impact an IEE must be prepared. This is subject to review by national activities.**

***Comprehensive Environmental Evaluation (CEE):* If an activity is likely to have more than a minor or transitory impact then a CEE must be prepared. CEEs must be circulated for comments to ATCPs and the public. They must also be submitted to the Committee for Environmental Protection (CEP), which will advice the ATCM.**

The final decision on whether to proceed with an activity remains with the proponent, but can not be made unless there has been an opportunity for the CEE to be considered at an ATCM. More detailed annexes have been developed, covering EIA (Annex I), conservation of flora and fauna (Annex II), waste disposal and management (Annex III), prevention of marine pollution (Annex IV) and area protection and management (Annex V), which introduces the *Antarctic Specially Protected Area* and the *Antarctic Specially Managed Area*.

In view of guidelines imposed under environmental protocol of Antarctic Treaty, Department of Ocean Development (DOD), Govt, of India, retained National Environmental Engineering Research Institute, Nagpur for evaluating impact of scientific and logistic activities on different components of environment in and around Indian station Maitri and to suggest effective Environmental Management Plan (EMP).

freezing of water in the pipe line. Water consumption is more in summer, and for the remaining period it fluctuates between 2.90 and 3.78 $m^3 day^{-1}$ (Fig. 1).

Environmental Status

Waste management strategy

The waste management strategy regarding Indian station, its field bases and on ship while it is in Antarctic waters is delivered from the recommendation adopted at Antarctic Treaty Consultative Meetings (ATCM) and based on the guidelines prepared by Scientific Committee on Antarctic Research (SCAR). The strategy is on the lines as envisaged in the protocol on environmental protection to the Antarctic Treaty (Madrid protocol). India recognises that Antarctica deserves much of its scientific importance from its uncontaminated condition and consequent need to reduce to me minimum level practicable in spirit of all potential contaminants introduced in Antarctic Treaty area by man and also considers that all efforts should be made to ensure that there is as minimum a damage as practicable to the environment by Indian expeditions. Considering this, the pillars of the strategy are based on :

* Waste avoidance and minimisation
* Waste reuse
* Waste recycling
* Waste disposal & cleaning up of old sites

Air environment

The sources of air pollution in and around Maitri station were identified as generators, boiler, incineration of night soil, vehicles movement, helicopter and open burning of food & other combustible solid wastes. Besides exhaust gases, helicopters and vehicles also contribute suspended particulate matter in the form of dust particles in the air while on ice free ground. The total flying time of the two helicopters during summer of thirteenth expedition was 226 hours.

Analysis of certain emitted gases (Plate 1) from different sources and of fresh air of the region by Orsat apparatus revealed that normal air which contained 21.6 percent oxygen, was devoid of CO_2 and CO. The oxygen contents reduced to 12, 14 and 13 percent in fumes released by vehicle, night soil incineration awd electricity generation (generator) respectively. Carbondi-oxide levels in these exhaust gases varied between 0.6 and 1.2 percent. The oxygen contents, in air samples collected at a distance 5 to 10 m off the source

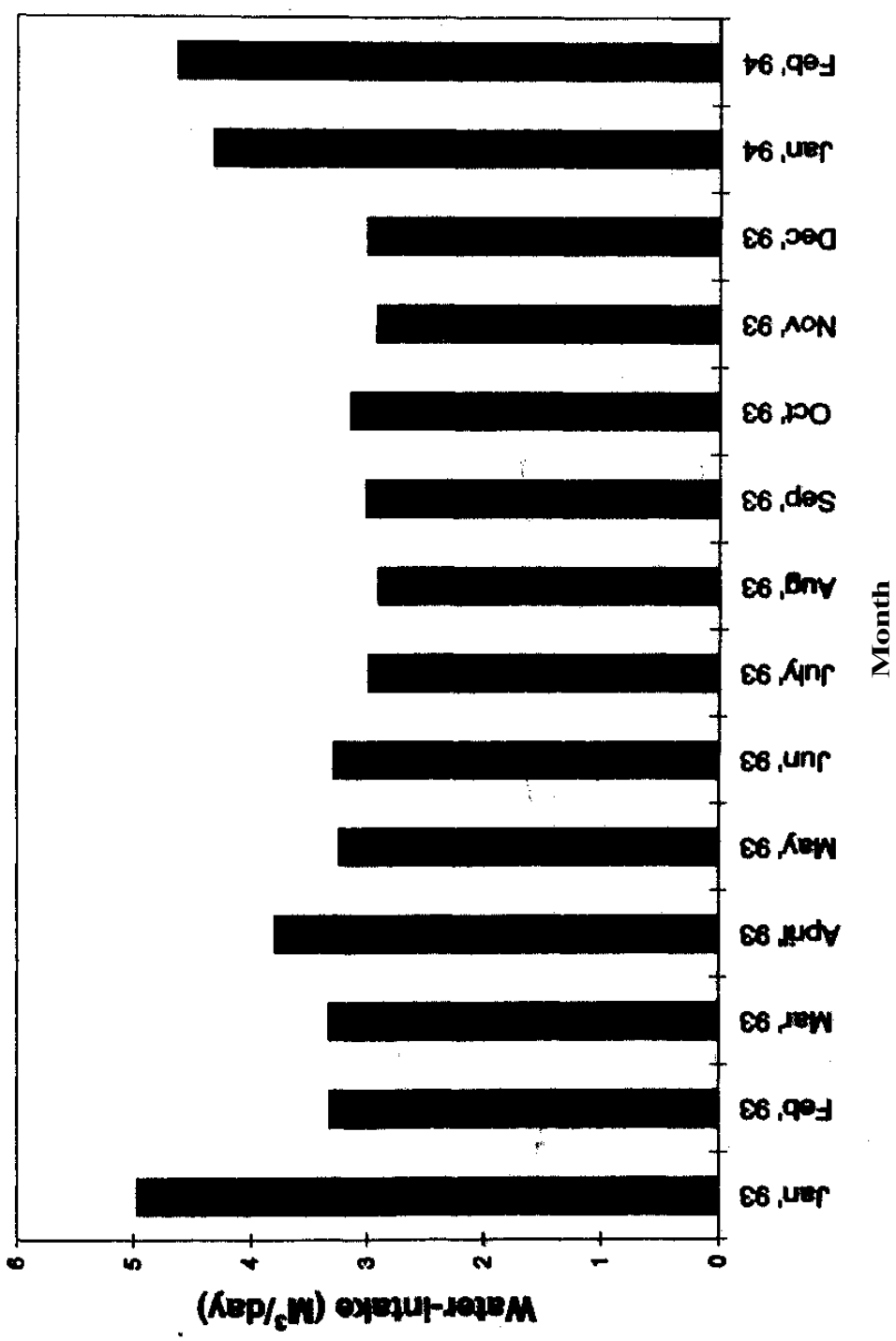

Fig 1: Rate of water - intake from zub Lake by Indian station Maitri in different months

Plate 1: Collection of exhoust gases from source al Aditya Generator Hut

towards the direction of wind, were measured as 20.5 to 20.8 percent. The levels are within the standard specified by CPCB (1994).

The meteorological details for January-February, 1994 are depicted Fig.2, however, the average pressure, temperature, wind speed and wind direction at Maitri station in January, 1994 were 987.8 hPa, 0°C, 13.4 knot and 128 respectively. There was no blizzard during this month.

Noise environment

The noise levels at various sources were identified and measured on different days/time with precision sound level meter having octave filters. The noise levels (Table 1) in most of the locations were estimated to be within the permissible limits as prescribed by CPCB (1989). While comparing the exposure of the operators at generator room, boiler room, workshop, helipad and radio room, with those of the standards for industrial areas, the existing noise levels were not at an alarming state. It may be mentioned that the permissible limits of noise for 8,4 and 0.25 hour exposure at industrial areas are 90, 93 and 105 dB respectively. The operators were conscious enough by not getting exposed for longer durations at enhanced noise levels. However, noise level at lounge appears to be high in view of personal discussions, viewing of video programmes, playing cards etc.

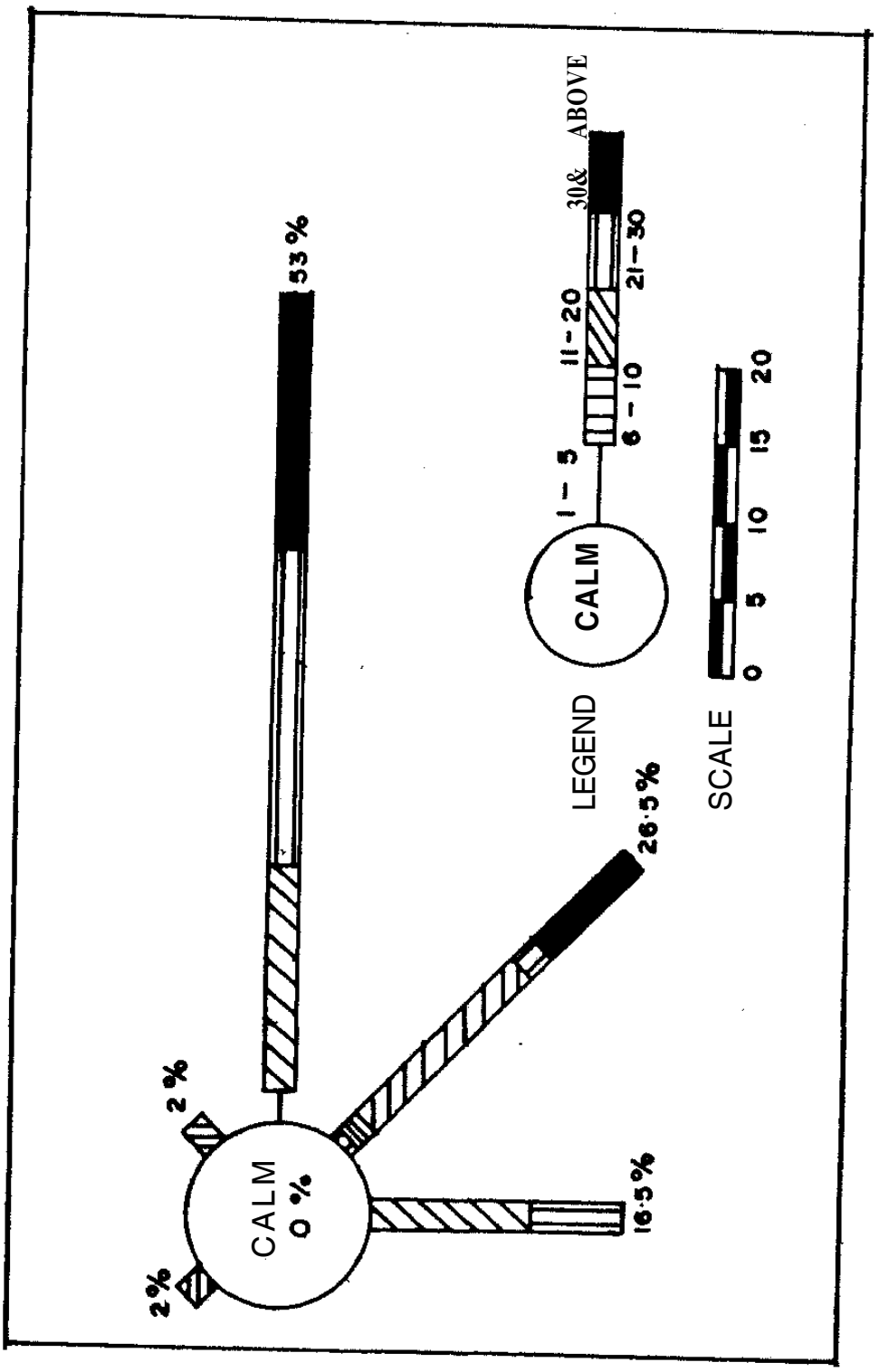

Fig. 2: Windrose around Maitri station, Antarctica for the month of Jan-Feb, 1994

Table 1: Noise Levels at Different Locations in and around Maitri Station, Antarctica during January-February 1994

Sl.No.	Location	Time (Hours:GMT)	Noise level dBA
	Living room of main station		
1.	North side	0-24	35-42
2.	South side	0-24	40-44
3.	Lounge	10-11	44
4.	Communication room	10-11	53-54
5.	Corridor	0-24	42-62
6.	New generator room (Aditya) (one generator running)	0-24	98-100
7.	Generator control room (door closed)	0-24	66-69
8.	Old generator room (one generator running) Workshop	0-24	98-99
9.	Not in working condition	0-24	68
10.	During working condition	10-11	72-75
11.	Boiler room	0-24	72-77
12.	Open working area (back side of Maitri station)	10-11	47-75
13.	Office room Landing & taking off of helicopter	20-22	34
14.	Near helipad	15	105
15.	Near gate of station	15	80
16.	In corridor (door closed)	15	70
17.	In summer hut (near Nandadevi) Open space with no activities	15	70
18.	Wind speed 5 knot hr^{-1}	16	45
19.	Wind speed 25-30 knot hr^{-1}	22	70-80

Further, the use of flat rubber strips for tightening the wooden summer huts with ground (Plate 2), often leads to enhanced sound due to heavy wind during night hours causing disturbance in sleep. At a wind speed of 10-18 m sec^{-1} towards S-E direction, noise level was measured as 50-60 dB within the hut, thereby showing far above the standard of 45 dB as prescribed by CPCB for residential areas in night hours.

Plate 2: Rubber strips tied with the summer huts generate noise tine at wind and cause disturbed sleep in night

Water environment

Water samples from Zub lake; a control lake located about 1.5 km away from Zub lake towards western side, and glacier waters on left and right sides of the station were collected and critically evaluated towards biotic and abiotic characteristics. The details of the features are encountered in two separate communications in this technical volume.

Wastewater

Liquid wastes generated by the station are treated by two biodiscs designated as B_1 and B_3 Klargesters. While the former caters for the kitchen waste the latter receives the wastes from bathroom, urinal, wash basins and washing machine. Volume, loading, efficiency and characterisation of the wastes are detailed separately in the same technical communication.

Soil and sediment

Biotic and abiotic components are especially intimate in soil and sediment, which consist of the weathered layer of the earth's crust with living organisms and products of their intermingled. Considering the activities by Indian expedition members around the station Maitri since 1988, detailed assessment of soils and sediments were carried out and delineated in a separate communication in this technical volume.

Table 2: Summary of Comments by Swedish Inspection Team on Selective Research Stations in Schirmacher Oasis at Antarctica in January 1994

Particulars	Maitri (India)	Particulars	Maitri (India)
Date of inspection	Jan.20, 1994	Fuel depot (outside)	Edge ice-shelf: 25 tanks, 160 m^3; no leak protection
Position	70°42' South 11° "44' East	Total fuel storage capacity in base	260 m^3
Type	All year,		
Approximate cstation area	0.02-0.03 km^2	Any other fuel in use	
Year completed	1989-90	Paraffin oil	-
Power generation	6x62.5 kW	Petrol	1 m^3 unleaded for skidoos
		Water supply	Fresh water lake
Fuel for generator & vehicle	ATF	Treatment of water	No
Measurement of gases	No	Water quality monitoring	No
Annual fuel con-sumptio for power generation	200 m^3 (includes vehicle)	Water consumption	
		Winter	0.5 m^3 /month
		Summer	2.0 m^3 /month
Fuel consumption by vehicles (per year)	?	Use of chemicals	Photographic, X-ray
Filtering of vehicle emission	No	Protected area in the vicinity	No
Fuel storage tank (inside/close to sta-tion)	One steel tank (50 m^3), another 50 m^3 in drums on ground; all without teak protection	E1A studies Informal EIA, details to be made	
		Training on environment protection	Written instruction in guidelines and orally informed by winter fellows

ATF : Aviation Turbine Fuel (Jet A1)

Contd.

Table 2: *Contd.*

Particulars	Maitri (India)	Particulars	Maitri (India)
Solid/hazardous waste collection & general practice	Separated in 6 categories; except paper, all packed in drums and removed from treaty area. Birds eat & disperse food scraps from drum	Empty fuel drums	Removed from treaty area; 500 stored at stn. for fuel storage
		Chemical wastes	Removed from treaty area
Quantity of waste per year	200 drums solid wastes, 2 drums ashes & 20 drums liquid wastes	Existing waste dump	No
Waste management	Incinerator/open burning	Papers are burnt in open; proposed to install compactor	
Sewage (night soil)	Incinerator toilets used, ashes collected in drums and transported	Concluding remark	Well maintained modern stn.; water quality & wastes should be monitored; food scraps should be in closed container, oil spill should be protected; joint management plan with Novo and Forster is recommended
Grey water	Treated in 2 biodiscs; stored in settling ponds for several months		
Food scrap	Removed from treaty area		
Plastic and metal wastes	Removed from treaty area		

Solid waste generation

The particulars regarding generation of solid wastes are summarised below.

- *** Around 6-7 kg and 20-30 kg of paper were burnt in the open per week during summer (Dec. to Feb.) and winter (March - Nov.) respectively.**
- *** Around 15-20 kg of food mainly cooked food waste including non-vegetarian food and other unusable food items were collected per day during summer, however, the quantity gets reduced to half during winter. Food wastes are usually burnt in the open.**
- *** The inorganic solid wastes are segregated into different categories like plastics, metal, glass, ash, cans etc. Around 200 barrels of these wastes - generated in the year 1993-94 were brought back to India for recycling and/or safe disposal.**
- *** Around 200 litres of liquid wastes mainly photographic chemicals, unserviceable lubricants, oil etc. were generated in a year. While a small quantity of these wastes is used for burning food wastes, majority of these are brought back to India for recycling and disposal.**

Inspection of the station

In order to promote the protection of the Antarctic environment and dependent and associated ecosystems, and to ensure compliance with the protocol, the Antarctic Treaty consultative parties can arrange, individually or collectively, for inspection by observers in accordance with article VII of the Antarctic Treaty. Accordingly a twelve-member Swedish inspection team visited the Indian station Maitri in Schirmacher Oasis of Antarctica on January 20, 1994.

The inspection report for the station is summarised in Table 2. It appears that certain additional steps are taken by the Indians in order to preserve the environment in a better way. However, due attention was not given in earlier expeditions on a few aspects like leak protection of fuel tanks, regular environmental monitoring, disposal of food scraps by birds, EIA studies etc. Since thirteenth expedition (1993-94) the matter has been considered and due weightage has been given on monitoring of environmental parameters, EIA studies, training on environment to the expedition members and management of food wastes. Laudable comments were received by the inspection team towards general maintenance of the station, use of eco-friendly fuel i.e. ATF and incineration of human waste in a scientific manner.

Environment Management Plan

By taking into consideration the present status of different components of the environment and also in accordance with the protocol on environmental protection to the Antarctic treaty, a comprehensive environmental management plan has been formulated. The aim being, minimization within practicable limits, the environmental impacts caused from the past, present and future activities associated with India's Antarctic operations.

To achieve this aim, the strategy has as its broad goal, the improvement of the existing practices and introduction of new practices or procedures at Antarctica. The suggested environmental management guidelines are summarised below.

* **The amount of wastes produced or disposed of in the Antarctic treaty area shall be reduced as far as practicable so as to minimise impact on the Antarctic environment.**
* **Inculcating the awareness of environment management programmes & their benefits to the expedition members.**
* **The efficiencies of biodiscs B_1 and B_3 for treating wastes like sewage or grey water should be increased and the wastes should be discharged on site at lower contour of the Zub lake.**
* **The wet food wastes should be burnt in incinerator at 600°C.**
* **Non-hazardous wastes like glass, metals, cans, wire etc. should be brought back in sealed labeled drums for disposal. A waste reuse programme be established and the wastes, with the potential for immediate or planned reuse, should hot be disposed of. Empty petrol drums which can build up explosive vapour should not be used as containers for solid waste storage.**
* **Medical wastes should be burnt and made sterile.**
* **Plastic, metal cans, cardboard etc. should be compacted and brought back to India.**
* **Leak proof lining to wastewater disposal pits should be adopted for preventing the seepage of treated/untreated wastewater into the lake.**
* **The A block generator room should be shifted from the main station for substantial reduction of noise level.**
* **Alternative eco-friendly antifreeze mixtures be used for duct heating systems.**
* **Environmental impact studies should be carried out prior to any change in an activity whether the changes arise from an increase or decrease in**

the intensity of an existing activity, from the addition of an activity, the decommissioning of a facility or otherwise.

* An environment management officer be designated who will have responsibility for monitoring the effectiveness of implementation measures for development and review of the strategy every year.

Acknowledgement

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