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Assessment of total mercury in the freshwater lakes of Schirmacher and Larsemann Hills, Antarctica

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ABSTRACT

The Polar Regions have long been recognized as important sinks for the aerosol, including mercury derived from natural and anthropogenic sources at lower latitudes. The volatile metals like Hg and Pb introduce to atmosphere mostly through burning of fossil fuel. Generally, the distribution of mercury in environmental media is related to pH, oxygen content, organic matter, reducing agents and microbial activity. In this paper we report for the first time, observed concentration of total dissolved mercury in the water samples. Water samples were collected during austral summer of 2009 from lakes of Schirmacher Hills, and Larsemann Hills- the two sites of Indian research stations in Antarctica. Mercury was determined using a Cold Vapor Atomic Absorption Spectroscopy (CVAAS) method. The results show that mercury distribution varies in the range of 0.063-0.56 μgL^{-1} in lakes of Schirmacher Hills and 0.27-0.72 μgL^{-1} in lakes of Larsemann Hills μgL^{-1}

Keywords: Antarctica, Mercury, CVAAS, Larsemann Hills, Schirmacher Hills.

INTRODUCTION

Mercury (Hg) is emitted into the atmosphere from a number of natural as well as anthropogenic sources. Gaseous mercury is relatively stable in the atmosphere and can be transported through air currents far from the place of its origin. At normal concentration it is not harmful to any organism. However, reaction between sea salt, sunlight and atmospheric mercury can transform gaseous mercury into more reactive mercury. Once deposited in terrestrial and aquatic ecosystems, this reactive mercury is partly re-emitted into the air, thus assuming the characteristics of global pollutants such as persistent volatile chemicals. The Polar Regions have long been recognized as important sinks for the aerosol, including mercury derived from natural and anthropogenic sources at lower latitudes (Bargagli. R. et al., 2007). Photo-chemically driven oxidation of gaseous Hg by reactive halogens have been suggested to result in areas of greatly enhanced Hg accumulation and anomalous concentrations of mercury have been reported from the lakes, snow, soil, sediment, mosses and lichens from differ-

ent parts of Antarctica (Vandal, G. et al., 1995, Lyons W. et al., 1999, Ullirich et.al., 2001, Dommergue A. et.al., 2010) The volatile metals like Hg and Pb introduce to atmosphere mostly through burning of fossil fuel. Generally, the distribution of mercury in environmental media is related to pH, oxygen content, organic matter, reducing agents and microbial activity (Boszke et al., 2003). Background concentration in unpolluted water range from 0.5 to 3 ngL^{-1} and in strongly polluted waters the concentration of total mercury reaches a few tens $\mu g\ L^{-1}$ (Stein E. et.al., 1996, Bonzo J. et.al., 2000, Heaven S. et.al., 2000).

The main objective of this study was to evaluate the concentration of total mercury in the lakes of Schirmacher Hills and Larsemann Hills.

Sampling Area

Schirmacher Hills (70°46'04"S to 70°44'24"S; 11°49'54"(± 48) to 11°26'03"(± 02) E) is one of the smallest oases in Central Dronning Maud Land, and is about 70 km south of the Princess Astrid coast of east Antarctica (Richter W. et.al., 1984). There are around 105 lakes exists in Schirmacher Hills (Figure-1). This region represents a small moraine of the main Antarctic glacier, with an area of 35 km^2, and a range of virtually barren and rocky low-lying hills. The lakes exist because of high radiation receipt in the summer months and the influx of snow melt water into rock basins eroded by prior glacial action in these regions.

The Larsemann Hills (69°20'-69°30'S latitude: 75°55'-76°30'E longitude.) is an ice-free coastal Hills with exposed rock and low rolling hills. The Larsemann Hills contain more than 75 freshwater lakes of varying size and depth (Figure-2). It is the second largest (50 km^2) of only four major ice-free oases found along the 5000 km coastline of East Antarctica (Gillieson D. et.al., 1990).

During the 28th Indian Scientific Expedition to Antarctica (ISEA) in 2009, water samples were collected for measurements of total Mercury from 15 lakes of Schirmacher Hills around the Indian Permanent station 'Maitri' and Russian Station' Novo' and 15 lakes from Larsemann Hills including different nunataks comprising, Bharati island, Fisher, McLeod, Brokness and Stornes Peninsula.

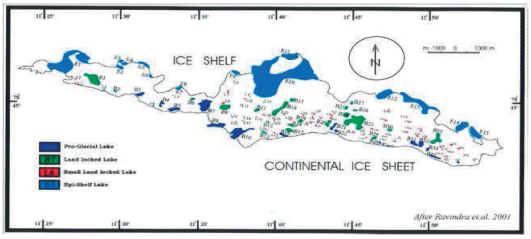

Figure 1: Location of Various Lakes Schirmacher Oasis (After Ravindra et.al)

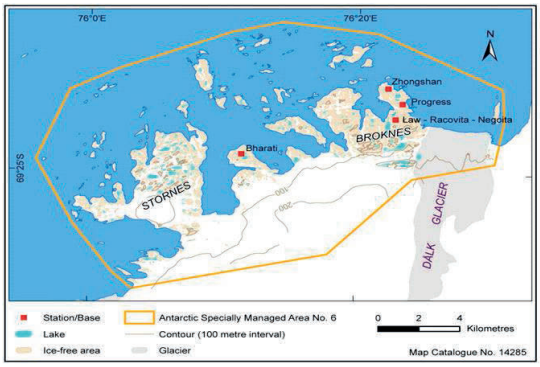

Figure 2: Location of Various Lakes in Larsemann Hills (Source: http:// www.antarctica.gov.au)

Materials and methods

Composite samples from various lakes were collected from only upper part of the water column in acid washed Teflon bottles containing-0.5% acidic solution of HCl in order to reduce contamination and to preserve the Hg in the sample (Parker J. et.al., 2005).The samples were analyzed in Polar Environmental Lab, National Centre for Antarctic and Ocean Research, India, adopting Cold vapor Atomic Absorption Spectroscopy (CVAAS) technique according to the standard method and procedure. Standards and reagents were prepared from Merck-Germany, NIST traceable chemicals using Type-1 water obtained from Synergy-Millipore™, water purification system. For preparation of standards and reagents, purified water was boiled for one hour to release dissolved mercury, present, if any and before use it was cooled down.

Water samples were mixed with oxidizing reagent, $KMnO_4$ and then heated in water-bath up to 90°C before mixing of hydroxylamine reagent. Samples were allowed to cool down and than through continuous flow analysis hydride generator system samples were reduced to Hg to an elemental state of evaporation, mixing with $SnCl_2$ and analysed by Thermo M Series™ Atomic Absorption Spectrometer attached with Hydride Generator and Mercury Concentrator. Procedural blanks were run with each set of samples.

Results and discussion

Results indicate that concentration of Mercury varies in the range of 0.063-3.56 (1.0 ± 1.41) μL^{-1} in lakes of Schirmacher Hills (Figure-3) and 0.27-0.72 (0.49 ± 0.24) μgL^{-1} in lakes of Larsemann Hills (Figure-4), however in few lakes presence of mercury has not been observed. RSD

values of results varied from 1.9 to 25.7, for all samples collected from both the regions. The Mercury concentration in few lakes has been below detection limit of the instrument, hence it is considered as zero.

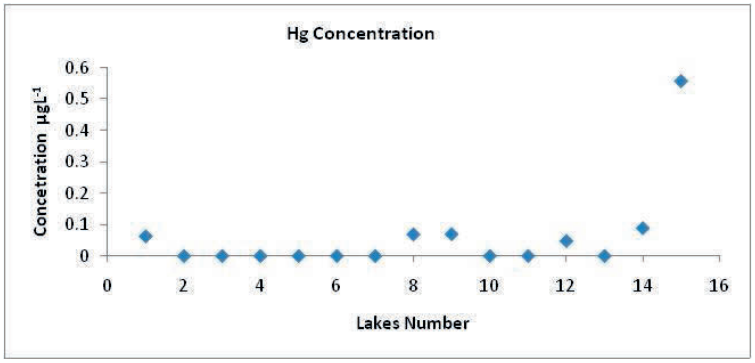

Figure3: Concentration of mercury in Schirmacher Hills

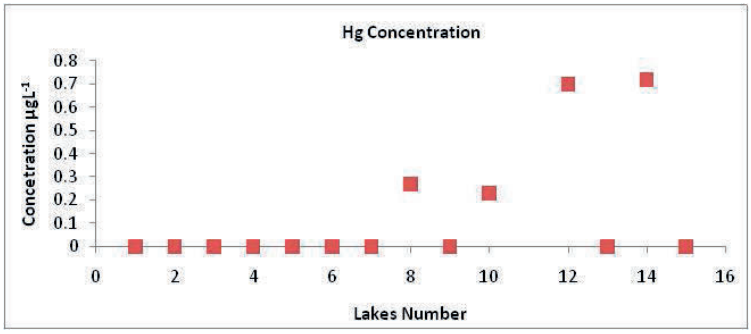

Figure4: Concentration of mercury in Larsemann Hills

Larsemann Hills area is potentially at noticeable environmental risk, due to the presence of four research stations and an ice runway which is used often, within a few km^2: Law Base (Australia, established in 1986, and regularly visited and resupplied by Australian expedition members mostly during the summer months), Zhongshan (People's Republic of China, permanently occupied since 1988), Progress I Station and ice runway (Russian Federation, now abandoned and largely dismantled), and Progress II. In Larsemann Hills human impact is more than Schirmacher Hills, as existing stations are situated in close proximity to each-other. Anthropogenic impact in the Larsemann Hills has resulted from construction and other activities related to station operations and resupply. Such activities have produced various types of waste, including sewage, domes-

tic and kitchen waste, building material (such as timber, galvanized iron, fiberglass, insulation materials, plastics), workshop waste (machine parts, batteries, gas cylinders, metal and plastic wires and cables, fuel drums), and spills of hydrocarbons (diesel, leaded and unleaded petrol, aviation turbine kerosene) and other liquid chemicals such as anti-freeze, lubricants, cleaning agents and laboratory chemicals. Most of this waste is found in the immediate vicinity of station areas and along resupply routes (airstrip, helicopter landing sites, fuel drum stock-piles and fuel resupply areas, and tracks connecting these sites with the stations). Some fragments of timber, paper, plastic, and fuel drums have been scattered around the Larsemann Hills by the strong katabatic winds (Burgess J. et.al., 1994). Another potential source of contamination is represented by exhaust fumes (burnt hydrocarbons, soot, and trace metals) emitted by helicopters during the frequent summer flights (Gasparon M. et.al., 2006) According to Goldsworthy (hydrocarbon contamination is the most common impact at all Larsemann Hills stations, and in general, high levels of contaminants are found only in the immediate vicinity of well-known "high impact" areas such as refueling and fuel storage sites, waste Incineration sites, sewage effluent discharge areas, and waste tips. However, marine biogenic influence may also contribute for Hg concentration, as these lakes are located in close Proximity to Sea Goldsworthy P. et al., 2003,.

Similar activities are also prevailing in Schirmacher Hills region but in low intensity as compared to Larsemann Hills Ice runway situated few km in leeward side of the stations, so airborne contaminations in the lakes due to aircraft operation from runway is not envisaged. However station activity, vehicle and helicopter operations may attribute to mercury contamination in the lakes, situated in Schirmacher Hills.

Activities at research stations are believed to have resulted in some anthropogenic input into at least some of the lake systems .The global distribution process and long range transportation could also be a route for Mercury deposition in Remote Environment. Further detailed studies are underway to understand the nature of Mercury its speciation and effect on Antarctic Ecosystem.

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