REVIEW OF RESEARCH

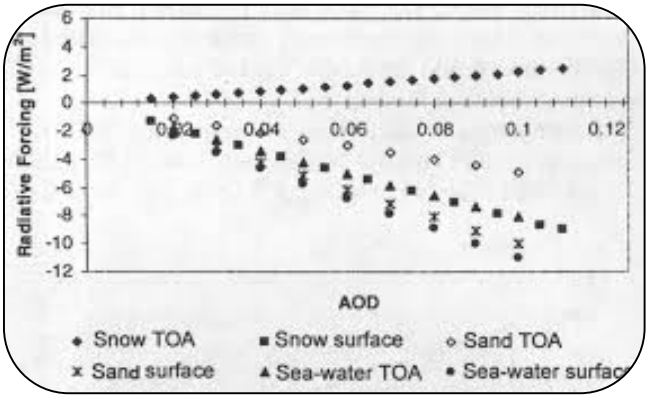
ISSN: 2249-894X
IMPACT FACTOR : 3.8014 (UIF)
VOLUME - 6 | ISSUE - 5 | FEBRUARY – 2017

# STUDY OF AMBIENT AEROSOLS AT MAITRI, ANTARCTICA

**Ritweej Rajeev Ranjan**
**M. M. Science College, Morbi, Rajkot.**

**ABSTRACT :**

*The measurement of total and size segregated mass concentration of ambient aerosols have been carried out using Quartz Crystal Microbalance (QCM) Impactor operated at Indian Antarctic Station, Maitri during December 2011-November 2012. The average mass concentration (Mt) is 11.27 ± 1.32 µg/m$^3$. It is low compared with the values obtained at Bay of Bengal, Indian Ocean and an arid location, Rajkot. This indicates the pristine nature of the atmosphere at the Antarctic continent. The derived parameters such as mass of super micron and sub micron particles, number concentration, effective radius, and number size distribution from QCM observations have been also studied.*




**KEY WORDS:** *Quartz Crystal Microbalance (QCM) , arid location , sub micron particles, number concentration.*

## 1.INTRODUCTION

The tiny particles in solid or liquid phase, suspended in the in the atmosphere are called atmospheric aerosols. Aerosols are produced by a variety of natural and anthropogenic processes. That is why they are poly-dispersive with sizes ranging from $10^{-3}$µm to $10^{2}$µm. Atmospheric aerosols are minor constituents of the Earth's atmosphere yet they have appreciable influence on the air quality, the chemistry of the troposphere and stratosphere, Earth's radiation budget, clouds and precipitation. Their sources and sinks are geographically localized and they have relatively short atmospheric life times. Due to this reason atmospheric aerosols are high spatial and temporal heterogeneity in the atmosphere.

Ambient aerosols are those that reside within the Earth's boundary layer (~500 m to 2000 m). The convective turbulence and winds cause a thorough vertical mixing of aerosols within the boundary layer, giving a vertical homogeneity. The land and sea breeze regimes lead to horizontal advection of continental aerosols offshore and on shore transport of marine aerosols. The Optical effects of aerosols include: scattering and absorption of solar and infra red radiation, altering of cloud properties acting as cloud condensation nuclei. So characterization of aerosol properties is highly important.

Antarctica is a unique continent at the extreme south, separated from the other populated continental masses, making it one of the most pristine places on the Earth (Wall, 2005). Due to the pristine characteristics (compared to other snow covered regions like the Arctic or the high altitude mountains in the Northern Hemisphere), it provides an excellent environment to examine the natural and background aerosols in the atmosphere over snow and ice. Not only that, the large ice sheet of the Antarctic continent affects atmospheric circulation patterns over this region, which affects the transport and removal of the aerosols particles. In the recent years, with the increase in human interventions (exploratory, scientific and tourism) there is an increase in the emissions of anthropogenic species arising from fossil fuel combustion, both at the research stations as well as those associated with transport. Antarctic aerosols comprise of mainly sea salt, sulphate, dust, $NO^{-3}$, Methane Sulphonate (Virkkula et al., 2006) and a small amount of efficient absorbing aerosols like black carbon (Chaubey et al., 2010). Even small quantity of absorbing aerosols (anthropogenic or natural) over the highly reflecting snow might enhance the warming of the atmosphere and the deposition of these particles over the surface of the snow or ice reduces the albedo (Russell et al., 2002). As such, there is an increased interest and need to investigate the properties of Antarctic aerosols, and their spatial temporal and microphysical properties to understand their climate forcing potential (Valero et al., 1983).

In this paper, in-situ technique is used for the measurement of total and size segregated mass concentration using Quartz Crystal Microbalance (QCM) Impactor. This gives measurement of total Mass ($M_t$) and size segregated mass of ambient aerosols.

## 2. METHODOLOGY AND DATA ANALYSIS

The observations were taken at the Indian Antarctic station, Maitri (Geographic Latitude 70.77$^o$ S, Longitude 11.75$^o$ E), situated in an ice free area of Schirmarchar Oasis of central Drauning Maud Land, East Antarctica.

The principle, working and other details of QCM are described by Krishna Moorthy and Pillai (2004). In this study QCM Impactor (Model PC-2 California Measurements, Inc) has been used. It has two sub assemblies: a sensing stack and a control unit which is detachable. Each stage of a cascade impactor has a certain size range over which the capture efficiency is high.

**During each measurement, the QCM provides direct information on two parameters:**

(i) The total mass concentration ($M_t$) which is the mass of aerosols in the size range 0.05 to 25 µm (stage Nos. 1 to 10 in inverse order) in unit volume of the sampled air, and

(ii) The mass concentration ($m_{ci}$) in each of the size bins i=1-10 which gives the mass-size distribution. These constitute the raw data, which in itself is useful. $M_t$ and $m_{ci}$ are related by

$$M_t = \sum_{i=1}^{10} m_{ci} \qquad (1)$$

However, in practice only channels 2-10 are used in the above summation as the first channel includes particles with size >25 µm.

PM, PM10, PM2.5 can also be estimated as

$$PM = \sum_{i=2}^{10} m_{ci} \qquad PM10 = \sum_{i=3}^{10} m_{ci} \qquad PM2.5 = \sum_{i=5}^{10} m_{ci} \qquad (2)$$

## 4. RESULTS AND DISCUSSION:

The observations were carried out for one year (December 2011-November 2012).

| PM ($\mu g/m^3$) | PM10($\mu g/m^3$) | PM2.5($\mu g/m^3$) | $R_{eff}$ ($\mu m$) | Total Surface area ($cm^2$) | |
|---|---|---|---|---|---|
| 10.57 | 9.36 | 6.80 | 0.178 | 0.298 | |
| $M_t$ ($\mu g/m^3$) | $M_a$($\mu g/m^3$) | $M_c$($\mu g/m^3$) | $N_t$($m^{-3}$) | $N_a$ ($m^{-3}$) | $N_c$($m^{-3}$) |
| 12.58 | 4.34 | 6.22 | $2.557 \times 10^9$ | $2.556 \times 10^9$ | $8.273 \times 10^5$ |

**Table-1.: Derived parameters**

Table-1 includes the average aerosol mass in three different size groups: PM, PM10, PM2.5 as defined in equation (2) and the other derived parameters. Certain larger size ranges are removed from PM2.5 and hence it is less than PM10. This indicates that there is significant contribution of larger size particles to the total Mass PM. Similar results were also reported by Gadhavi and Jayaraman (2004) who observed that 63% of the particles were of Coarse mode (>1 µm).

**Figure-1 shows the average size segregated aerosol mass concentrations for different channels.**

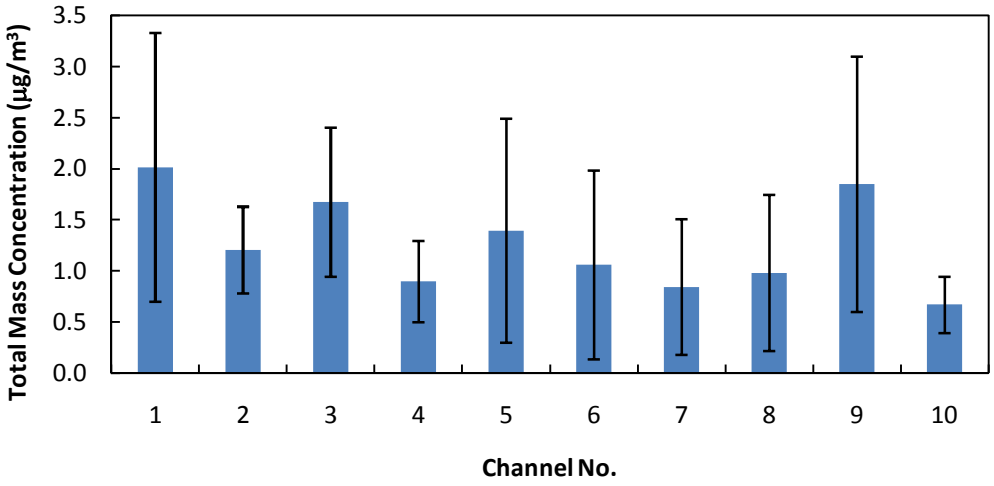



**Figure-1.: The average size segregated aerosol mass concentrations.**

The average mass concentration is very low at all size ranges. Total mass concentration ($M_t$) is 11.27 ± 1.32 µg/$m^3$. Kumar et al. (2011) and Chowdhury et al. (2001) reported that this value is very low compared to those at Bay of Bengal, Indian Ocean, where the values are 28.4 ± 5.7µg $m^{-3}$ and 113 µg $m^{-3}$ respectively. Gadhavi and Jayaraman (2004) reported a value of 6.97 µg $m^{-3}$ (after correcting for humidity effects) during Jan-Feb, 2001 at Maitri. Chaubey et al (2011) reported $M_t$ of 8.25 ± 2.87 µg $m^{-3}$ at Maitri during the International Polar Year 2007-2008. This suggests the pristine nature of the Antarctic atmosphere, Though $M_t$ seems to be increasing with years.

The particles with size <1 µm are termed submicron and those with size >1 µm are called supermicron. The number concentration of particles in these categories are calculated and studied. It is observed clearly that the number of sub micron size particles is higher than that of supermicron range. Also it is observed that the mass of the submicron particles is less than that of supermicron particles.

The number size distribution and the mass size distribution of aerosols are derived from the basic size segregated mass measurement and other derived parameters plotted in Figure-2 and Figure-3 respectively.

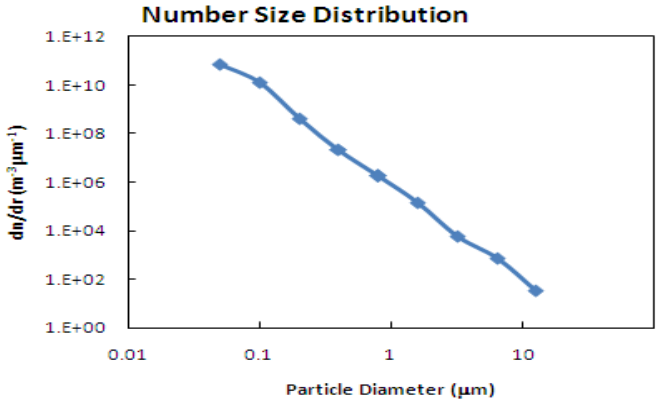



**Figure-2.: Number size distribution.**

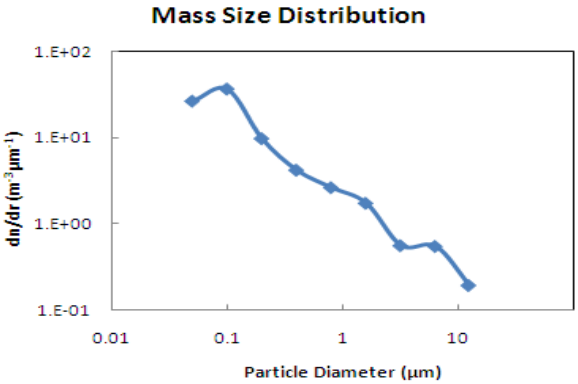



**Figure-3.: Mass size distribution.**

Here we see the power law type of size spectrum indicating the dominance of smaller size particles consistent with values of $N_a$ and $N_c$ in Table-1.

Large variation was noticed in day-to-day observation of $M_t$ (3.37 $\mu gm^{-3}$ to 16.24 $\mu gm^{-3}$ with mean11.27 ± 1.32 µg/$m^3$) at Maitri. Troposphere-stratosphere exchange process of aerosols is very less effective over Antarctica due to the low pressure in the upper stratosphere that makes wind flow always towards the oceans. Only when the polar vortex breaks down, the exchange of the stratosphere and troposphere air takes place and the aerosols are brought down to the lower troposphere (Hogan et al., 1979). These aerosols are then transported towards the coastal Antarctica by the katabatic wind and strength of this cycle may contribute significantly in the day to day variation in the ambient mass concentration.

**ACKNOWLEDGEMENTS:**

Author is thankful to Gujarat state govt. for special grant for Environment Science and Nanotechnology to the Dept. of Physics, SaurashtraUnversity, Rajkot, under which the QCM was procured. I thank Mr. Anoop K Soman (working at IIG, Mumbai) for meticulously operating QCM at Maitri. The facilities provided at Maitri by NCAOR, Goa are gratefully acknowledged.

**REFERENCES:**

Chaubey, J. P., Moorthy, K. K., Babu, S. S., Nair, V. S., and Tiwari, A.: Black Carbon aerosols over Coastal Antarctica and its scavenging by snow during the Southern Hemispheric Summer, J. Geophys. Res., 115, D10210, doi:10.1029/2009JD013381, 2010.

Chaubey, J.P., K. Krishna Moorthy, S. Suresh Babu, and Vijayakumar S. Nair,The optical and physical properties of atmospheric aerosols over the Indian Antarctic stations during southern hemispheric summer of the International Polar Year 2007–2008, Ann. Geophys., 29, 109–121, 2011

Chowdhury Z., Hughes L.S., Salmon L.G., Atmospheric particle size and composition measurements to support light extinction calculation over the Indian Ocean, J. Geophys. Res., **106**, 28597-28605, 2001.

Gadhavi, H. and Jayaraman, A.: Aerosol characteristics and aerosol radiative forcing over Maitri, Antarctica, Current Sci., 86(2), 296–304, 2004.

Hogan, A. W., Barnard, S., and Bortiniak, J.: Physical properties of the aerosol at the South Pole, Geophys. Res. Lett., 6, 845–848, 1979.

Krishna Moorthy, K, Preetha S. Pillai, Aerosol Climatology and Effects-II, Characterization of near surface aerosols at Thumba, ISRO-GBP SR 06 2004.

Kumar K. Raghavendra, Narasimhulu K., Balakrishnaiah G., Reddy B. Suresh Kumar, Rama Gopal K., Reddy R. R., Reddy L. S. S., Krishna Moorthy K., Suresh Babu S. and Dutt C. B. S., *Spatial heterogeneities in aerosol properties over Bay of Bengal inferred from ship-borne and MOSDIS observations during ICARB-W cruise campaign: Implications to radiative forcing*, Atmospheric Environment, **45**, 404-412, 2011.

Russell, P. B., Redemann, J., Shimid, B., Bergstrom, R. W., Livingston, J. M., Mcintosh, D. M., Ramirez, S. A., Hartley, S., Hobbs, P. V., Quinn, P. K., Carrico, C. M., Rood, M. J., O'stro'm, E., Noone, K. J., Hoyningen-Huene,W. V., and Remer, L.: Comparison of Aerosol Single Scattering Albedos Derived by Diverse Techniques in Two North Atlantic Experiments, J. Geophys. Res., 59, 609–619, 2002

Valero, J. P., Ackerman, T. P., and Gore, W. J. Y.: Radiative effects of the Arctic haze, Geophys. Res. Lett., 10, 1184–1187, 1983.

Virkkula, A., Teinila K., Hillamo R., Kerminen, V. M., Saarikoski, S., Aurela, M., Koponen, I. K., and Kulmala, M.: Chemical size distributions of boundary layer aerosol over the Atlantic Ocean and at an Antarctic site, J. Geophys. Res., 111(D5), D05306,doi:10.1029/2004JD004958, 2006.

Wall, D. H.: Biodiversity and ecosystem functioning in terrestrial habitats of Antarctica, Antarctic Science, 17(4), 523–531, 2005.

**Ritweej Rajeev Ranjan**
**M. M. Science College, Morbi, Rajkot.**