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MONITORING OF PARTICULATE MATTER CONCENTRATIONS AT HIGH ALTITUDE ECOSYSTEMS OF PAKISTAN AND CHINA

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ABSTRACT

Particulate matter exhibits different behavior with altitude. A comparative analysis was carried out to monitor $PM_{1,}$ $PM_{2.5}$, PM_4, PM_{10} and PM_{Total} at elevations above 3000 m in both China and Pakistan. Real time monitoring of PM was carried out at both sites using a DustTrak DRX (model 8533, TSI Inc.) for 24 hours each. In Pakistan, the average value of PM_{Total} was 415 $\pm$ 16 µg/m³ while in China the value was considerably lower i.e. 110 $\pm$ 57 µg/m³. The 24-hour mean values recorded were well above the WHO recommended limit of 25 µg/m³. These results indicate that, even at sites some distance from anthropogenic sources, PM concentrations still pose a health risk.

Key words Fine particulate matter, high altitude, China, Pakistan.

INTRODUCTION

Ambient air pollution, particularly exposure to particulate matter (PM), accounts for 3.7 million premature deaths annually, 88% of these deaths occurring in developing countries (WHO, 2014). PM is one of the six criterion pollutants and responsible for a wide range of respiratory and cardiac diseases. The disease burden is large with 16% of deaths due to lung cancer, more than 20% deaths due to stroke and other cardiac problems, and 11% of deaths by chronic obstructive pulmonary disease (WHO, 2014).

Among the various size fractions of PM, the smaller fractions are of more significance from the public health point of view as particles with an aerodynamic diameter of less than 2.5 microns are capable of penetrating deeper into the alveoli and interfere with gas exchange process in the blood capillaries. Increased mortality has been reported along with exacerbation of existing symptoms of respiratory illness due to continuous exposure to fine PM (WHO, 2014).The levels of ambient particulate matter vary from place to place owing to the presence or absence of point sources, location of the area, meteorological factors, and seasonal variations also. Urban areas are reported to be more polluted than rural due to increased industrialization and vehicular activities in urban centers.

Generally it was considered that air pollution is wholly a problem of the industrially developed nations; however, current studies have shown that air pollution is a growing problem in developing countries as well, and hence, attention should be paid to this before it is too late. In addition household fuel used for cooking in developing countries is major contributor for indoor air pollution due to the widespread use of coal and biomass.

The fast-growing economies of south-east Asian have resulted in increased PM concentrations. Satellite observations have identified large expanses of brown clouds, up to 3 to 5 km thick over India, which consist of mainly aerosol particles, such as black carbon (Decesari *et al*, 2010). It is often considered that the Himalayas act as a northern barrier. Dust has also been shown (Liu *et al*, 2008) to be a major component of the aerosol burden over the Tibetan Plateau (average elevation over 4500 m).

The current study was designed to monitor ambient PM levels at alpine areas of Pakistan and China.

METHODOLOGY

Sampling sites

Pakistan: Makra Catchments, Shogran (34°37'42''N, 73°29'22''E) is a scenic tourist spot located at an elevation of 3089 m in Khyber Pakhtoonkhawa (KPK) province of Pakistan. The catchments and Payee meadows can be reached through trekking and /or through jeeps or mules. The climate is of high land type and the temperatures are as low as 20°C during the day and around 3°C during the nights for most of the year with snow fall making the place inaccessible during the winters (Köppen-Geiger climate classification: Cfa).

China: Lang Mu Si (34°05'25N, 102°37'27E) is located in Ruo Er Gai, Tibet at an elevation of 3300 m above sea level. The grassland and surrounding scenic landscape of the area make it a popular tourist spot. The climate of the

area is cold and temperate with annual mean temperature of 2°C (Köppen-Geiger climate classification: Dwc).

Experimental setup: Real time monitoring of fine particulate matter was carried out for twenty four hours at each site (Figure-1) using a DustTrak DRX (Model 8533, TSI Inc.) that simultaneously measure size-segregated mass fraction concentrations corresponding to PM_1, $PM_{2.5}$, PM Respirable, PM_{10} and PM_{Total} size fractions.

Figure 1: Location of monitoring sites (Site A: Lang Mu Si, China; Site B: Makra catchments, Pakistan)

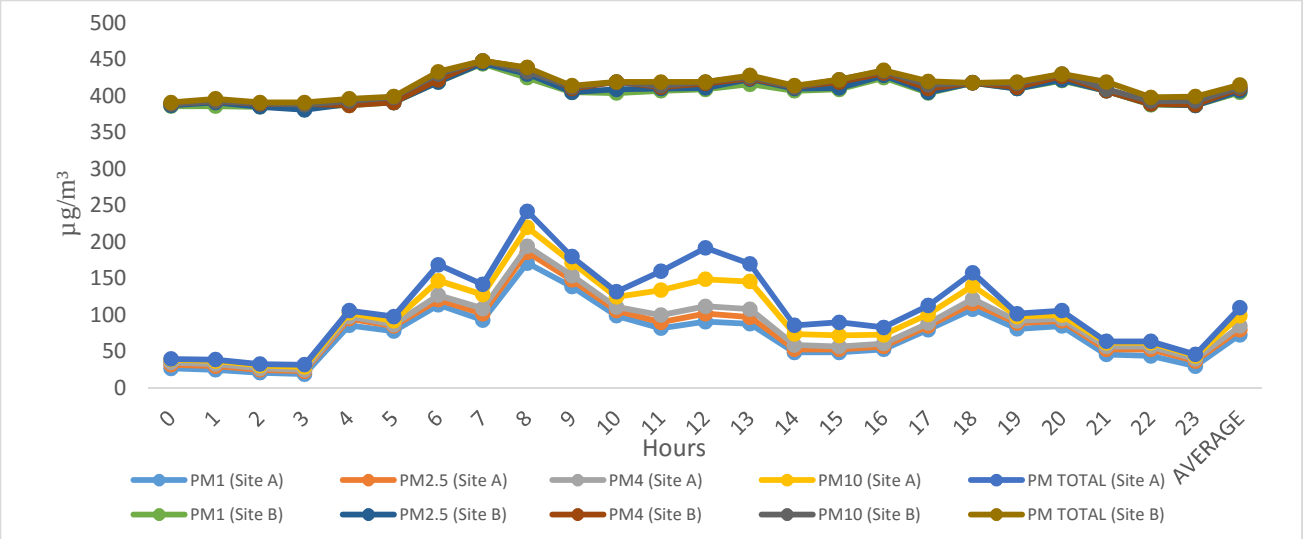
CO_2, temperature and relative humidity were simultaneously measured with a Gas Probe IAQ (BW technologies). An independent t-test was applied on the data to observe any association between the various PM fractions at both sites.

RESULTS AND DISCUSSION

Table 1 summarizes the results for both sites. The average concentration of PM_1 observed at Lang Mu Si was 73 ±39 µg/m³ while at Makra Catchments it was much higher i.e. 405.17 ± 16 µg/m³. Concentrations for all size fractions were of the order of five times higher at Makra Catchments than at Ru Er Gai (Figure-2).

Table: 1. Hourly concentrations with standard deviations for particulate matter and other parameters at both sites. a, b, c, d, e = the values with the same super script are significantly different at 5 % level of significance.

PM	China		Pakistan	
	Hourly Concentration	SD	Hourly Concentration	SD
PM_1	73^a	±38	405^a	±15
$PM_{2.5}$	80^b	±40	407^b	±16
PM_4	85^c	±42	410^c	±17
PM_{10}	99^d	±49.4	413^d	±16
PM_{Total}	110^e	±57	415^e	±16
Humidity	60	±13	77	±10
Temperature	7	±4	13	±3
CO_2	605	±144	368	±33
CO	0	±0	0	±0



Figue-2: Comparative PM Concentrations at China and Pakistan sites

Based on a single day's data it is difficult to draw any firm conclusions. Given the diurnal variation at Lang Mu Si it does suggest that the site was influenced by anthropogenic sources, possibly emissions from biomass burning for cooking. The concentrations at Makra Catchments are much higher and show little variation. Virtually all the PM measured was in the PM_1 size fraction suggesting that the whole region of Pakistan is affected by air pollution. Concentrations at this remote site are similar to those in urban areas. What the data do indicate is the urgent need to establish a reliable air quality monitoring network across Pakistan covering both rural and urban sites.

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