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Baseline Assessment of Short-lived Climate Pollutants in Bangladesh

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ABSTRACT

Bangladesh has local urban air quality problems affecting the health of the countries inhabitants, in addition to being a top greenhouse gas (GHG) emitter. The Short-Lived Pollutants (SLCPs) of methane, black carbon (BC), and tropospheric ozone are seen as a new indicator of pollutants which are forcers impacting the climate at a much greater/faster rate than the traditional GHGs. Global emissions databases, inventories, and models were used as sources to compile SCLP emissions for Bangladesh for the most recent years available, in addition to limited historic and future emissions analysis. This baseline assessment of SLCPs for Bangladesh shows that emissions of methane, BC, and ozone pre-cursor gasses have been increasing over the last decades, where the particular source sectors for each component are identified.

INTRODUCTION

Dhaka can be considered the mega-city with the world's worst urban air quality [1]. A combination of numerous local emission sources in addition to special local and regional winter meteorological conditions gives the city exceedingly high air pollution concentrations throughout the year, and especially during the winter season [2, 3]. The exposure of the city's estimated 15 million residents to this alarmingly poor air quality poses the greatest health risk of the top mega-cities in the world and demands attention [4], including immediate research and corresponding mitigation [2, 3]. The World Health Organization (WHO) estimates that up to 10,000 pre-mature deaths are associated with outdoor air pollution annually in Bangladesh [5].

While urban air quality is a major health issue at the local level in Bangladesh, there are also particular issues regarding local emissions impacting the global climate - Bangladesh is noted as one of the top 25% worst greenhouse gas (GHG) polluting countries in the world [6]. Recently, the Climate and Clean Air Coalition To Reduce Short-Lived Climate Pollutants initiative [7] was established between the U.S., Canada, Sweden, Mexico, Bangladesh, and Ghana to address the Short-lived climate pollutants (SLCP's) which are impacting the global climate at the highest rate, and are now seen as more threatening forcers in the short term than just GHGs in general, or CO_2 alone [7, 8]. SLCPs include the main pollutants of methane (CH_4), Black Carbon (BC) and tropospheric ozone (O_3); in addition, hydrofluorocarbons (HFCs) can also be included as an SLCP threat [8].

The Malé Declaration compiled the first baseline emissions inventory specifically for Bangladesh with data up to 1998 [9]. Since this initial inventory, a comprehensive assessment or inventory of country-wide emissions for the suite of criteria pollutants is lacking, and no assessments have been made specifically for the new pollutant grouping of SLCPs and their corresponding emissions at the national level in Bangladesh. This paper will present an initial assessment and compilation of SLCPs, examining the sectors, sub-sectors, and activities making up these current and projected future atmospheric emissions for Bangladesh. The assessment for these emissions will be based on top-down regional and/or global emissions database sources, where multiple sources are necessary to cover the range of pollutants making up SLCPs.

MATERIALS AND METHODS

Various emissions database/inventory sources were utilized to compile the different pollutants examined in this assessment for Bangladesh: Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)[10, 11], Emissions Database for Global Atmospheric Research (EDGAR) [12, 13], Transport and Chemical Evolution over the Pacific (TRACE-P)[14], Intercontinental Chemical Transport Experiment B (INTEX-B) [15], Regional Emission Inventory in Asia (REAS) [16, 17], and Multi-Sensor Re-analysis of total ozone (MSR) [18, 19].

The GAINS South Asia model (Final Report, Baseline08 scenario) was utilized to compile methane emissions for the years 1990-2030 for Bangladesh, in addition to identifying the sectors and activities making up these emissions. EDGAR database (v4.0-4.2) was utilized to investigate and compile methane emissions for 1970-2008, and ozone pre-cursor emissions for 2008 in Bangladesh. TRACE-P/INTEX-B databases were utilized to investigate BC emissions in Bangladesh for 2000 and 2006 respectively. REAS inventory (v1.11) was utilized to compare methane, BC, and ozone pre-cursor emissions for Bangladesh and the region in 2000. MSR was used to investigate ozone data from 1978-2008 over Bangladesh and region.

RESULTS AND DISCUSSION

The primary components making up SLCPs (methane, BC, and ozone) will be examined for Bangladesh for the most recent data. Where possible, the activities making up these emissions will be identified, and projections up to 2030 estimated. Global methane emissions for 2008 (Fig. 1) show that Bangladesh is located in a region of relatively high emissions exceeding 500 tons per year per 0.1 degree grid cell shown. REAS shows similar distribution patterns as EDGAR for the Asian region.

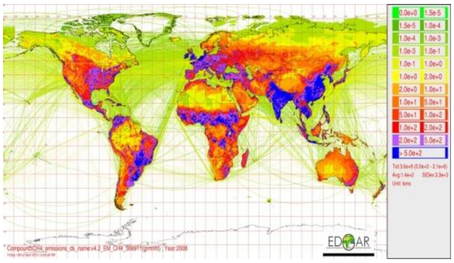

Fig. 1. Global methane emissions for 2008 (Source: EDGAR v4.2)

The EDGAR database also reveals that methane emissions for Bangladesh have been variable each year from 1970-1990 (between 4.0-4.4 Mt CH_4/year), while from 1992-2008 emissions have steadily increased 15% during this period to over 4.6 Mt CH_4 in 2008. GAINS also shows a similar increase of approximately 15% for methane emissions for the similar overlapping period of 1990-2010, and also projects this increase to remain steady through 2030 with emissions of 5.0 Mt CH_4/ year. The agricultural sector consistently makes up the vast majority (between 75-80%) of the increasing methane emissions from 1990-2030 in Bangladesh (Fig. 2). Emissions from the industrial sector are also increasing over time but at a rate which is consistently about 2.5 million tons/year less than the agricultural sector. Methane emissions from the other sectors of residential and traffic are very low in comparison as expected.

GAINS calculates that the sole activities of rice cultivation (1.8 Mt CH_4/year) and cattle (1.4 Mt CH_4/year) make up the agricultural sector emissions of methane for 2010 in Bangladesh, in which this is 42% and 33% of the total methane emissions respectively for that year. EDGAR also shows rice cultivation as the greatest contributor to methane emissions in Bangladesh, which has decreased from approximately 3.2 Mt CH_4/year in 1970 to 2.2 Mt CH_4/year in 2008 for this single activity. EDGAR on the other hand shows that the next greatest contributing activities to methane emissions of cattle (enteric fermentation) and wastewater treatment are greatly increasing for the period 1970-2008 at approximately 30% and 130% respectively, with 2008 emissions for methane from cattle at 0.9Mt CH_4/year and for wastewater treatment at 0.7 Mt CH_4/year. REAS data is not presented or compared to other data sets for methane because the values are up to a factor 1000 greater than the EDGAR and GAINS data presented, which possibly suggests data errors in REAS.

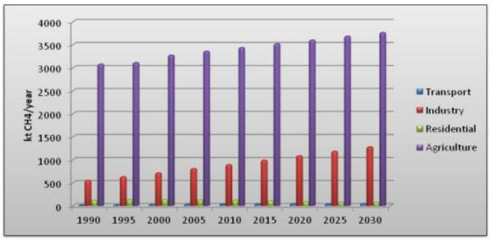

Fig. 2. Methane Emissions Sector Distribution for Bangladesh from 1990-2030; compiled using GAINS South Asia.

Asian BC emissions for 2006 (Fig. 3) shows Bangladesh is in a specific region with high BC emissions of 750 – over 1000 tons per year per 0.1 degree grid cell shown. This spatial representation from INTEX-B presents a similar distribution as other global BC distribution map found [20, 21] which shows that Bangladesh and the surrounding region has some of the highest BC emissions in the world. In addition, REAS Asian BC maps also show Bangladesh in a hot-spot region for Asia in 2000.

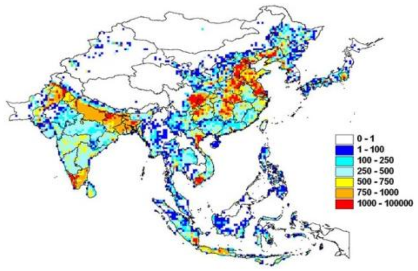

Fig. 3. Asian BC Emissions for 2006 (Source INTEX-B, 2007).

INTEX-B registers Bangladesh with 43.1 kt/year total BC emissions for 2006, increasing at approximately 10% from 39.1 kt/year for 2000 as found in TRACE-P. The sector distributions of the BC emissions for these two years (Fig. 4) show emissions from the industrial sector are surprisingly low (0.1 kt/year for 2000 and 2006). There are 3000+ brick kilns as BC sources which operate in the country, so it is assumed that these industrial sector emissions in INTEX-B are severely underestimated; doubts have been raised regarding the emission factors used for brick kilns in the INTEX-B database [22], which can explain part of this underestimation. REAS presents BC for Bangladesh at 67.1 kt/year for 2000, which is almost double the value presented in TRACE-P for the same year.

Global mean ozone values using monthly averages for 1978-2008 taken from MSR show that Bangladesh is located in an area of lesser ozone (as per indicated Dobson Units) than other areas around the globe (Fig. 5a). In addition, the anomaly map presented for the year 2008 (Fig. 5b) shows that Bangladesh experienced lesser ozone for this year (as indicated by approximately -5 Dobson Units) than the mean value of the previous 30 years. When looking closer in at Bangladesh in the South Asian region (Fig. 5c), it is apparent that the 30 year mean for ozone is slightly greater (at a range of approximately 5 Dobson Units) in the northern areas of the country closer to the Himilayas. During the year 2008, the anomaly map (Fig. 5d) shows ozone is slightly less overall for the country (at a range of approximately -2 to -4 Dobson Units) for this year in comparison to the mean value of the previous 30 years.

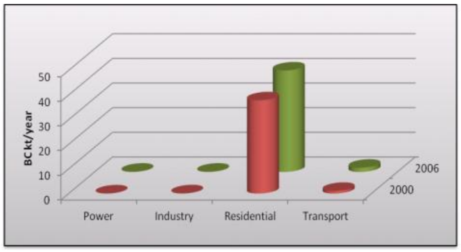

Fig. 4. BC Emissions for Bangladesh divided by Sector for 2000 and 2006; compiled using INTEX-B for 2006 data and Trace-P for 2000 data.

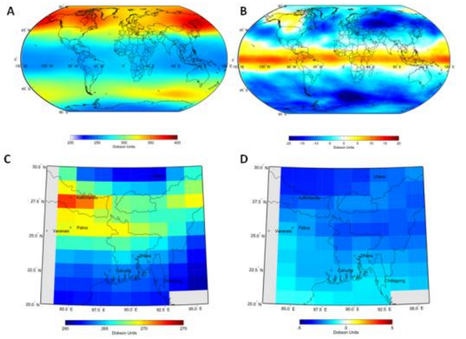

Fig. 5. A) Global average ozone for years 1978-2008 (Dobson Units) based on monthly mean values; B) Anomaly map showing 2008 global ozone values and the difference (Dobson Units) from the 1978-2008 mean based on monthly mean values; C) Regional mean ozone for years 1978-2008 (Dobson Units) based on monthly mean values; D) Anomaly map showing 2008 regional ozone values and the difference (Dobson Units) from the 1978-2008 mean based on monthly mean values; compiled using MSR data.

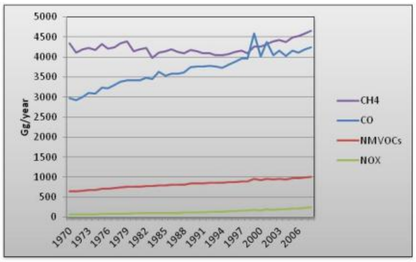

Fig. 6. Emissions of ozone pre-cursors methane, CO, NMVOCs, and NOX in Bangladesh, 1970-2008, compiled using EDGAR v4.2.

The primary pre-cursor gasses to ozone include carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), nitrogen oxides (NO_X), and methane – these individual pollutants can be assessed as an indicator for possible ozone formation. To understand how Bangladesh is contributing to ozone levels, it can be valuable to examine the pre-cursor gas emissions as an indicator for the Bangladesh ozone contribution (Fig. 6). EDGAR indicates that all of these gasses have been increasing during the period 1970-2008, somewhat contradicting the MSR data that 2008 ozone values where lesser than the mean of the data from 1978-2008. During this 30 year period, methane has increased approximately 10% where as previously indicated the primary contributor to these emissions are from the agricultural sector (rice and cattle); CO has increase 40% where a majority of these emissions are coming from the residential sector; NMVOCs have increased 70%, also coming from the residential sector; and NO_X increased 200%, coming from transport and residential (including electricity production) sectors.

Table 1. Summary of SLCP emissions for Bangladesh.

HLCP Component	Emissions Trend	Contributing Sector	Global Hot Spot
Methane	Increasing	Agriculture	Yes
BC	Increasing	Residential/Industrial	Yes
Ozone			
Methane	Increasing	Agriculture	
CO	Increasing	Residential	
NMVOCs	Increasing	Transport	
NOX	Increasing	Transport/Residential	

CONCLUSION

This paper presents an overview of the current SLCP emissions in Bangladesh, including historic value comparisons, and future emissions projections for select components. Bangladesh is in one of the most polluted regions (hot-spot) of the world for SLCPs of methane and BC in which each are increasing at the national level, in addition to the increase of ozone formation pre-cursor gasses, while Bangladesh is not necessarily located in a hot-spot for this pollutant (Table 1). Methane emissions have increased 15% from 1990-2010, and are expected to continue at this rate through 2030. A majority of these emissions are coming from the agricultural sector, primarily rice cultivation and cattle. BC emissions are increasing 10% between 2000 to 2006, in which sources used indicate the majority of these emissions are originating from the residential sector; doubt has been expressed regarding this sector distribution, in which the industrial sectors must contribute more than is being indicated. Emissions of ozone pre-cursor gasses have increased between 10-200% from 1970-2008, where the bulk of these emissions are originating in the residential and agricultural sectors.

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