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Ambient CO Levels during Winter and Summer Agricultural Burning Seasons of Northern India

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Abstract: Field burning of crop residues (FBCR) has significant environmental costs in terms of concerning emissions and natural resource loss. Such burning is increasingly common in the developing world regions like India, and the ambient levels of carbon monoxide (CO), a criteria-pollutant, during such burning seasons has not been studied as yet by any research or pollution monitoring agencies in the region. In this instance, in-situ field studies were conducted in the northern Indo-Gangetic plains to study the ambient CO levels during the rice and wheat crop (the major crop residues subject to FBCR in the region) residue burning seasons. The ambient CO levels were observed to be 1.90±0.69 ppmv and 1.35±0.53 ppmv during the rice residue burning season at Pantnagar and Ludhiana respectively. During the wheat residue burning seasons, it was observed to be 0.41±0.23 ppmv at Pantnagar and 0.69±0.22 ppmv at Patiala and Ludhiana (combined). The ambient CO levels remained near the National Ambient Air Quality Standard during the study period and also crossed it several times. It was further observed that the levels were higher in case of rice residue burning season as compared to that of wheat. The long residence time of CO and the increasing FBCR practice may aggravate the problem in future.

Key words: Crop residue, biomass burning, carbon monoxide pollution, agricultural fire.

Introduction

The share of agricultural waste [i.e. 2020 (Levine, 1990), 1900 (Crutzen et al., 1979) and 540 (Andreae and Merlet, 2001) Tg/yr] in the total biomass burnt globally [8680, 6800 and 8600 Tg/y, respectively] is considerable and such activities are becoming significant in developing countries as well. Field burning of crop residues (FBCR), though a common environmental concern in the Indian sub-continent has scarcely been studied. Streets et al. (2003) stressed the urgent need for biomass burning studies in the Indian region. Indian FBCR contributes about 23% of the Asian non-fuel biomass burning. Due to wide use of combine harvesters and other reasons (Sahai et al., 2007; Gupta et al., 2004) the activity is increasingly common in India, and northern India may be considered as the hotspot of such activities. FBCR emits trace gases and particulate matter leading to deleterious impact on human health, natural environment and ecological systems (Cheng et al., 2000). The various impacts of these emissions have been well studied by Cheng et al. (2000), Levine (1990), Bardouki et al. (2003), Andreae and Crutzen (1997), Sahai et al. (2007), Yang and Sheng (2003), Heenan et al. (2004), Blair (2000), Prasad et al. (1999), Smil (1999), Aulakh et al. (2001) and others. Some studies of Indian emissions from FBCR such as Bhattacharya and Mitra (1998), Yevich and Logan (2003), Streets et al. (2003), NATCOM (2004) and Sahai et al. (2007) are available. However, the pollution aspect of the source in the region is still under-

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represented in terms of its scientific understanding. This probably is because: firstly, most of the studies related to air pollution, either by various research groups or by pollution monitoring agencies, have been based in the urban areas in the developing world regions like India; and secondly, it is difficult to measure all the emission species under rural settings. That is, measurement facility for some air pollutants (like SPM, NOx, Sox etc.) are relatively more easy manageable, whereas, for others (like CO) require sophisticated setups which is still not easily manageable under rural settings in developing countries.

Mittal et al. (2009) have studied the pollution aspect of FBCR; however, the study did not include one of the six criteria air pollutants i.e. CO, that has widely acceptable bearing on the human health, natural environment, atmospheric chemistry and is closely linked to the global climate change. It may be noted that in India, the major share in FBCR and the consequent impact of its emissions is expected from that of rice and wheat crop residues, and the present study deals with the ambient CO levels during the field burning seasons of these two crop residues. The rice residue burning season starts with harvesting of crop in September-October and extends upto whole of November. In case of wheat the burning activity starts with harvesting in April-May and extends roughly to whole of May. Similar seasonality of FBCR under rice and wheat cultivation have been reported by Mittal et al. (2009) in Punjab (India), who have stated that April and May as well as October and November are the months considered as the crop stubble burning months. In view of limited scientific understanding of the pollution aspect of FBCR in the region, efforts have been mounted to study the status of carbon monoxide (CO) ambient levels during the wheat and rice crop residue field burning season in the northern Indo-Gangetic plains (IGP). IGP forms the heart of agricultural activities in India and ambient CO, one of the criteria air pollutants, has scarcely been studied under rural settings in the region. Experiments were carried out in combine harvested rice and wheat fields in the humid sub-tropical IGP at Pantnagar, Ludhiana and Patiala (India) to measure ambient CO levels to provide a basis for assessing relevant concerns. The results of the study have been presented here.

Methodology

Study Area

The experiments were conducted at three places viz. Pantnagar (29^o N and 79.5^o E, in the agricultural farm of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal State of India), Ludhiana (30.9^o N and 75.9^o E, in Jaspal Bangar village, Ludhiana, Punjab); and Patiala (30.3° N and 76.5° E, Sidhu Bal village, Patiala, Punjab) (Figure 1). The three study sites fall under sub-humid and sub-tropical climatic zone. The measurement for rice residue burning season was carried out at Pantnagar from 19-20 November 2003 and at Ludhiana from 7-10 November 2006, whereas the measurements for wheat residue burning season was carried out at Pantnagar from 9-12 May 2003, at Patiala from 2-7 May 2007 and at Ludhiana from 8-12 May 2007. The wind was observed to be predominantly north-west during the two rice residue burning season experiments, whereas that during the three wheat residue burning season experiments varied predominantly between southeast, south and southwest.

Sampling and Analysis

The experiment was planned to represent clear local environmental conditions during the period when such open burning is normally practiced in the region. CO measurement was carried out by real-time infra-red gas filter correlation CO analyzer (model: 300, API Inc., USA). The detection and measurement of carbon monoxide in the CO analyzer is based on the absorption of Infra Red (IR) radiation by CO molecules at wave lengths near 4.7 microns and the system has a lower detectable limit (LDL) of <0.050 ppm, a precision 0.5% of reading, sample flow rate (SFR) of 800 cc/min (±10%), temperature range of 5-40°C and humidity range 0-95% RH. CO standards from Scott-Marrin Inc., California were used for calibration of CO analyzer.

Results and Discussions

Real-time CO measurements with diurnal trends that are representative of the FBCR season are scarcely available for rural settings of the Southeast Asian region. FBCR at the three sites of Pantnagar, Ludhiana and Patiala were generally observed to start from late afternoon and reached its maximum after the sunset in case of both rice and wheat crop residues field burning. A similar observation has been reported by Yang et al. (2008) in China, who stated that in Sequian part of China crop residue burning in the field generally is concentrated for several hours after dark.

The findings of the study show important characteristics of the ambient CO during the two burning seasons. The ambient CO levels were observed to be 1.90±0.69 ppmv and 1.35±0.53 ppmv during the rice residue burning season at Pantnagar and Ludhiana,

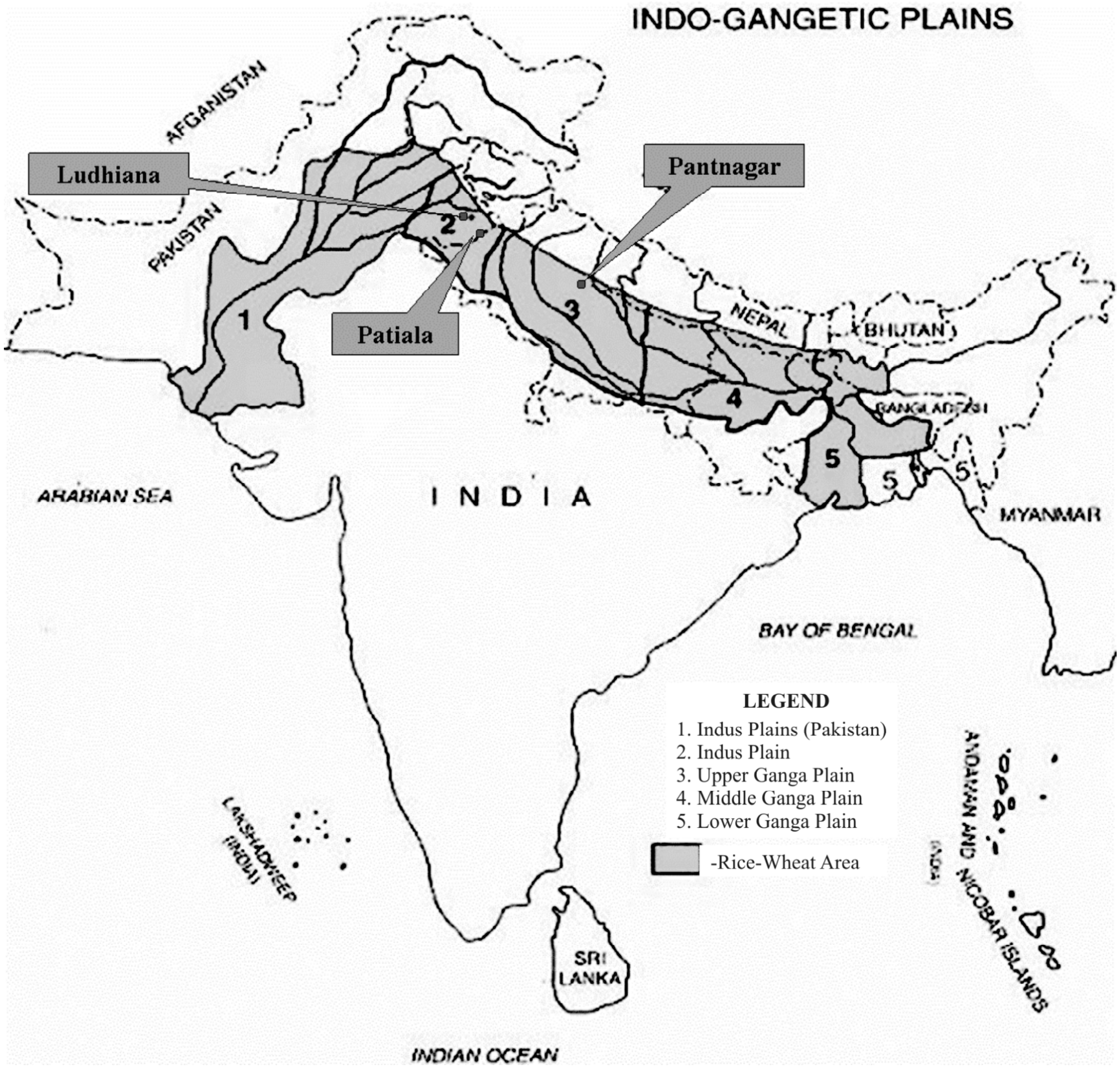

Figure 1: Locations of experimental sites at Pantnagar, Ludhiana and Patiala.

whereas that during wheat residue season was observed to be 0.41±0.23 ppmv at Pantnagar, and 0.69±0.22 ppmv at Patiala and Ludhiana combined, respectively (Figure 2). CO levels remained around or above the National Ambient Air Quality Standard (NAAQS) of 1.75 ppmv at all the three sites during the study period (Figures 2-5). The ambient CO was higher in case of rice residue burning season as compared to that of wheat. This shows that from the air quality perspective, rice residue burning season is bigger concern as compared to that during the wheat residue burning season. The diurnal variation of the ambient CO recorded during the different experiments has been presented in Figures 3-6. On comparison of these figures it is very clearly established that the CO levels are in general higher during the rice residue burning season (Figures 4 and 5). It is observed that though the CO level remained below the NAAQS, it crossed the level several times and more so during the rice residue burning season. The observed levels are further concerning as, for most of the time, they remain very close to the NAAQS. Also there is a rise observed in the evening hours onwards which may be linked to field burning, domestic fuel burning and lowering of planetary boundary layer (PBL).

The observation that, in general, the pollution levels are found to be more during the rice residue-burning season as compared to that of wheat residue is very important for the atmospheric studies in the region. One important reason for this difference, apart from higher emissions from rice residue burning, is the diverse meteorological conditions during the two burning seasons. The wheat residue-burning season falling in

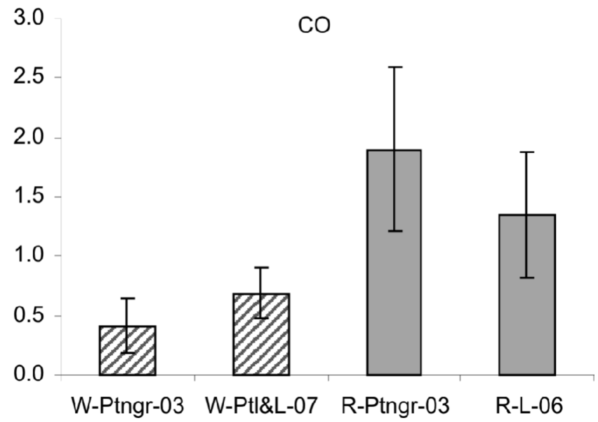

Figure 2: CO ambient concentrations during the wheat and rice residue burning seasons (W – wheat; R – rice; Ptngr – Pantnagar; Ptl – Patiala; L – Ludhiana; years 2003, 2006 and 2007 are represented as 03, 06 and 07 respectively).

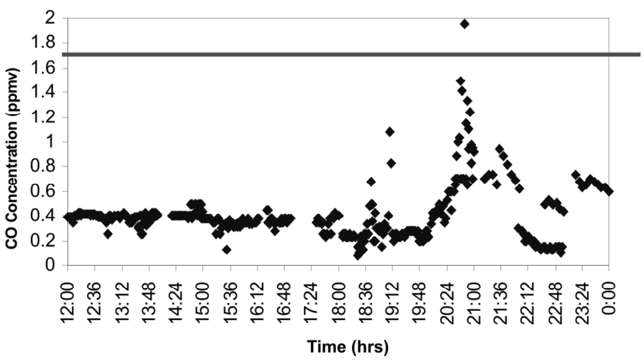

Figure 3: Diurnal variation of CO (ppmv) for the non-fire event (NFE) period at Pantnagar during the wheat residue burning season in May 2003 (the straight line parallel to x-axis represents the NAAQS for CO).

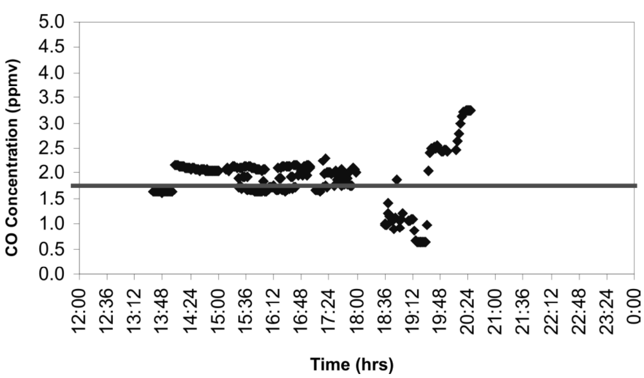

Figure 4: Noon to mid-night variation of CO (ppmv) for the non-fire event (NFE) period at Pantnagar during the rice residue burning season in November 2003 (the straight line parallel to x-axis represents the NAAQS for CO).

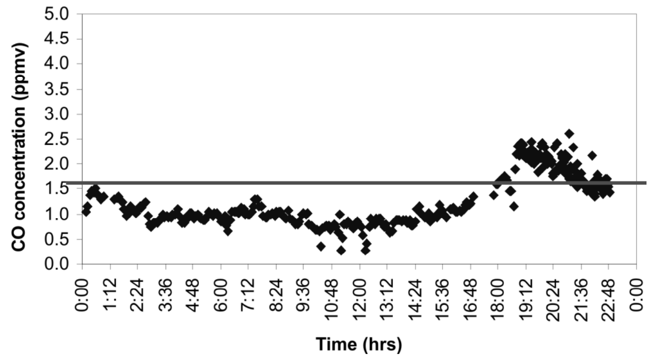

Figure 5: Diurnal variation of CO (ppmv) at Ludhiana during the rice residue burning season in November 2006 (the straight line parallel to x-axis represents the NAAQS for CO).

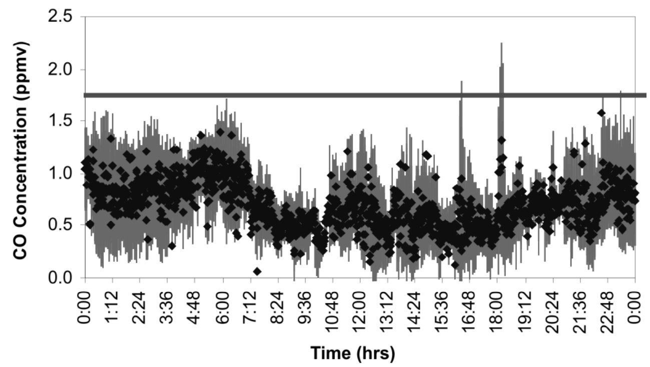

Figure 6: Diurnal variation of CO (ppbv) at Ludhiana and Patiala during the wheat residue burning season in May 2007 (Shaded portion indicates the standard deviation values and the straight line parallel to x-axis represents the NAAQS for CO).

summer experiences comparatively higher temperature and planetary boundary layer (PBL) as compared to that during the rice residue-burning season that falls in the winter. Moreover, the maximum wind speed in the IGP during the two seasons has been observed to be between 8-10 km/hr in summer season and between 2-4 km/hr in the winter season (Singh et al., 2002). It is thus expected that there will be much higher convections during the summer, which due to the higher PBL will result in better conditions for escape of the pollutants (in this case CO) from the region. The lower PBL coupled with the lower convection and turbulence during winter, will consequently provide conditions for trapping of the pollutants below the PBL resulting in higher effective pollutant loading.

Another important concern about CO emission from FBCR is its long residence time as compared to some other criteria pollutants that may cause its accumulation in the boundary layer. Thus the long residence time may aggravate the problem with increase in FBCR in future. In case of rice FBCR, the adverse meteorology coupled with the long residence time of CO is a bigger concern. A comparison with similar measurements during non-burning seasons of the year in future studies would address some more concerns related to ambient CO in the burning seasons. It is important to note here that the pollution from the burning source in the study area are concerning from its regional impact as well. In this instance, the observation by Yang et al. (2008), that the ambient air quality in Sequian (China) is influenced by crop residue burning not only in Sequian but also in the vicinages, raises important concerns about regional impact of the CO pollution during the rice and wheat residue burning seasons in northern India, that should be studied further.

Conclusion

Field burning of crop residues (FBCR) is increasingly common in the developing world regions like India, and the ambient levels of carbon monoxide (CO), a criteria pollutant, during such burning seasons has not been studied in the region. In-situ field experiments in the northern Indo-Gangetic plains, to study the ambient CO levels during the rice and wheat crop (the major crop residues subject to FBCR in the region) residue burning seasons, revealed important information on the ambient air quality with respect to ambient CO of the region. The ambient CO levels were observed to be 1.90±0.69 ppmv and 1.35±0.53 ppmv during the rice residue burning season at Pantnagar and Ludhiana respectively. During the wheat residue burning seasons, it was observed to be 0.41±0.23 ppmv at Pantnagar and 0.69±0.22 ppmv at Patiala and Ludhiana (combined). The ambient CO levels remained near the National Ambient Air Quality Standard during the study period and also crossed it several times. It was further observed that the levels were higher in case of rice residue burning season as compared to that of wheat. The long residence time of CO and the increasing FBCR practice may aggravate the problem in future. The findings, apart from enriching the pollution studies in the area, will be important missing input for environmental modelling studies, climate change studies, health impact studies and for understanding its ecological cost in the region. Future efforts to make similar study in the non-FBCR seasons in the region can be very useful to address relevant local and regional implications.

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