Atmospheric Environment 137 (2016) 127–134

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Short communication

Respiratory health concerns in children at some strategic locations from high PM levels during crop residue burning episodes

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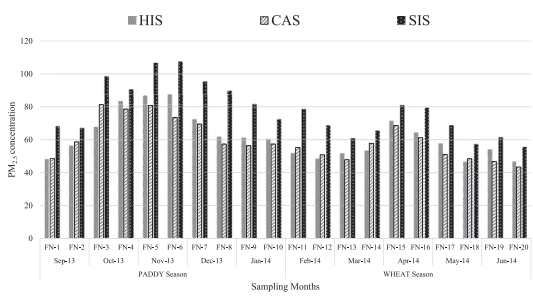
HIGHLIGHTS

- PFT of low age group fall as SIS > HIS > CAS, mixed trend was observed for other groups.
- FVC of children of all age groups from SIS decreased 5–7% more than of HIS and CAS which is due to their poor BMI.
- Lung capacity of children recovers only up to 80% after the CRB events.
- Children of CAS recover much faster than SIS and AMR due to their better BMI.
- A fall of PEF by 3% during non-CRB (winter) months may be due to PM_{10} and $PM_{2.5}$ levels due to automobiles activity.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 22 September 2015
Received in revised form
21 April 2016
Accepted 21 April 2016
Available online 27 April 2016

Keywords:
Pulmonary function test
Children
Particulate matter
Crop residue burning
Ambient air

ABSTRACT

Particulate Matter (PM) levels in the ambient air of three urban sites of strategic importance in Punjab (second largest agricultural state of India) were monitored from September 2013 to June 2014 covering two seasons of crop residue burning episodes of rice and wheat, respectively. During both crop periods, the levels varied from 71 to 167 μgm^{-3}(PM_{10}) and 43–107 μgm^{-3} ($PM_{2.5}$), which were observed to be much beyond the permissible limits of 100 μgm^{-3} for PM_{10} and 60 μgm^{-3} for $PM_{2.5}$ set by state pollution control agencies. Simultaneously, Pulmonary Function Test (PFT) parameters of children (age group 10–16 years) residing at these sites were monitored. PFT parameters like Forced Vital Capacity (FVC) and Peak Expiratory Flow (PEF) were monitored on 50 healthy subjects at each site. The results indicated an alarming fall in FVC (5%–7%) and in PEF (4%–6%) parameters during the crop residue burning period's .The decrement was almost same for all age groups of children. The adverse effect was more on female subjects than male subjects. The impact of particulate matter pollution was more prominent in industrially important site (7%, SIS) as compared to historically (3%, HIS) and commercially (4%, CAS) important sites.

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1. Introduction

The smooth working of body organs represents the status of health. Various epidemiological studies in different countries

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http://dx.doi.org/10.1016/j.atmosenv.2016.04.030
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examined that, raised level of suspended particulate matters having size PM_{10} and $PM_{2.5}$ in the ambient air produced adverse effects on various physiological parameters i.e., respiration capacity of human subjects (Dvonch et al., 2009; Samet et al., 2009; Ostro et al., 2009; Strickland et al., 2010; Li et al., 2013; Chakmak et al., 2014). According to World Health Organisation (WHO) report, it is a cause of cardiopulmonary morbidity and mortality of 6.4 million people (WHO, 2003) and 3.7 million premature deaths (WHO, 2012) worldwide. Children are more susceptible to higher PM levels (Gotschi et al., 2008; Miller and Marty, 2010; Buonanno et al., 2011; Cohen et al., 2005; Pope and Dockery, 2006; Davidson et al., 2005). As compared to adults and elder age groups, they have higher respiration rate and narrower airways (Buonanno et al., 2013; Altug et al., 2014; Sharma et al., 2010; Gauderman et al., 2015). Children have less body immunity. They are mentally not aware about their surrounding environmental conditions. Having higher respiration rate, the dose inhalation rate is more than other age groups. Among the sources, automobiles and industries are considered as the main source of PM generation in the urban areas. From several decades, studies are revolving around the effect of PM on pulmonary functions of human health which are generated due to combustion of fuels in vehicles, factories or production units (Margolis et al., 2009; Gasana et al., 2012; Rovira et al., 2014). Open burning of agriculture crop residue is also one of the important sources of particulate matter generation (Lexieux et al., 2004). Agriculture crop residue burning is episodic by nature which occurs in particular months. In these months, the level of PM is alarmingly high with respect to environmental conditions (Singh et al., 2010; Mittal et al., 2009). Few studies have been done to investigate the effect of crop residue burning on human subjects especially in urban areas (Awasthi et al., 2010; Agarwal et al., 2010; Uriarte et al., 2009). There is scarcity of necessary evidences which are exhaustively focusing on the effect of crop residue burning on human subjects, especially children of urban areas of strategic importance like historical, commercial and industrial cities with reference to crop residue burning seasonal months. Because children in urban areas are constantly influenced by pollutants from vehicles and industries, the main focus of this epidemiological study is to exhaustively investigate the effect of PM due to crop residue burning on pulmonary functions of children living in some selected urban areas.

2. Materials and methods

2.1. Study design

For investigation, the study was carried out from September 2013 to June 2014 which covers one season of Rice and one season of Wheat crop. Three major urban areas were selected in the region surrounded by agriculture land. For the selection of subjects having age 10–16 years, three high schools were selected. The study period was divided into two seasons, one for Rice (September 2013 to January 2014) and one for Wheat (February 2014 to June 2014). For sampling and exhaustive data analysis, months were further divided into fortnights. The Samples of PM and PFTs were collected twice in a fortnight from each site. For evaluation of PFT parameters, the age group was divided into four categories (Less than 12 year, 12–13 year, 13–14 year, Above 14 year) with respect to subject's gender.

2.2. Selection of sites

Punjab state, which is the second largest producer of grains in India, is situated in the North-West side of India. Wheat and Rice are the main cereal crops of this area. These are cyclic crops. Rice is sown in the month of June and ready to harvest in the middle of October and wheat is sown in the month of December and ready to harvest in middle of April. Due to harvesting by modern machineries in particular months, about 46 Metric tons of crop residues are generated in the fields (Jain et al., 2014). Less time period between harvesting and sowing of these crops encourage farmers to dispose of crop residue in the fields by burning. This practice results in a huge amount of air pollutants in the ambient air especially aerodynamic coarse particulate matters PM_{10} and $PM_{2.5}$. For investigation, three major urban areas of Punjab region (Amritsar, Ludhiana and Mandi Gobindgarh) were selected. The strategic importance of these sampling sites is shown in Table 1.

Three high schools, one in each city, were selected for sampling of PM and PFT parameters. Location of sites is shown in Fig. 1.

2.3. Selection of subjects

The study includes 50 children of 6th and 7th standard from each site (Total 150 children) in the age group 10–16 years as the human subjects for data collection. To inspect their health level, American Thoracic Society (ATS) and British Medical Research Council (BMRC) protocols were used (Miller et al., 2005). Initially, the subjects having FEV_1/FVC ratio more than 75% were considered as healthy (Samet, 1978). On the basis of these, healthy non-smoker candidates, having no history of any kind of diseases were selected for the duration of study. The consent forms were duly signed by subjects and their parents. The demographic characteristics of 50 healthy subjects from each site are given in Table 2.

2.4. Instrumentation

The concentration level of suspended particulate matters (PM_{10} and $PM_{2.5}$) were measured using Optical Real Time Spectrometer (ORTS, Grimm's Technology, Model 1.108, Germany). Due to modern integrity, this device needs no perpration like standard gravimetric method (Cheng and Li, 2010; Cheng and Lin, 2010). The functional modes and calibration of test device were done as per previously documented methods (Cheng, 2008; Cheng and Li, 2010; Cheng and Lin, 2010). The data was measured using mass concentration mode (15 channels, 0.23 μm–20 μm) having calibration factor closer to gravimetric method as compared to other modes (Tang et al., 2012). For actual estimation, initially the testing device was calibrated with standard gravimetric method at each site. PM measurements were taken once a week during crop residue burning season at rooftop of selected schools i.e. 4–5 m above the ground level. The days of sampling were selected so as to stagger on different days of different weeks. The Data was not measured on rainy days. Simultaneously, PFT parameters were measured by trained field attendants. MIR's Spirodoc G model was used for the measurement of lung function parameters like FVC and PEF. The spirometer was based on infrared turbine based phenomenon. In each trail of sampling, pulmonary function test manoeuvres were performed three times as per ATS methodology in standing position of subject. Highest value from three manoeuvres was selected as the best value. The averaged values of both PM and PFT parameters were considered for discussions. Necessary precautions were taken during the measurement of pulmonary function test.

3. Results and discussion

3.1. PM concentration

The PM levels were measured twice in a fortnight at all the selected sites. Figs. 2 and 3 present the episodic trends in PM_{10} and $PM_{2.5}$ during rice crop and wheat crop periods. Rice crop period

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