

Does air quality from crop residue burning in close proximity to residential areas adversely affect respiratory health?

Study on improvement & management of the air quality in the Delhi-NCR region

Supported by
Central Pollution Control Board



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Does air quality from crop residue burning in close proximity to residential areas adversely affect respiratory health?

Key Messages

- Crop residue burning (CRB) contributes to high particulate matter (PM) concentration in ambient air in Delhi and NCR region.
- High PM_{2.5} concentration in ambient air poses adverse health effects to public.
- This study is one of the first large-scale studies with a total of 3644 study participants aged 10-60y.
- The study aimed to understand and quantify the effect of poor air quality (PM_{2.5}) and the respiratory health of the population exposed to PM during CRB period.
- During period, the mean daily PM_{2.5} concentrations increased almost four times (193-270 $\mu\text{g}/\text{m}^3$) the ambient air quality standard for PM_{2.5} (60 $\mu\text{g}/\text{m}^3$) adopted by India.
- The study observed increase in respiratory complaints across all age groups (>10-60y) during CRB period. However, the elderly group (>40-60y) reported maximum number of respiratory complaints during CRB.
- The decline in lung function based on test parameters (FEV1, FVC and PEF) with poor air quality during CRB period was noted in all age groups.
- The youngest age group (>10-18y) reported the highest reduction in lung function as compared to other age categories (>18-40y and >40-60y) for both male and female groups.
- The adverse effect of CRB (PM_{2.5}) on lung function was found to be more pronounced in females than males in the youngest age category (>10-18y). We noted at least 10% decline in LFT parameters (FEV1, FVC, PEF) in males and at least 15% decline in female population with every 100 unit ($\mu\text{g}/\text{m}^3$) increase in PM_{2.5} concentration
- On-field and off-field stubble management interventions should be encouraged to reduce the health effects in the farmers.

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Crop residue burning (CRB) is a huge contributor of fine particulates (e.g. PM_{2.5}) in Delhi and NCR region during winter season every year. These fine particles (PM_{2.5}) pose a higher health risk to the public, especially the farmers living in CRB and nearby areas.

PM_{2.5} particles can enter into our lungs and get settled on the inner lining of the alveoli. Earlier studies on PM_{2.5} and its effects on public health have established that short-term exposure to PM_{2.5} can damage lung function and exacerbate asthma and heart diseaseⁱ while long-term exposure are associated with an increased rate of chronic bronchitis, reduced lung function, and increased mortality from lung cancer and heart disease (Figure 1).

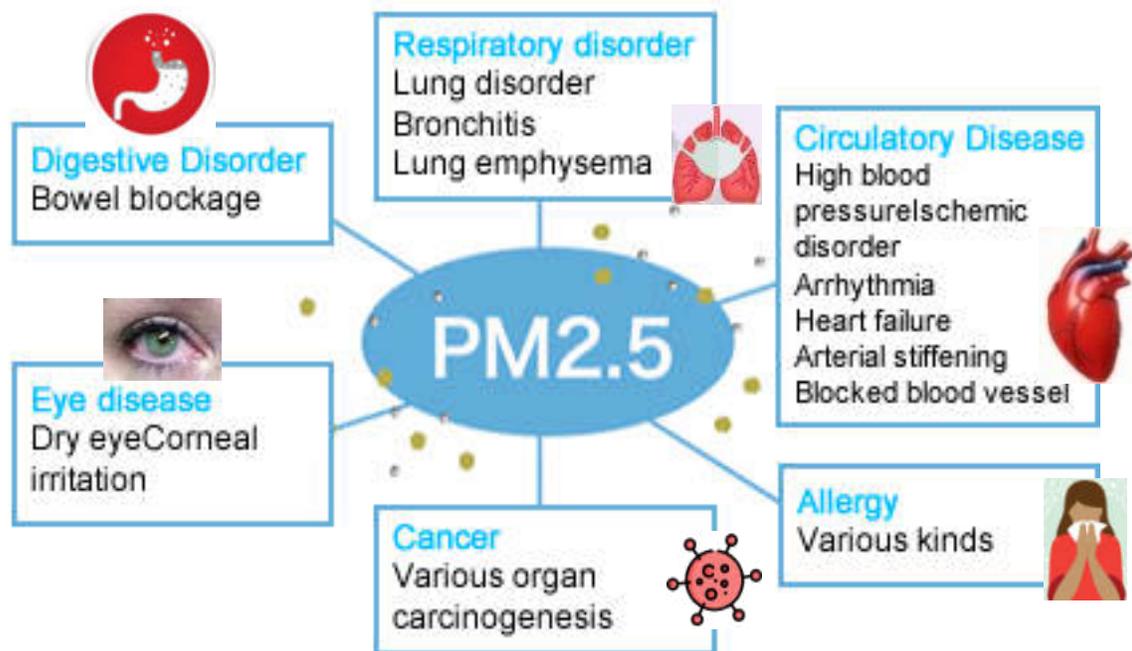


Figure 1 - Health effects of high level of PM_{2.5} exposure

Study Overview:

- The present study was undertaken to understand and quantify the association of air quality (PM_{2.5}) and the respiratory health of the community exposed to air pollution from CRB.
- The health impact of CRB was studied on the community residing in the agricultural belt of *Nabha* block (an administrative unit within a district) in Patiala district of Punjab where CRB is a recurring issue. The six study villages

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selected for this purpose included *Ageti, Narmana, Thuhi, Kalhe Majra, Mehas* and *Ajnauda Kalan* located in the *Nabha* block (Figure 2).

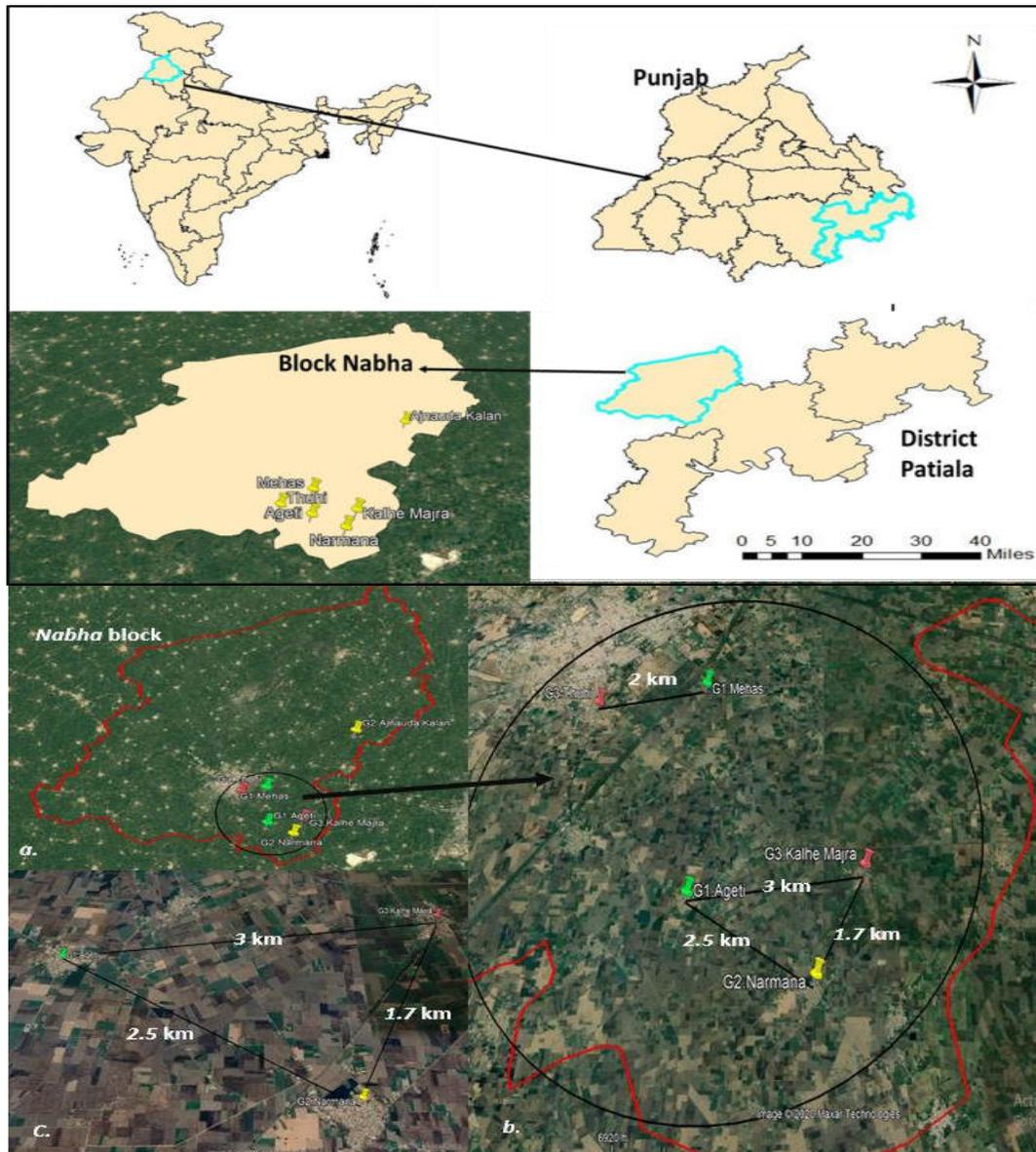


Figure 2 - Map showing locations of selected study villages in the Patiala district of Punjab

- The first phase of this study was conducted during the non-burning season (Phase1) before the onset of CRB, i.e., Oct, 2018 and again in the summer season, i.e., Mar-Apr, 2019. While the second phase was undertaken in the same study villages for the period of late Oct-Nov, 2018 during the burning period (Phase 2).

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- In the study villages, both **air quality monitoring** and **respiratory health parameters** were measured and compared during different exposure periods. And, statistical comparison was undertaken to assess the respiratory health effects of short-term high exposure of poor air quality.
- The present study strengthens the evidence on association between PM_{2.5} exposure due to crop residue burning and poor respiratory health with increased respiratory symptoms and compromised lung function in the farming community. The field-based study supports the evidence of health benefits to the farming community from the use of intervention(s) to eliminate stubble burning and focus on policy-level intervention(s) to improve air quality in the state and the neighboring region.

Impact of CRB on Ambient Air Quality

Stubble burning releases several particulate precursors which increase the organic substances capable and fine particles released can trap the toxic heavy metals and gases due to their adsorptive surface which intensify their adverse health impacts.

In this study, the concentrations of PM_{2.5} was found to increase almost four times (193-270 $\mu\text{g}/\text{m}^3$) the ambient air quality standard for PM_{2.5} (60 $\mu\text{g}/\text{m}^3$) set by CPCB (Figure 3).

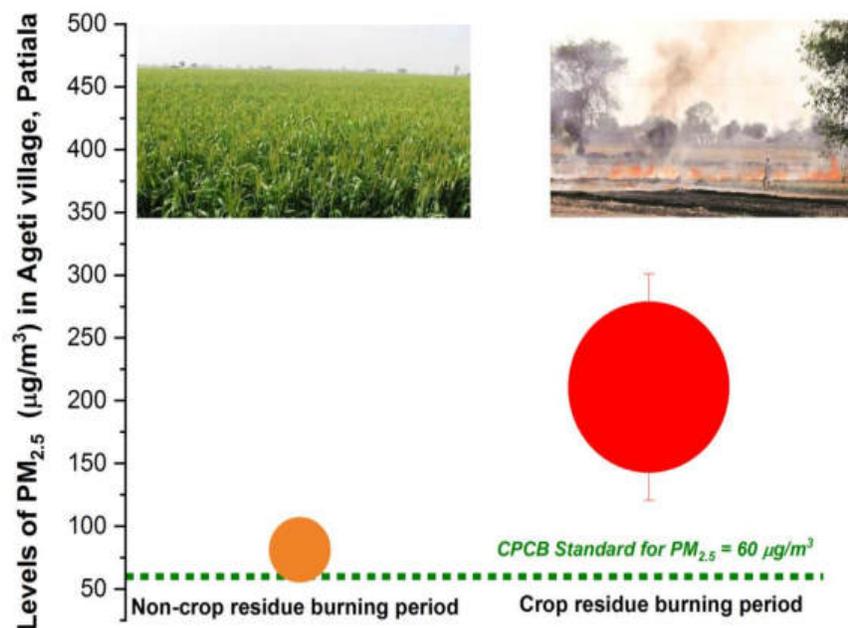


Figure 3 - Levels of PM_{2.5} measured during NCRB and CRB periods

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Another interesting study finding included **similar PM_{2.5} exposure in intervention (90% farmers using stubble management interventions), partial (50% farmers using stubble management interventions) and non-intervention study villages** as the farms adopting interventions are few and closely clustered with stubble burning farms.

Impact of Crop Residue Burning (CRB) on Public Health

A. CRB and respiratory complaints:

- During CRB, a two to three-fold increase was noted in most of the respiratory symptoms including wheezing, breathlessness on exertion, cough in morning, cough at night, skin rashes, runny nose or itchiness of eyes etc. across all age groups (10-60y) (Figure 4).
- However, the highest number of respiratory complaints were reported by the elderly population (>40-60 y) and the lowest in the younger age group(>10-18 y) during crop burning period.

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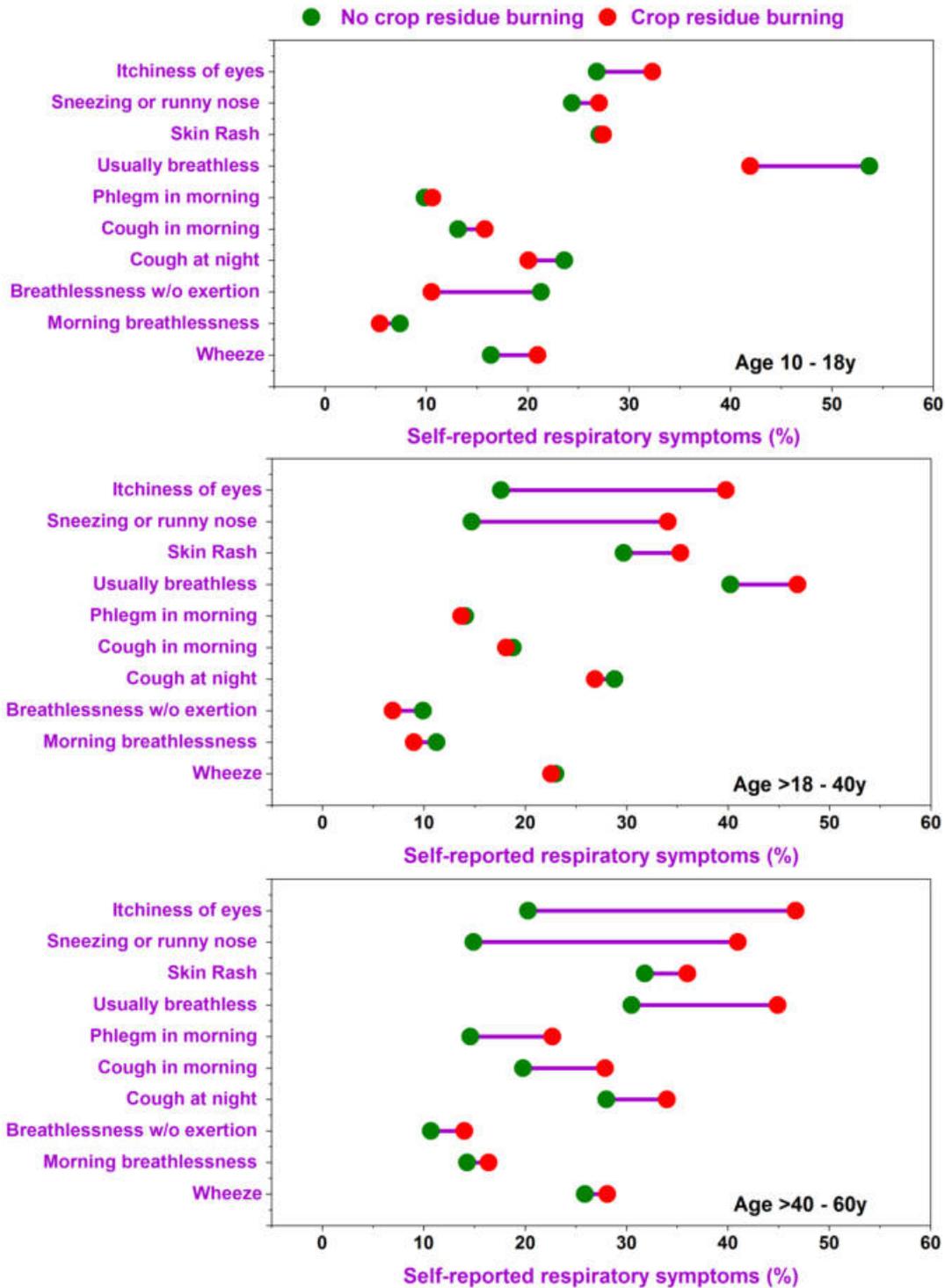


Figure 4 - Self-reported respiratory symptoms observed across three age categories during CRB compared to non-burning period

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B. Crop residue burning and decline in lung function

The decline in lung function with increase in PM_{2.5} concentration (during CRB days) was noted **across all age groups** even after controlling for several other exposure variables, i.e., cooking fuel, ventilation, distance from road etc. (Figure 5). We noted almost 10-14% decline in lung function test (LFT) parameters (FEV₁, FVC, PEF) in male population and nearly 15-18% decline in female population across all age categories.

The **youngest age group (>10-18 y) reported highest decline in lung function** as compared to the other age categories (>18-40 y and >40-60 y) both for male and female groups. Further, in this age group we estimated at least 10% decline in LFT parameters (FEV₁, FVC, PEF) in males and at least 15% decline in female population for every 100 unit (µg/m³) increase in PM_{2.5} concentration. Also, this indicates adverse effect of CRB (PM_{2.5}) on lung function was found to be more pronounced in females than males in the youngest age category (>10-18y).

Accounting for the effects of other factors (such as cooking fuel type, distance to road, etc.), a 100-unit increase in PM_{2.5} is likely to decrease predicted forced expiratory volume in one second (PREDFEV₁) by about 10% in males and 17% in female population across all age categories. Similarly, for every 100-unit increase in PM_{2.5} it is likely to decrease predicted forced vital capacity (PREDFVC) by about 10% in males and 15% in female population across all three age groups.

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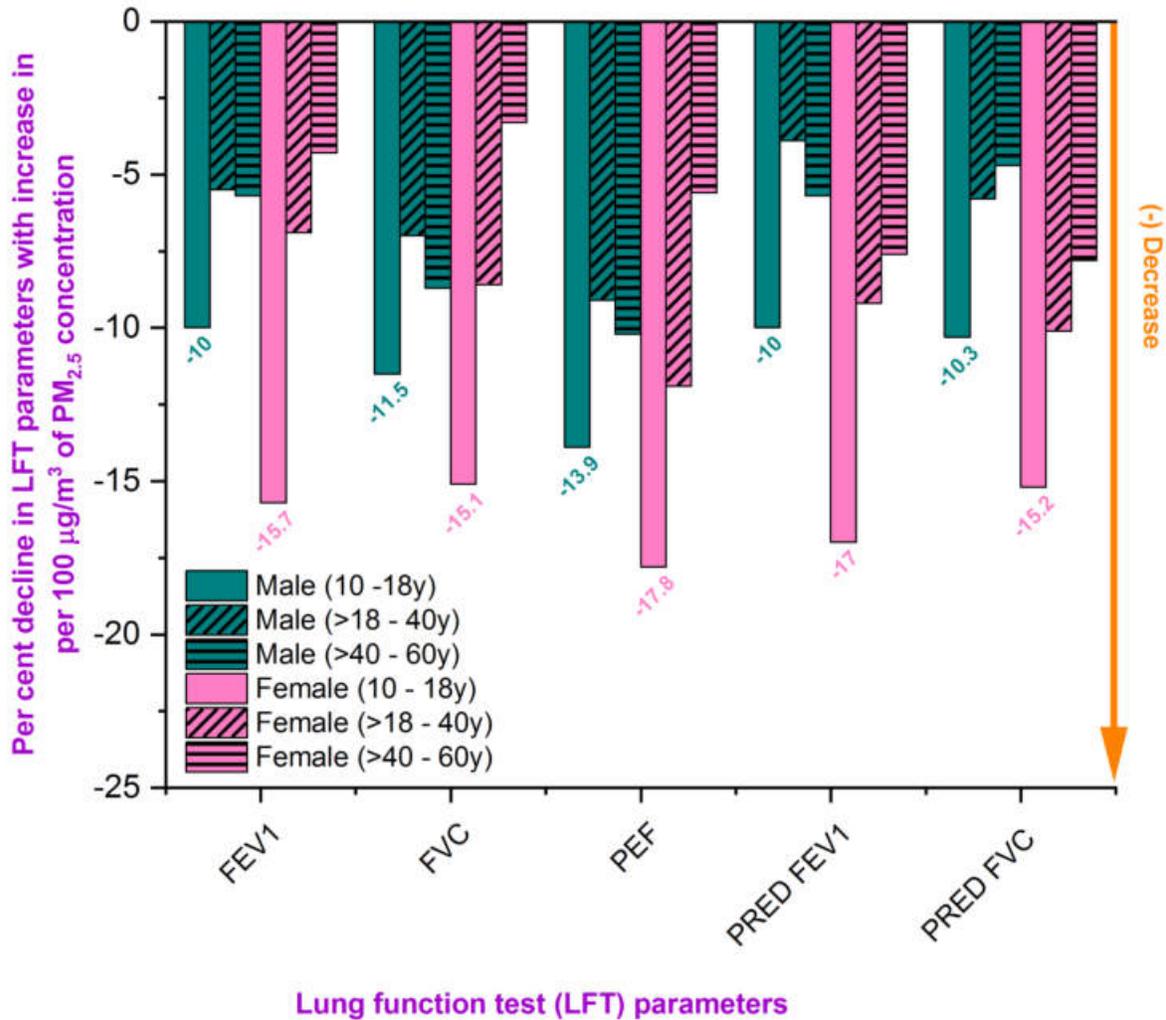


Figure 5 - Regression model outputs for predictor variable ($\text{PM}_{2.5}$) stratified by age and gender categories for different LFT parameters

Agriculture Challenge: Stubble Waste Disposal

Enormous quantity of crop residue in the form of stubble is generated in Punjab, Haryana and Western Uttar Pradesh due to paddy and wheat farming. As per a recent report by Ministry of Agriculture and Farmers' Welfare, nearly 30 million metric tons of paddy straw is generated in Punjab and Haryana and about 23 million metric tons of paddy straw was burnt in the field as an easy and quick method of disposal. CRB is a tremendous waste of biomass resource; however, there are several plausible alternatives for straw management (Figure 6).

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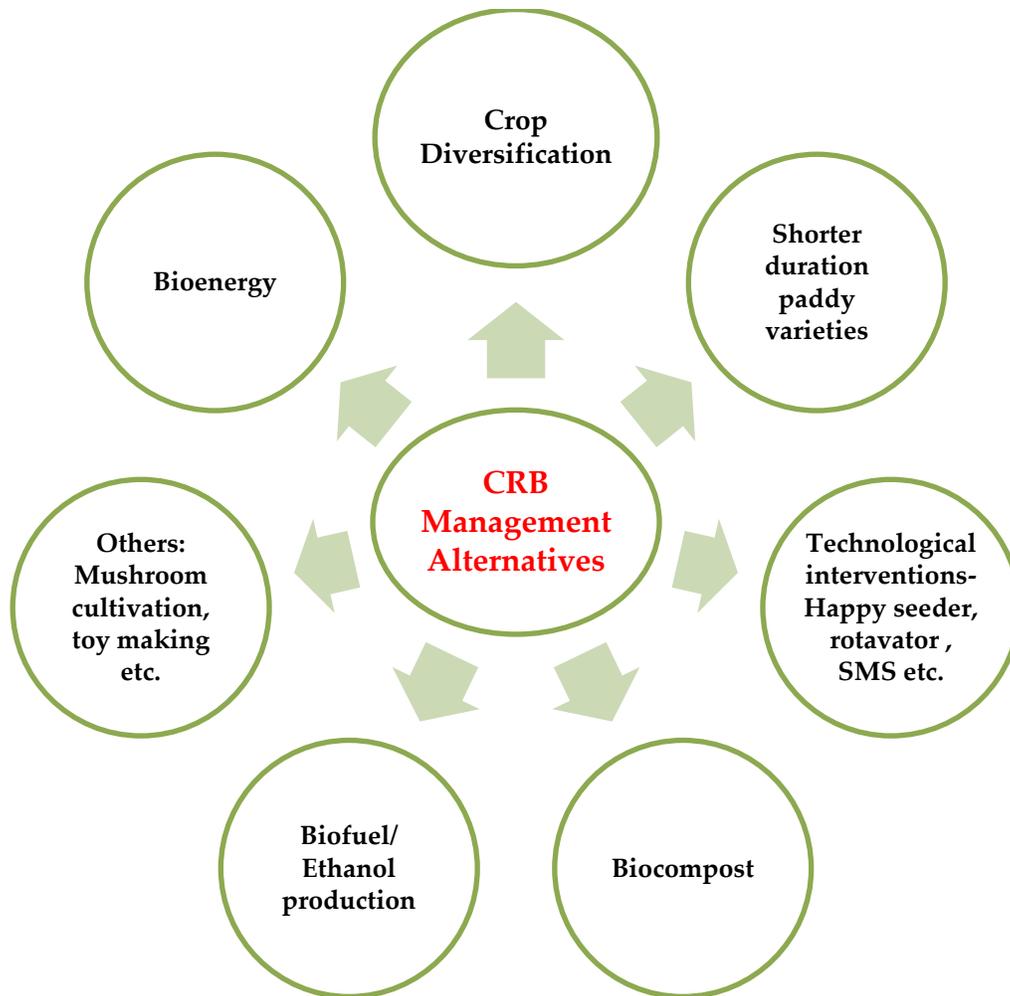


Figure 6 - Plausible interventions for crop residue management

Environmental Challenges: Toxic Pollutants in Ambient Air

Biomass burning is reported to contributing up to 42% of PM concentrations in Delhi and NCR region. The size, composition, origin, solubility, and composition is of prime importance as it decides the overall toxicity of PM_{2.5}.

CRB: Problem, Impact and Plausible Solutions

The mitigation measures include zero tillage agriculture, stubble used as cattle fodder, bio-compost, and biomass based thermal power plant and mushroom cultivations (Figure 7).

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Crop Residue Burning

Nearly **70mn** people are at harm in the Indo-Gangetic belt

Finding: A two- time increase in self- reported symptoms of cough, phlegm and almost four- fold increase in eyes itchinness complaints during the period of crop residue burning

Mitigation Measures



Zero tillage Agriculture



Biomass used as animal feed



Bio-compost



Biomass-based thermal power plant



Mushroom cultivation

Figure 7 - Most common health problems (self-reported) during CRB period and plausible mitigation measures of CRB

New Vision in Decision Making

The pollution in Delhi and NCR region gets severe during winters due to stable atmospheric conditions and low dispersion of air pollutants. Besides, taking steps for control of pollution from major sources in Delhi-NCR, action is required to be tackle the impact of stubble burning.

A holistic approach is needed to address CRB issue with a multi-disciplinary approach involving technical agencies, market-based economic tools, supporting agricultural and environmental policies, and awareness and capacity building for farmers.

This study highlights the need to strengthen the use of interventions to eliminate crop residue burning and reduce the exposure from poor air quality to reduce harm to health.