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Agricultural dust exposure during threshing: Health implications and abatement solutions

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Abstract

Dust generated during agricultural activities, particularly threshing, poses significant health risks to farm workers due to exposure to particulate matter (PM), including PM_{10} and $PM_{2.5}$. This review explores the sources, types, and health impacts of agricultural dust, emphasizing the differences between organic and inorganic dust. It highlights the need for effective dust control solutions, particularly in developing regions where personal protective equipment usage is low. The study underscores the importance of developing economical, user-friendly, and maintenance-free dust abatement systems to reduce exposure and protect worker health while maintaining agricultural productivity.

Keywords: Mean dust concentration, particulate matter, threshing, thresher

1. Introduction

The term dust is used to describe a range of particle sizes of material, which can be transported by air. Dust is defined strictly by particle size, however as dust particles are moved in the air, they are often in close proximity to a variety of particles, including water molecules. Dust is often associated with agricultural activities, which include a work environment with a high degree of atmospheric temperature, noise, chemical and biological agents and physical drudgery. Soil tillage and seed bed preparation, planting, fertilizer and pesticide application, harvesting, and post-harvest activities are all examples of agricultural field operations that generate dust in conventional crop production. However, air pollution is widely acknowledged to be the effect of industrialization and automation. Agriculture is not viewed as a major source of air pollution. Dust exposure in agriculture was initially established as a cause of respiratory disease in the 16th century and remains a significant source of respiratory morbidity among farmers [1]. Dust can result from many farm practices and could be a source of complaint concerning farm activities. Agricultural workers have been found to be exposed to higher levels of airborne dust than non-agricultural workers [2]. Personal exposure to inhalable dust has been assessed in practically all agricultural sectors, and studies have found that dust is dangerous to human health. The intensity of dust's impact on human health is determined by particle source, particle size, dust concentration, and exposure period [3].

Air borne dust particles are commonly referred to and quantified as "Particulate Matter," which consists of microscopic solid particles or liquid droplets that float in the air we breathe. Farmers and tractor operators are exposed to variable quantities of particulate matter (PM) during field operations. The dust concentration level (mg/m^3) and PM particle size distribution may change based on working conditions. Dust formed during agricultural activities is categorized into two types based on its composition: inorganic dust (soil/mineral dusts) and organic dust (plant/animal debris).

Although dust arresting technology and methodologies are easily available for mining and coal sectors, there is limited study on agro-processing businesses, with essentially no research relevant to dust released or dust abatement devices for wheat threshers. There is plethora of personal safety equipment available in the market for farmers to use, but not all farmers in India are willing to use it. Therefore, there is a lot of scope and potential for improving the current state of the problem of dust exposure caused by threshing. The proposed research work aims to assess the concentration of various types of dust fractions that farm workers are exposed to during the threshing process and propose a remedial method for farm workers to reduce their exposure to environmental and personal dust at the source during the operation of a threshing machine. The project focuses on reducing dust exposure to farm workers during crop threshing while maintaining high levels of production. The project intends to provide an economical and maintenance-free solution to the problem of dust exposure to agricultural workers during crop threshing [4].

Inorganic Dust: The dust particles originating predominantly from the soil, resulting in non-allergic

reactions in lungs fall into the category of inorganic dust. In an open field with dry climate, exposures of inorganic dust are generally the highest. The tractor operators involved in haymaking, combine operators, harvesting and thresher operators also have exposures to a high total dust, normally in the range of 1-20 mg/m³ in an open cab and in a closed cab with air filtration it is less than 0.5-1 mg/m³. Only about 10 per cent of such particulate matter is inorganic [5-8].

Organic Dust: Organic dust comes from plants and animals, and it is a common cause of allergy illnesses like asthma. Microbes are present in large numbers in organic dusts derived from livestock. Molds, fungi, pesticides, herbicides, insecticides, feed and bedding particles, animal-derived particles, and endotoxin are all found in organic dust [9-10]. Inhalation has been identified as the primary method of exposure to organic dust that can be harmful to one's health [11]. Lung disease, acute organic dust toxic syndrome, persistent asthma, asthma-like syndrome, and chronic bronchitis have all been associated to organic dust exposure.

2. Classification of Particulate Matter

Based on the outcomes of the various experimental studies conducted in different laboratories, an international agreement between CEN (European Committee for Standardization, CEN (1993)), ISO (International Organization for Standardization, ISO (1995)), and ACGIH (American Conference of Governmental Industrial Hygienists, ACGIH (1996)) has been reached to classify airborne particles into different aerosol fractions based on the penetration of these particles in the various regions of the respiratory tract. They are described as follows:

- **Inhalable Fraction:** Particles ≤100 µm affecting the entire respiratory tract.
- **Extrathoracic Fraction:** Particles that do not pass the larynx.
- **Thoracic Fraction:** Particles ≤10 µm that penetrate the larynx, associated with conditions like asthma.
- **Respirable Fraction:** Particles ≤4 µm that reach alveolar regions, linked to chronic diseases such as pneumoconiosis (EPA).

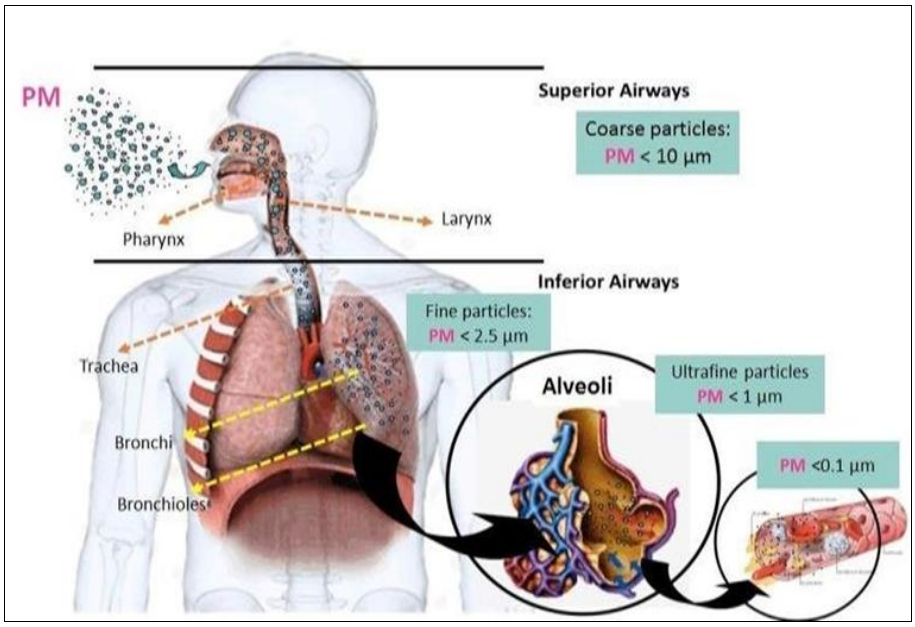

Fig 1: Respiratory tract and particulate matter (Source: Barazza 2017)

PM_{10} and $PM_{2.5}$ are of particular concern due to their ability to penetrate deep into the lungs and even enter systemic circulation, posing significant health risks.

3. Effect of agricultural dust exposure on human health

The allergen responsible for the mid-April - mid May nasobronchial allergy seen in North India. A total of 39 children suffering from wheat harvest period (mid-April - mid May) respiratory allergy along with randomly selected controls were considered for the study [12]. This was observed to be due to heavy exposures to organic dusts that may occur in agricultural work place (plant or animal dust) and to a large literature on respiratory effects these exposures (examples: occupational asthma, hypersensitivity pneumonitis etc.) [13]. The occupational agricultural exposures including dust, animal, and pesticide exposures with asthma in adult populations. Several retrospective studies demonstrate agricultural work to be protective against asthma in adults, especially with increased farming exposure over time [14]. Farmers and nearby resident are exposed to high levels of organic dusts and bio-aerosols during wheat harvesting season, causing health problems in exposed human relating to toxic or allergic reaction [15]. Child dwelling in rural settings may face environmental hazards derived from agricultural production activities. Health consequences of organic dusts, farm chemicals including pesticides, machinery noise, excess sun exposure, and zoonotic infectious agents have been evidently described among farm-working adults [16].

3.1 Dust fraction assessment during agricultural operations

The concentration of environmental dust generated during various agricultural activities in the Rabi season, including ploughing, seedbed preparation, sowing, harvesting, and threshing. It identified the operation that produced the

highest levels of hazardous dust and proposed protective measures to mitigate dust exposure [17]. Three types of dust protector cloth, foam, and tissue paper were assessed for their effectiveness in reducing personal dust exposure. The filtration efficiency of selected dust protectors varied between 50.76 to 59.71 per cent for cloth, 89.91 to 92.78 per cent for foam and 96.50 to 98.70 for tissue paper [18]. Dust concentration in breathing zone in manual harvesting and threshing operation of wheat crop. The dust concentration of inhalable, thoracic, and respirable dusts was found 11.89, 4.67 and 3.20 mg/m^{3,} respectively. The mean PM_{10} dust concentration at workers collar level during harvesting was recorded 3.8 mg/m^3 and respirable dust concentration was recorded 2.70 mg/m^3. The study also found that during threshing operation, in comparison to grain outlet and 3 meters away from the feeding chute, the highest dust concentration was measured as 1.51 mg/m^3 near feeding chute for PM_{10} and the highest respirable dust concentration was measured as 2.64 mg/m^3 near feeding chute [19]. Four most dust generating operations were identified as disc harrow, rotavator, combine and thresher with mean dust density values 2.50, 2.60, 3.40 and 3.17 mg/m^3. Fifteen different filtering elements were evaluated for their dust filtering performance during the selected operations [20].

4. Risk Factors Influencing Dust Exposure

- **Crop Variability:** Research indicates that dust levels vary depending on the crop type, with grains like wheat and rice being significant contributors [21].
- **Mechanization and Maintenance:** Poorly maintained threshing equipment exacerbates dust emission [22].
- **Environmental Factors**: Studies highlight the role of dry, windy conditions in increasing airborne dust levels [23].
- **Lack of Awareness and Protection:** Workers limited access to protective gear and insufficient training on dust hazards are recurring themes in literature [24].

4.1 Risk Reduction Strategies

- **Engineering Controls:** Improved threshing equipment with dust extraction systems has shown promising results in reducing exposure [25].
- **PPE Adoption:** Consistent findings indicate that the use of masks, goggles, and gloves significantly mitigates health risks.
- **Workplace Practices:** Research supports practices such as spraying water to suppress dust and implementing worker rotation to minimize exposure duration [26].
- **Health Monitoring and Awareness:** Studies emphasize the importance of regular health check-ups and educational campaigns to enhance awareness among workers [27].

5. Conclusion

The study highlights the critical issue of organic dust exposure during the threshing process, particularly its adverse effects on the health of farm workers and the environment. It establishes that the inhalation of particulate matter, especially PM_5 and PM_{10}, poses serious health risks, including lung diseases, organic dust toxic syndrome, chronic asthma, and chronic obstructive airway diseases. The findings emphasize the necessity of controlling dust emissions at the source to mitigate these hazards effectively. This study underscores the urgent need for integrating such dust abatement systems into threshing operations to safeguard farm workers' health and reduce environmental pollution. The findings provide a strong basis for further research and the development of advanced dust control technologies in agricultural practices.

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