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Aradhana Verma*
Department of Chemistry, Govt. Geetanjali Girls College, Bhopal, Madhya Pradesh, India
Email: aradhanaverma471@gmail.com

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Aradhana Verma*

Department of Chemistry, Govt. Geetanjali Girls College, Bhopal, Madhya Pradesh, India

Email: aradhanaverma471@gmail.com

ABSTRACT

South Asia (India, Bangladesh, Pakistan) and other countries Stubble burning is a practice of removing paddy crop residues by burning them to prepare the field for the next crop. Farmers used this practice to prepare land for the next cultivation and after burning the ashes were mixed with the same soil and then ploughed. According to various global scientific research studies, due to air pollution caused by the burning of stubble, thousands of citizens die from respiratory diseases. In some places, even more dangerous diseases develop. Burning of crop residues harms the biological quality of the soil as well as other microorganisms present in the upper layer of the soil, and also reduces the solubility of the upper layers of the soil. Currently, various studies are highlighting the catastrophic nature of stubble burning by examining the incidence of field fires, pollutant emissions and its harmful impacts. The message conveyed by the author in this review article is that the burning of crop residue in the fields by farmers can have harmful effects on human health, the environment, soil fertility, natural ecosystem.

In this review, the author summarizes studies of literature review articles and explains the harmful effects of PM2.5 on the human respiratory system and the potential for health-related illness problems.

Keywords: *Stubble burning, air pollution, diseases, soil fertility, health, natural ecosystem etc.*

INTRODUCTION

Stubble burning is a human-induced disaster and is a sizzling topic of the current scenario of South Asia. It is a long-standing post-harvest practice that is extensively common in regions worldwide which aimed at elimination of field waste after harvesting [1-2]. It is one of the main suppliers to atmospheric pollution worldwide in releasing gaseous pollutants and particulate that effects severely on human health and environment [3]. In India, temperature lower during the winter especially for the period of month of October - December every year, incidents of stubble burning have increased manifold over the last two-three years, indicating that the farmer-industry efforts to repurpose stubble for commercial applications is yet to deliver.

According to various sources, satellite-retrieved data on stubble burning in 2023 shows a decrease in the number of incidents, but some say that pollution levels raise doubts about the accuracy of the data. From September 15, 2023 to October 29, 2023, there were 6,391 stubble burning incidents in Punjab, Haryana, NCR- Uttar Pradesh, NCR-Rajasthan, and Delhi. This was a 44.3% reduction from 2021 and a 54.2% reduction from 2022 [4]. Stubble burning incidents increased in Uttar Pradesh, Rajasthan, and Madhya Pradesh. In 2023, stubble burning contributed to more than 10% of Delhi's air pollution on 58% of days, more than 15% on 44% of days, and more than 20% on 30% of days. The impact of stubble burning on Delhi's air quality was higher than in 2021 and 2022 due to meteorological conditions [5].

The punitive haze found over South Asia during the winter season has been related to this biomass burning, as it matches with the stubble burning periods [6]. Studies also state that near about 1.1–1.2 million demises (deaths) in the North India province is associated with ambient air pollution [7-9]. Every year at the onset of winters (October–November), stubble or Parali burning starts in Norther India (Haryana, Punjab, Rajasthan, Western Uttar Pradesh, Madhya Pradesh (Uttar Pradesh and Rajasthan Boarder districts) leading to heavy air pollution and adversely affecting the human and environment.

Effects of Stubble Burning:

The burning of stubbles not only damages the environment, but also causes very severe harm to wildlife, humans, and soil by releasing a concoction of very detrimental pollutants, including, nitrogen oxides (NOx), particulate matter (PM), volatile organic compounds (VOCs) and carbon monoxide (CO).

*Author for correspondence

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Air Pollution:

Stubble burning significantly contributes to air pollution **as it releases harmful pollutants like carbon dioxide, particulate matter, and methane and leads to air pollution.** Burning this straw of rice (stubble or parali in hindi) probably releases 70% of the carbon in the straw as CO_2, 7% as CO, and 0.66% as CH_4 and 2.09% of the nitrogen in the straw is released as N_2O right in the atmosphere which leads to pollution and global warming [10]. Furthermore, burning waste from agriculture releases significant amount of air-polluting particulate matter, most of these toxins in significant concentrations in biomass smoke are known as suspected cancer causing agents and also can cause serious respiratory disorders associated with other related vital fatality [11].

Impact on community health:

Researchers conducted worldwide have proved that air pollutants are dangerous to human health. Direct exposure to $PM_{2.5}$ has been directly connected to higher rates of incidence of asthma-related emergencies and increases the mortality rates in chronic obstructive pulmonary disease (COPD) cases, and so decreases the life expectancy [12]. Stubble burning poses a serious danger to the air quality of the exposed environment [13], air quality is significantly affected by agricultural burning because of the emanation of gaseous pollutants and aerosols. Stubble burning liberates fine particulate matter ($PM_{2.5}$), which is a fatal air pollutant and chiefly concern with the human health when the concentration or levels of $PM_{2.5}$ is alarming high [14]. $PM_{2.5}$ and PM_{10} are reported to have the highest and adverse effect on the health of the population exposed to these pollutants. The gaseous emissions which are released because of the burning stubble, which possess the risk to the health ranging from irritation of skin and eyes, to severe cardiovascular (CVD), neurological and respiratory diseases including asthma, chronic bronchitis, emphysema, and decreased lung function, etc. Health effects of high level of $PM_{2.5}$ exposure shown in Figure 1.

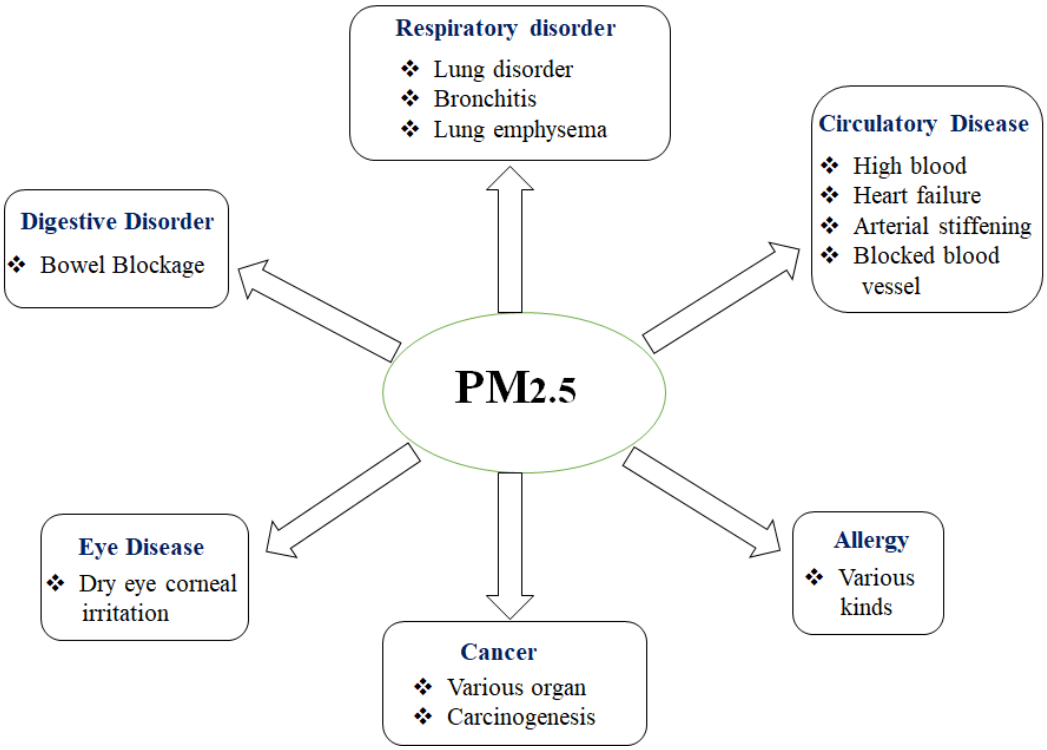

Figure 1 - Health effects of high level of $PM_{2.5}$ exposure

Soil Health Impact: Burning of stubble decreases the fertility of soil by reducing essential nutrients existing in residues of crop. The residue (ash) left behind possibly may consists of some nutrients, but the on the whole, impact on fertility of soil is negative. This adversely affects the long-standing agricultural sustainability and productivity.

Heat Penetration:

Heat generates during the stubble burning penetrates and enter the soil, which increases the soil erosion, loss of beneficial microbes and moisture, leading to soil degradation and loss of soil fertility.

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Effects on agricultural productivity:

The harmful effects of burning crop stubble are also extended to the agricultural sector. There is substantial pragmatic confirmation, that air pollution badly affects food production. Stubble burning has many negative effects on agricultural productivity, including:

(i) Soil fertility: Burning stubble destroys the nutrients in the soil, such as nitrogen, phosphorus, and potassium (NPK). It also kills soil microorganisms that are important for soil fertility.

(ii) Soil temperature: Burning stubble can raise soil temperatures to around 42°C, which can kill soil microorganisms and cause the soil to lose moisture. This makes it difficult for subsequent crops to grow.

(iii) Soil moisture: The heat is generated after the burning of stubble or crop residue penetrates the soil, which results in the loss of moisture and useful microbes.

Stubble burning is also common as "wealth from stubble" as residue of crop can be used for electricity generation which is a creative and productive way of producing wealth from residue. The crop residues produced by the major crops are shown in Table 1. Some categories are being adopted for air quality and its effects on human health. In Table 2, the standards of WHO and NAAQS (National Ambient Air Quality standards) for $PM_{2.5}$ and PM_{10} have been compared. Table 3 shows the particulates are released into the atmosphere in large quantities [16]. Air quality standards are set by individual countries to protect the public health of their citizens are shown in Table 4.

Table 1 Crop residues produced by major crops

S.No.	Source	Composition
1	Rice	Husk, Bran
2	Wheat	Bran, Straw
3	Maize	Stover, Husk, Skins
4	Millet	Stover
5	Sugarcane	Sugarcane tops

Table 2 Source: Revised National Ambient Air Quality Standards [15]

S.No.	Pollutants	Time Weighted Average	Concentration in Ambient S. Air		Measurement Method of Air Quality
			Industrial, Residential Rural and other Areas	Ecologically Sensitive Area (notified by Central Government)	
1	Sulphur Dioxide (SO_2), µg/m^3	Annual* 24 Hrs*	50 80	20 80	1. Improved West and Gaeke 2.Ultraviolet Fluorescence
2	Nitrogen Dioxide (NO_2) µg/m^3	Annual* 24 Hrs*	40 80	30 80	1. Modified Jacob & Hochheiser (Na Arsenite) 2. Chemiluminescence
3	Particulate Matter (Size<10µm) $PM_{1.0}$ µg/m^3	Annual* 24 Hrs*	60 100	60 100	1. Gravimetric 2. TOEM 3. Beta attenuation
4	Particulate Matter (Size<2.5µm) $PM_{2.5}$ µg/m^3	Annual* 24 Hrs*	40 40	60 60	1. Gravimetric 2. TOEM 3. Beta attenuation
5	Ozone (O_3), µg/m	8hours** 1hours**	100 180	100 180	1. UV photometric 2. Chemiluminescence 3. Chemical Method
6	Lead (Pb), µg/m^3	Annual 24 hr**	0.5 1.0	0.5 1.0	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
7	Carbon Monoxide (CO), m^3	08Hrs** 1 Hour**	02 04	02 04	Non dispersive Infra-Red (NDIR) Spectroscopy

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week

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24 hourly at uniform interval.

** 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

TOEM-Tapered element oscillating microbalances

Table 3 Particulates releasing in air

S. No.	Particulars	Range
1	$P.M_{2.5}$	146-221 μgm^{-3}
2	$P.M._{10}$	300 μgm^{-3}
3	NO_2 and NH_3	40–50 μgm^{-3}

Table 4 Central pollution control board, INDIA-AQI category and range for possible health impacts

S.No.	AQI Category	AQI Range	Possible Health Impacts
1	Good	0-50	Minimal Impact
2	Satisfactory	51-100	Minor breathing discomfort to sensitive people
3	Moderate	101-200	Breathing discomfort to the people with hugs, asthma and heart diseases
4	Poor	201-300	Breathing discomfort to most people on prolonged exposure
5	Very poor	301-400	Respiratory illness on prolonged exposure
6	Severe	401-500	It is hazardous and can cause significant health issues for everyone

Though Indian AQI standards are less strict as compared to WHO. Degradation of air quality results in an increase in pulmonary disorders including cough, asthma, bronchitis, skin and eye diseases. Sometimes stubble burning is also reason for poor visibility which further leads to an increase in road accidents [17-19].

Effective Ways to Stop the Burning of Stubbles in Madhya Pradesh, India:

To stop stubble burning practice, a comprehensive and collaborative approach need to be developed, involving farmers, policymakers, and the society. The government should provide financial incentives to farmers who adopt modern machinery and advanced technologies

Effective Ways to Stop the Burning of Stubbles in Delhi, Haryana, Punjab, India:

There are many ways to stop stubble burning in Delhi, Haryana, Punjab**,** India, which are as follows

Use technology: Use modern machines like the Happy Seeder to cut and lift straw, sow seeds, and cover the area with straw instead of burning it.

Convert stubble into manure: To convert stubble into manure, technologies like Pusa dispenser should be used, so that there is no environmental problem.

Use modern sustainable techniques: Use sustainable techniques like composting, biochar production, and mechanization.

Use collection and storage centers: Establish collection and storage centers in close proximity to farms to get relief from problems arising after burning of stubble.

Laws and Enforcement Mechanism: Higher authorities passes several laws to discourage stubble burning and promotes safe and diverse uses of residues [20-23]. According to the Air Prevention and Control of Pollution Act, 1981 and the Code of Criminal Procedure, 1973, burning crop residue is stringently banned by the government of India. The government can control and regulate the burning of any crop residue by the means of remote sensing, to measure the situation.

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CONCLUSION

In this article the team reviewed many papers and fire count data to understand the evolution of the stubble-burning season in northwestern India in 2022-23. Overall, we can wrap up with the conclusion, that residential combustion, industry, and power generation are the chief anthropogenic source, that contribute to the high $PM_{2.5}$ disease burdened in India and other associated parts of South Asia and in particular within the Indo Gangetic Plains (IGP). $PM_{2.5}$ is a noteworthy source of mortality in the northeast and central regions of India. Presently, agricultural institutions and government agencies regularly advise farmers to stubble burning are extremely harsh and sensitive to the health of soil, environment, and human. Crop residue burning destroys soil health by removing advantageous microorganisms of soil and so, harms health of human and the environment by polluting air and becomes the major cause for different pulmonary(respiratory), skin and eye diseases and other chronic diseases like cancer.

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