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Study of Burning Behaviour of Four Different Varieties of Paddy Grown in Paddy Cultivating Districts of Haryana To Recognize the Air Pollutants Released Resulting in Health Effects and Climate Change

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KEYWORDS

Carbon dioxide, Carbon monoxide, Sulphur, Volatile organic compounds, Particulate matter, Central Pollution Control Board (CPCB), Medical Officer (MO), Combine Harvester.

ABSTRACT:

Green revolution belt in the Northern India includes the state of Haryana. It's a major producer of Paddy in India as 18 districts are involved in Paddy cultivation. Out of these 7 districts are having very good paddy cultivation yielding more than 2500kg per hectare. In these districts the farmers are utilising the fields all through the year and for that matter are using all types of machinery to increase the speed of harvesting. Hence, they are using Combine harvesters to harvest the crops of Paddy. This increases the speed of harvesting at a low cost but brings with it another problem which is it cuts the crops at a height of about 10cm from the ground. This stubble of paddy which is left in the field is a major issue as the farmers are burning and removing the stubble from their fields after harvesting the crop. Burning of paddy stubble and other agro wastes has resulted in air pollution problems which are not only in Haryana but has also spread to Delhi particularly which results in a smog condition in the cold winter months.

Research is done by burning the stubble and straw of four different varieties of paddy which are majorly grown in Haryana. Then the gaseous pollutants are tested along with suspended particles which are released by burning of the stubble and straw of paddy. The data is compared with the CPCB data to find out the consistency in the results. Also, the months in which there is more pollution is found by comparison of the results with the CPCB data. Then consultation is done with Medical Officer at Panipat to understand that whether the findings are correct or not. Also, with the help of the Medical Officer it is found that which health effects are happening more often in the paddy growing belt of Haryana. The change in climate is determined by the temperature increased during a period of ten years.

This study is to understand the pollutants released by burning of stubble and its relationship with health effects and climate change for determining the adverse effects.

1. Introduction

Paddy stubble and straw burning is a serious issue in the Haryana and Punjab states of India which is mainly done after the harvest of Paddy crop. Labor cost being too high and availability of machinery at low cost has made the farmers do the harvesting of Paddy by machinery like Combine harvesters. This has resulted in the stubble being left in the field that has to be removed by using labor. But farmers have instead resorted to burning stubble. This has resulted in the release of pollutants and particulate matter which is causing huge air pollution problems in NCR regions. This has resulted in adverse health effects in the population and Climate Change. This study is conducted mainly to understand the pollutants released, the CPCB data and comparison and understanding this with help of Govt. Health Officer. The results are then compared to the change in temperature of the regions in the burning months resulting in climate change.

There is a dearth of market demand for stubble, which encourages farmers to burn Kharif crop leftover to prepare the land for subsequent Rabi cultivation in November (Singh et al. 2021).

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Stubble burning is a continuous issue in Haryana, India, with serious environmental and health consequences. Alarming levels of particulate matter are released by stubble burning and it results in respiratory diseases (Mishra et al. 2021)

Extensive stubble burning releases massive toxic air pollutants in the northern states of India (Kulkarni et al. 2020).Biomass burning emits particulate matter (PM) and various gaseous compounds such as carbon dioxide (CO2), carbon monoxide (CO), sulphur dioxide (SO2), nitrogen dioxide (NO2), and various volatile organic compounds (VOCs), among others (Koppmann et al. 2005; Ministry of Agriculture & Farmers Welfare 2018; Kumar et al. 2021).

It was observed that burning 63 Mt of crop stubble emits 3.4 Mt of CO, 0.1 Mt of NOx, 91 Mt of CO2, 0.6 Mt of CH4, and 1.2 Mt of PM into the atmosphere. (Abdurrahman et al. 2020a), By Crop Residue Burning the mean daily PM2.5 levels increased about four times from 60 µg/m3 to about 270 µg/m3(Central Pollution Control Board 2021).This resulted in an increase in respiratory diseases, deterioration of lung function.

The burning of crop residues in Haryana has resulted in increase in levels of fine particulate matters PM2.5 concentrations in National Capital Region rises about 20 times the WHO's threshold limit the burning of agricultural crop residue to clear fields contributes significantly to air pollution. This has resulted in a threefold increase in the risk of acute respiratory infections. The negative impact affected more women than males regarding the functioning of the lungs. Children are especially vulnerable to the health consequences of crop burning. (Chakrabarti et al. 2019)

The onset of winter and retreating monsoon (October to November) with northwest wind causes the spreading of such pollutants in the surrounding areas and degradation of air quality (Cusworth et al. 2018). India's capital Delhi and surrounding region (NCR) is landlocked by the surrounding states, i.e., Haryana and Uttar Pradesh, and the Hindu Kush Himalayan mountainous range bounds the entire region in the north. Such a landscape distribution and northwest wind transport the toxic air pollutants from the crop field of Haryana and Punjab to the NCR. In addition to the pollutants from stubble burning, the use of firecrackers during the festivals in October and November, fossil fuel burning, and industrial emissions degrade the air quality in the NCR (Kulkarni et al. 2020). More than 46 million population in Delhi and NCR experience severe air quality each year during the onset of winter, i.e., October and November (Census 2011).

Each year, India generates approximately 352 Mt of stubble, with wheat and rice stubble accounting for 22% and 34%, respectively. Every year, approximately 84 Mt (23.86%) of the stubble is burned on the field shortly following harvest. The terrible haze experienced over India during the winter season has been related to stubble burning because it corresponds with the burning season (October–November). During this season, most Indian cities, particularly those in the National Capital Region (NCR), suffer from severe pollution, which frequently exceeds the air quality index (AQI).

The stubble burning results in economic and social repercussions as health issues arise. (Sharma et al.). Respiratory disorders like asthma, cough, wateryeyes, irritation in eyes were associated with burning of crop residue in the villages of Sonipat and Jhajjar districts of Haryana. These were found to be more in the months of October and November when the crop residue burning incidences were found to be more. (Kumari & Chaudhary, 2020) 85% of people were found to be suffering from health effects like irritation of eyes,nose, throat, cough and wheezing issues. (Dr. Gupta in 2016)

Some farmers use straw burning to compensate for losses or to increase their income. The stubble burning is mainly occurring in Haryana due to gaps in implementation of legislative policies that govern stubble management and there is scope for improved implementation. (Gupta et al. 2004)

The crop residue burning has resulted in increase in temperature particularly in the months when the burning is done resulting in climate change. (Jabrinder Singh 2018)

2. Materials and Methods

2.1 Objectives

1. To identify the pollutants released by stubble burning.
2. To understand the adverse effects of stubble burning on health.

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3. To find the effect of burning on Climate Change.

2.2 Methodology

The research samples are collected by stratified random sampling method from four different varieties of Paddy growing farms which are marked.

2.3 Research Samples

Four research samples are collected which are of the four varieties of Paddy from five districts of Haryana-Panipat, Sonepat, Karnal, Kaithal, Kurukshetra.

The burning behavior of these samples are checked by burning the stubble in the flue Gas analyzer (Testo,380). For performing the flue gas analysis, a probe is inserted into the flue of the furnace between the draft diverter and the heat exchanger. An electrochemical probe is used to do this analysis.

Figure 1. Samples collected from paddy fields

2.4 Survey of Farmers to analyze the Health Effects and the Climate change-

Total of 100 farmers were interviewed for the health effects from the five districts chosen for the study using a questionnaire based on Likert scale and it was found that the farmers have health effects like watery eyes, irritation of eyes,cough,sneezing and breathing issues like asthma more during the stubble burning months of October and November. Farmers reported that there is an increase in temperatures when stubble burning is done. Its date is compared with the data available with CPCB and IMD Annual Report.

2.5 Discussion with Medical Officer of Panipat

Panipat is having very good production of Paddy which is about 2500kg/ha hence the issues of burning of agro-waste after paddy harvesting is high in this district. When the Medical Officer of Panipat Hospital was contacted it was found through his hospital records of patients that the number of patients who suffer from cough, breathing issues and watery eyes is more during the paddy stubble burning months of October-November.

2.6 Climate Change Analysis

Secondary data is collected from the CPCB site regarding temperature in Haryana over a period of 10 years and it is compared with the temperature of Haryana during stubble burning month of end of October or beginning of November. Then based on the comparison the temperature increase is noted.

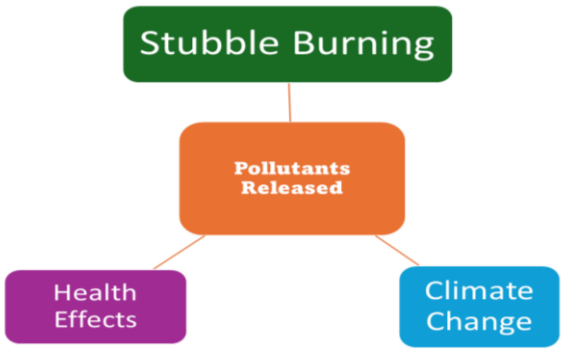

Figure 2. Flow Chart showing effects of stubble burning

3. Observation

3.1.1. The pollutants which are released by burning of stubble in the flue gas analyzeris as follows

Table 1. Pollutants released by Burning Stubble of Four Paddy Varieties

S. No.	Pollutant	1121 Var.	1718 Var.	1509 Var.	Traditional Basmati Var.
1.	SPM (mg/m^3)	139	153	148	139
2.	Sulfur Dioxide (ppm)	28.4	24	23.8	17

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S. No.	Pollutant	1121 Var.	1718 Var.	1509 Var.	Traditional Basmati Var.
3.	Nitrogen Dioxide (ppm)	298.7	715	410	443
4.	Carbon Dioxide (ppm)	1076	1064	1085	1025
5.	Hydrocarbon (ppm)	1800	1484	1740	1700
6.	Carbon Monoxide (ppm)	127	125	125	100

3.1.2 Figures

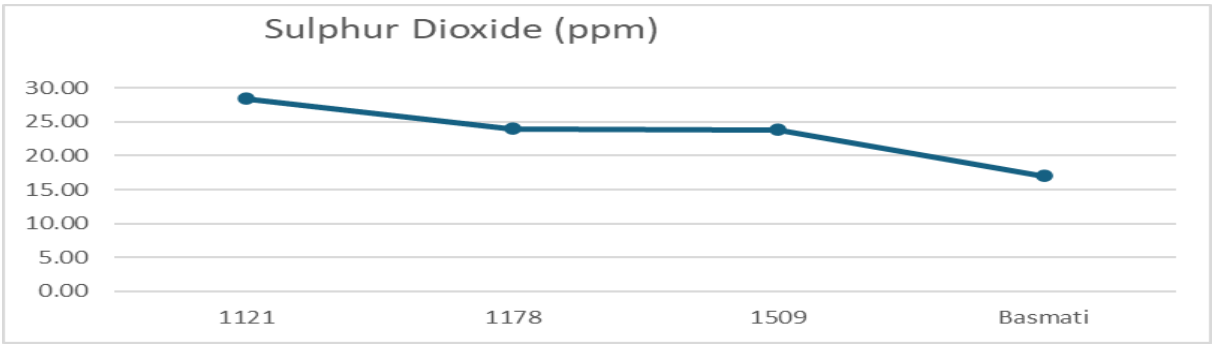

Figure 1. Graphical representation of SO_2

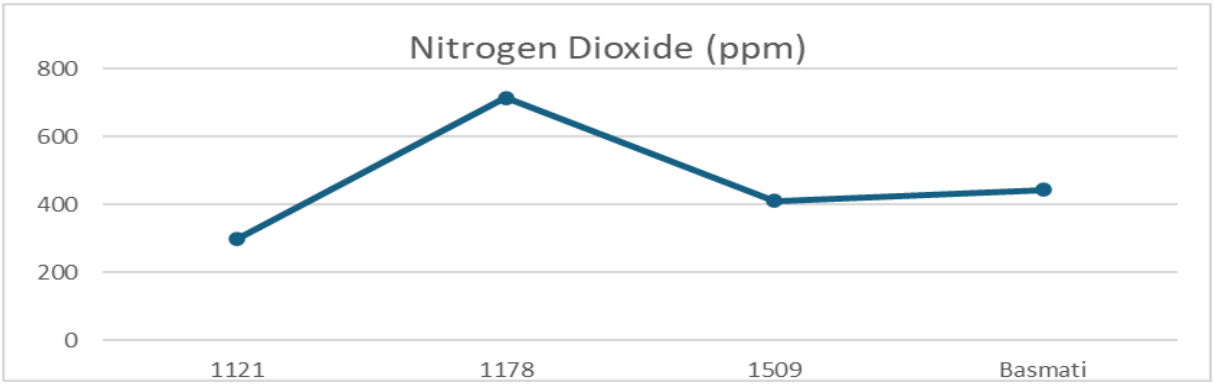

Figure 2. Graphical Representation of NO_2

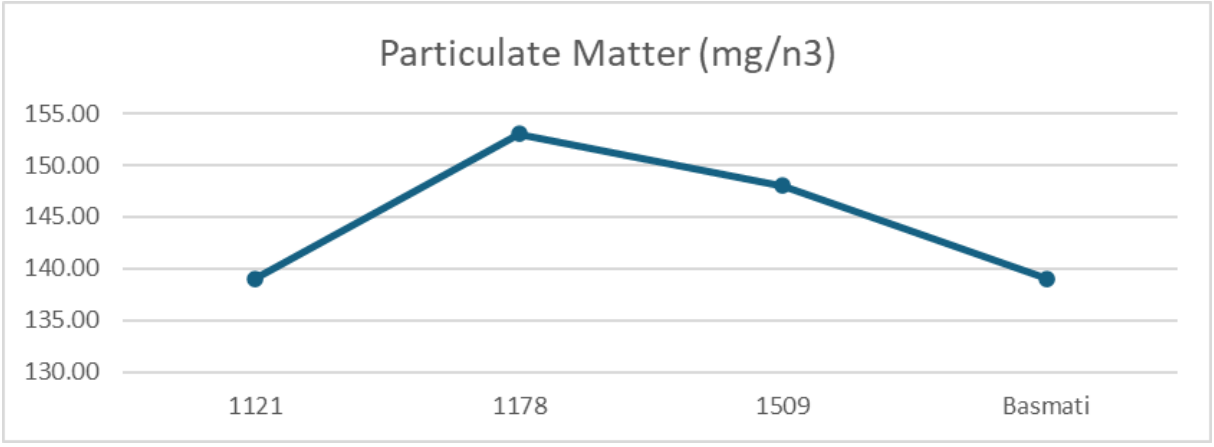

Figure 3. Graphical Representation ofParticulate Matter

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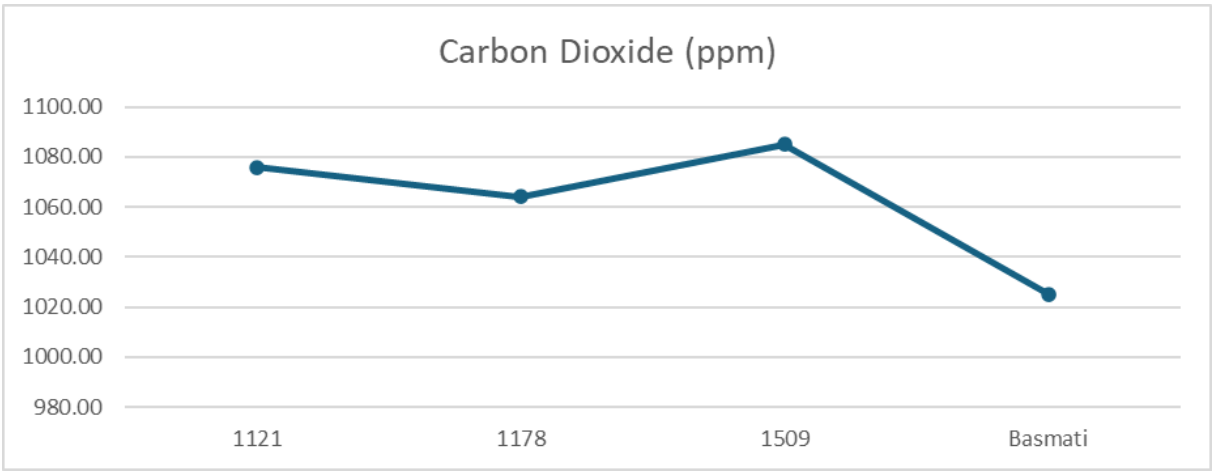

Figure 4. Graphical Representation of CO2

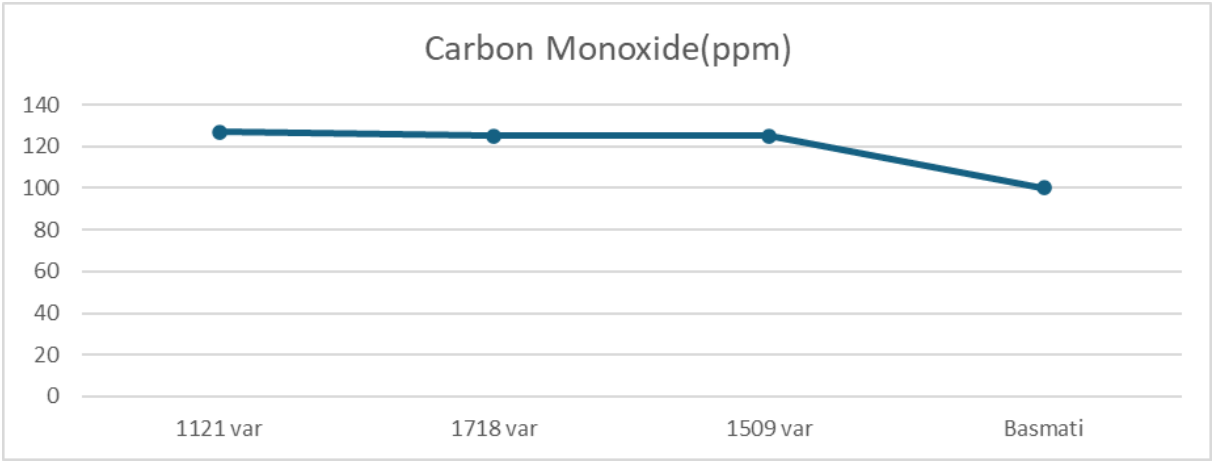

Figure 5. Graphical Representation of CO

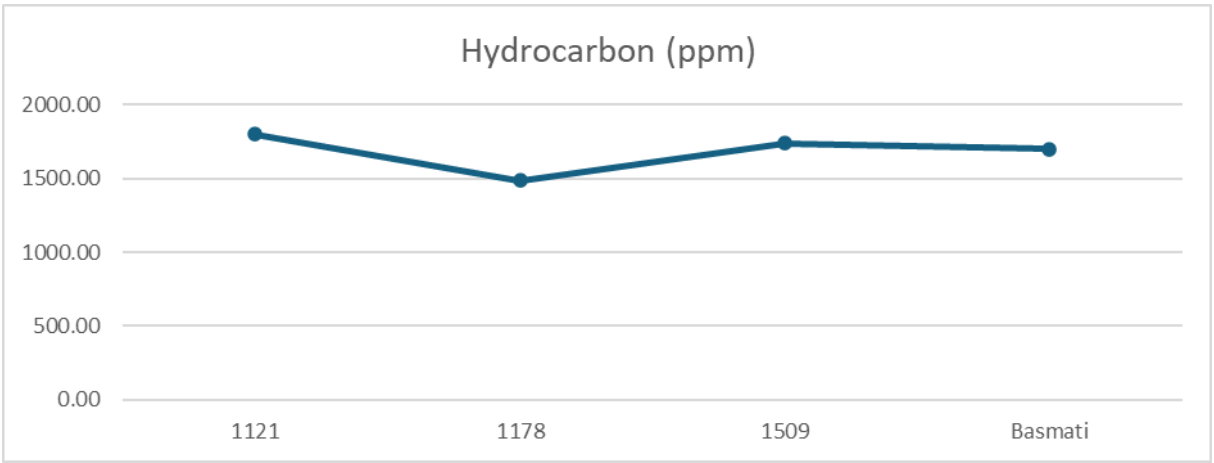

Figure 6. Graphical Representation of Hydrocarbon

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3.1.3 Central Pollution Control Board Data and Graph indicating Air Quality in Delhi NCR from 30-10-2023 to 09-12-2023

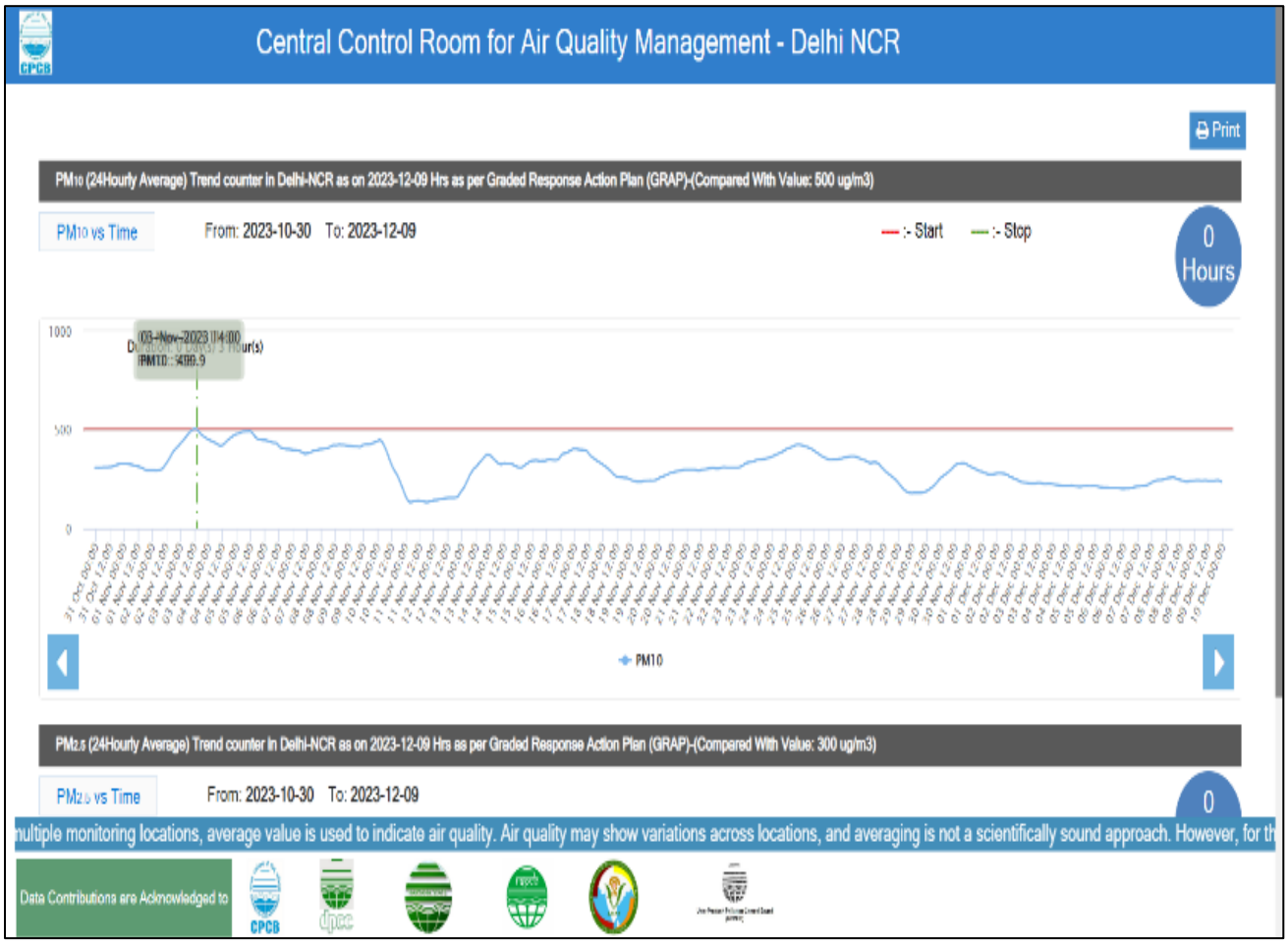

Figure 1. CPCB data of Pollutants released from 30 Oct-12 November, 2023

3.1.4 Climate Change in Haryana over a period of 10 years

Table 1. Temperature Change in Stubble burning period over 10 years in Haryana (Source-Internet)

Year	Maximum	Average	Minimum
2010	35	31	24
2011	35	31	25
2012	37	33	26
2013	35	33	28
2014	37	33	26
2015	37	33	26
2016	38	35	29
2017	38	35	26

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2018	37	33	27
2019	37	33	27
2020	40	36	30

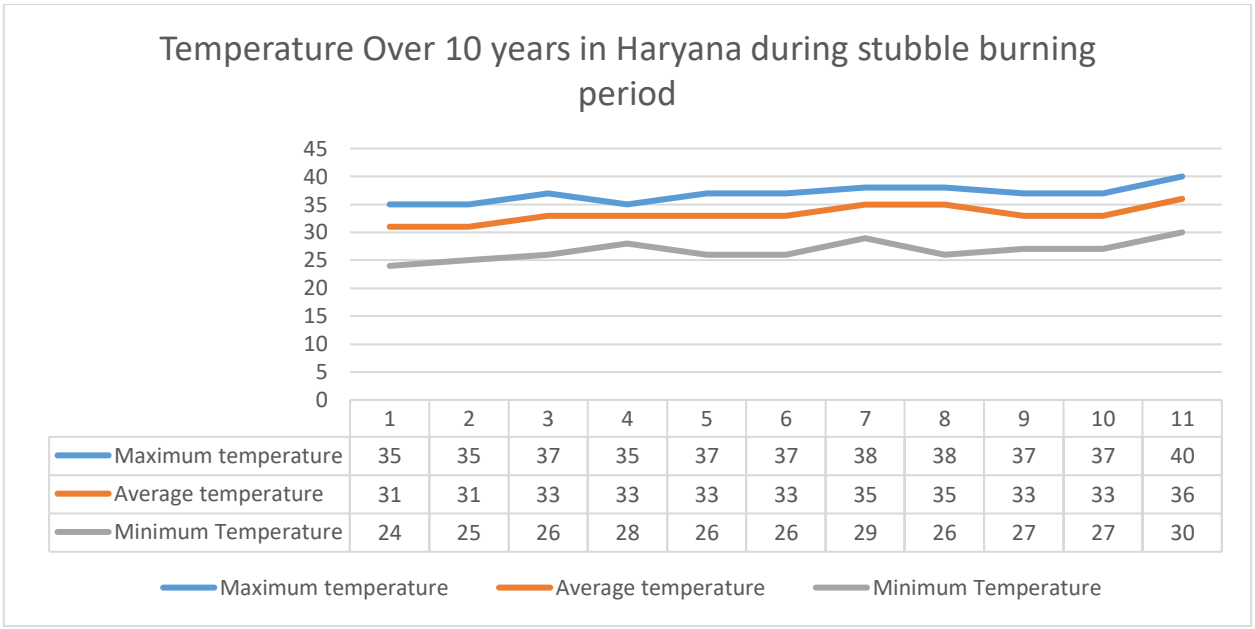

Figure 1. Temperature change in Haryana in the month of October End-November Beginning

3.1.5 Patients Consulted by Four different specialists in two different years

Table 1. Number of Patients consulted in 2022 in Panipat

Month	Physician	ENT	Ophthalmologist	Skin
January	376	159	290	251
February	362	173	270	161
March	433	203	343	251
April	472	176	442	289
May	390	175	348	261
June	322	127	335	208
July	374	177	396	273
August	372	189	396	247
September	373	252	402	321
October	474	143	470	260
November	533	341	482	380
December	380	166	383	257

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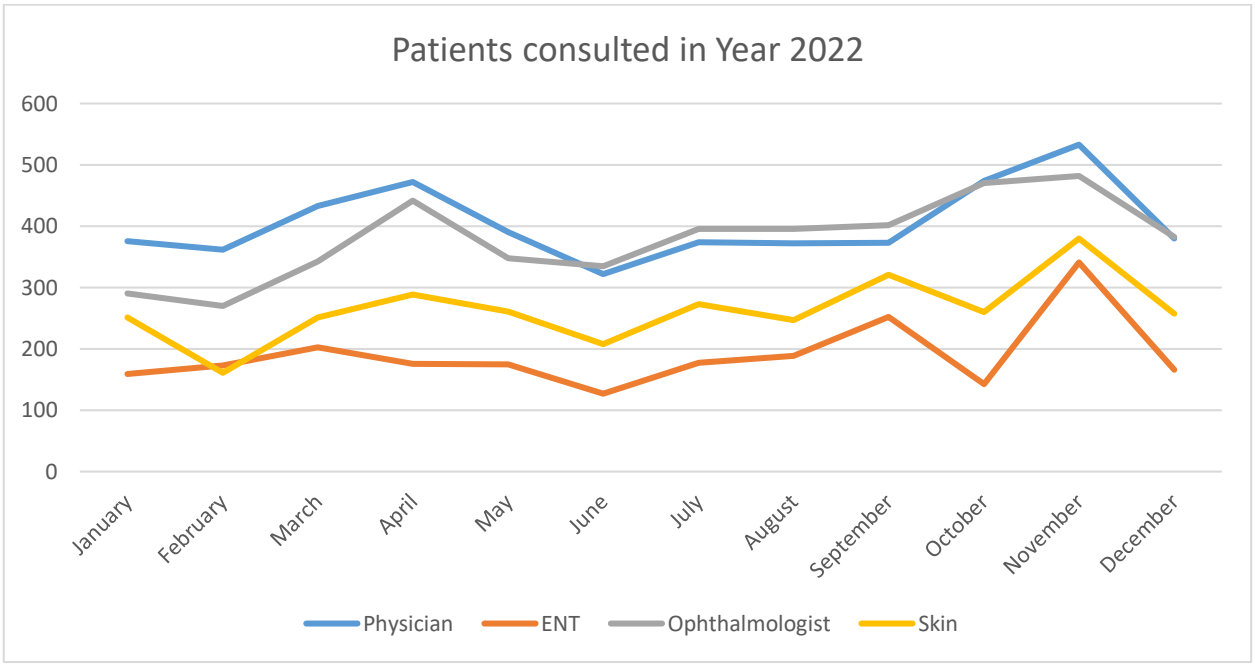

Figure1. Patients consulted by four Medical Branches in 2022 in Panipat

Table 2. Number of Patients Consulted in Year 2023 in Panipat

Month	Physician	ENT	Ophthalmologist	Skin
January	356	161	339	190
February	496	193	329	275
March	472	362	443	187
April	518	166	413	231
May	519	193	466	245
June	378	183	491	220
July	361	224	496	237
August	352	231	495	190
September	399	221	483	180
October	450	267	421	198
November	541	392	582	470
December	454	293	454	321

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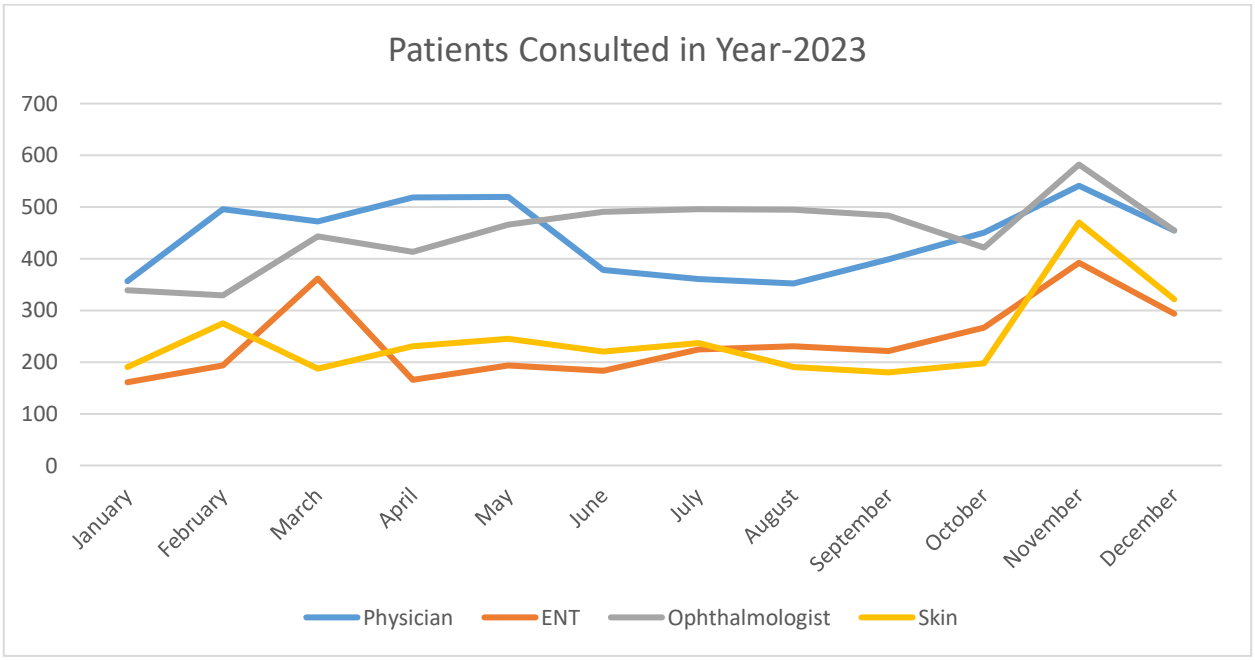

Figure 2. Patients Consulted by Four Medical Branches in 2023 in Panipat

3.1.6 Statistical Analysis

Table 1. Statistical Analysis of Pollutants released

Statistical Measures	*Particulate Matter (mg/n3)*	*Sulfur Dioxide (ppm)*	*Nitrogen Dioxide (ppm)*	*Carbon Dioxide (ppm)*	*Carbon Monoxide (ppm)*	*Hydrocarbon (ppm)*
Mean	144.75	23.3	466.675	1062.5	119.25	1681
Standard Error	3.47	2.35	88.34	13.22	25.48	68.80
Median	143.5	23.9	426.5	1070	63.5	1720
Standard Deviation	6.946222	4.706	176.68	26.43861	50.97957	137.613
Sample Variance	48.25	22.147	31217.8	699	2598.917	18937.33
Kurtosis	-3.57712	1.8057	2.26	1.966255	-4.8268	2.47
Skewness	0.428906	-0.7479	1.25	-1.40255	0.202717	-1.47
Range	14	11.4	416.3	60	100	316
Minimum	139	17	298.7	1025	25	1484
Maximum	153	28.4	715	1085	125	1800

Table 2. Statistical Analysis of Climate Change

Statistical Measures	Max temp.	Average temp.	Min. temp.
Mean	36.90909	33.27273	26.72727
Standard Error	0.45636	0.468865	0.523813
Median and Mode	37	33	26

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Standard Deviation	1.513575	1.55505	1.737292
Sample Variance	2.290909	2.418182	3.018182
Kurtosis	0.512724	-0.20003	0.047237
Skewness	0.396762	0.227249	0.510882
Range	5	5	6
Minimum	35	31	24
Maximum	40	36	30
Sum	406	366	294
Confidence Level (95.0%)	1.016833	1.044697	1.167128

4. Analysis of Data-

1. For Pollutants Released

1. Particualte matter is released least by 1121 variety of Paddy
2. Basmati releases least amount of Sulfur Dioxide, Carbonmonoxide, Carbon dioxide
3. Nitrogen dioxide is released in least amount by 1121 variety
4. Hydrocarbon is released in least amount by 1718 variety

Conclusion-Hence it shows that varietal development is not supportive of burning of stubble as the traditional variety of Basmati is better than others in releasing less pollutants.

2. CPCB Data

It indicates, as the graph also shows, that the stubble burning and resulting release of pollutants is maximum around 3rd of November.

3. Patients Consultations

The months of October-November and March-April have a sharp rise in number of patients in mostly ENT and skin departments.

4. Temperature Change

The temperature is continuously rising during the period of ten years from 2010 to 2020, indicating a sharp rise in effects on climate.

5. Conclusion

Burning of stubble releases harmful chemicals like carbon monoxide, nitrogen dioxide, sulfur dioxide, carbon dioxide, hydrocarbons and particulate matter which should be stopped. There should be control over the burning of stubble. The varietal development is not supportive of stubble burning.

As per the statistical analysis the null hypothesis is not valid as the standard deviation and sample variance is high in nitrogen dioxide and hydrocarbon. Also, the sample variance is significant in case of carbon monoxide released. Hence, we can conclude that the quantity of various pollutants released by burning stubble varies with the varieties.

After discussion with the Medical Officer, it can be concluded that in the months of Oct-Nov. and March-April as stubble is being burnt the health effects are visible in the people and hence more health care is needed in these months indicating that agricultural waste burning is harmful for the people who are living near paddy fields.

CPCB Data indicates that maximum pollutants are released on 3rd November which is the main harvesting and burning date for Paddy straw and stubble.

According to the data obtained of temperature change Maximum, Average and minimum temperatures are continuously increasing, The sample variance is high in all cases indicating that there is a continuous rise in temperature

Hence to overcome the health effects the Paddy waste burning must be stopped completely to improve the environment and the farmers'conditions. To stop the temperature, rise the stubble burning should be stopped as it is clearly seen that Maximum temperature rise is by

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5 degrees, Average by 5 degrees and minimum temperature rise is by 6 degrees Celsius.

6. Future Scope of Work

The stubble burning is a very popular act among the farmers of Haryana as it only needs to burn a matchstick for putting up the fire. But it has such bad implications which can be only stopped if the farmer gets value to the stubble byrecycling it to make a new product. This can only help in reducing the climatic change effect and health effects. Hence more detailed work must be done in this area.

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Declarations:

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Availability of Data and Materials:

The data and materials for the study were collected by Ms. Sobha Vinod and there is no involvement of any organization or entity in the study.

The medical officer has provided the information on his own discretion to help out the people and has no other personal interest or financial interest regarding the provision of data.

Competing Interests:

The authors have no competing interests to declare that are relevant to the content of this study.

- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

Author Contributions:

All authors have contributed to the study conceptualization and design.

Material preparation, data collection and analysis were performed by Ms. Sobha Vinod

The original draft preparation was done by Ms. Sobha Vinod which was reviewed by Dr. Ravi P.Singh who is the Guide of Ms. Sobha Vinod in her PhD research work.

The supervision of the work was done by Mr. Ajay Patel, co-guide for the PhD research work.

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