Plant Archives Vol. 23, No. 2, 2023 pp.194-199 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2023.v23.no2.033

STUBBLE BURNING IMPACT ON ENVIRONMENT, HEALTH AND AGRICULTURE: A REVIEW ON MANAGEMENT PRACTICES

Sanjeeb Kumar Das
Department of Botany, Regional Institute of Education (NCERT)
Achrayavihar, Bhubaneswar, Odisha, India, 751 022
Email: sanjeebdas75@yahoo.com/ dassanjeebbotany75@gmail.com; Mo: 09437194035
(Date of Receiving : 26-05-2023; Date of Acceptance : 30-07-2023)

ABSTRACT

Stubble burning is a practice of removing paddy crop residues by burning it in order prepare the filed for next crop. Farmers used this practice for the preparation of land for next cultivation. This practice now considered as one of the vital activities that degrade or affects the ambient air quality which in how responsible for air pollution. It involves the removal of a large portion of the organic matter, nitrogen, phosphorus and great loss of biodiversity. It causes damage to the microorganisms present in the upper fertile layer of the soil which further affects the organic quality of soil. Last few decades it has also been observed that this practice has increased due to excessive use of combine harvester that leaves the stalk behind. Nowadays many researchers, Environmentalist are using remote sensing and GIS technique to estimate the stubble burn area. Thus in this review an attempt is made to study the impact of stubble burning on environment and agriculture.
Keywords: Stubble burning, Air Pollution, Health, Particulates, Impact, Environment.

Introduction

India is a country which is an agricultural driven economy where 60% population is practicing in cultivation of agricultural products. Crops like rice, sugarcane and wheat not only nourish the country but they are also the major contributor to the foreign sector. In India rice is basically sown in the month of June and harvested during October-November and wheat is shortly sown after rice harvesting during the month of November and December. To make the field available for sowing of subsequent crop, crop residue is burnt to clear the land (Singh, 2015). The burning of crop residue causes different pollution of air, water, land and soil on large extent. Due to stubble burning there is adverse effect on the nutrient composition of soil i.e., organic carbon, nitrogen, potassium and phosphorus. Even the minerals present in the soil are also destroyed due to burning of crop residue which in how hampers the growth of next crop (Kumar, 2015). Stubble burning emits large amount of toxic pollutants in the atmosphere which consists harmful gases like CH_4 (Methane), CO_2 (carbon dioxide), CO, and carcinogenic poly-cyclic aromatic hydrocarbons. When these pollutants scatter in the surroundings they undergo chemical and physical transformation and ultimately affect the human health by causing a blanket of smog. Stubble burning also affects the soil moisture as heat generated by the burning penetrates into the soil thereby leading to the loss of moisture and useful microbes. Punjab, Haryana and western Uttar Pradesh have been known for crop residue burning but nowadays it's spreading more commonly in the other parts of states. According to Kumar 2015, it was surveyed that stubble burning is done in two ways, one is partial burning which includes running of combine harvester followed by burning of small stalks and another is complete burning, which means entire field is set on fire. Both these ways causes air pollution but the impact of complete burning is severe. The stubble burning is known as the most easiest and economical choice for removal of stubble. Lack of awareness and non-availability of technologies often compel the farmers to take this step (Chawala, 2020). The crop residues produced by the major crops shown in Table 1. Stubble burning is also quite common as “wealth from stubble” as this crop residue can be used for electricity generation which is productive way of generating wealth from residue. Even this residue can be used for mushroom cultivation as wheat and rice straws are best substrates for the cultivation of button mushrooms and straw mushrooms. They can also be used for packaging straw board, mat making, paper board etc. and most importantly crop residue can be used to make bio-fuels which can solve our problem of oil (Yadav, 2017). This review aims to generally cover the literature and existing status of stubble burning in India. The most important is to study the impacts of stubble burning on environment and agriculture.

Effects of Stubble Burning

Effects on air quality: Stubble burning brings serious threat to the air quality. Sidhu (2015) pointed out that air quality is deteriorated due to emission of Carbon monoxide, NO_2, PM_{10} and $PM_{2.5}$ which have surpass the permissible limits prescribed under NAAQS (National Ambient Air Quality standards) by the CPCB. To present the status of the air quality and its effects on human health, some categories are being adopted. In Table 2, the standards of WHO and NAAQS for $PM_{2.5}$ and PM_{10} have been compared. The WHO standard for permissible levels of $PM_{2.5}$ is 10 µg m in -3 air and if we see the standard of India's NAAQS, the permissible level for $PM_{2.5}$ is 40 µg m in air. However our three national capital Delhi sometimes reach to 98 to 100 µg m^{-3} which is ten times higher than of WHO and at least twice the standards of NAAQS.

Effect on soil fertility: Stubble burning also affects the soil productivity by burning some of the essential nutrients which are present inside in the soil (Singh *et al*., 2018). Fire destroy the remains of organic matter which directly effects the structure of the soil (Hesammi *et al*, 2014) reported that fire has a significant impact on soil physical, chemical, biological and biochemical properties. Plants utilize the nutrients from the soil and burning also affects the available soil nutrients. According to (Fasching, 2001) burning alters the soil temperature, soil moisture and nutrient availability.

Effect on agricultural productivity: Stubble burning directly affects the food production i.e. threat to the agriculture production (Fig. 1). Pollutants which are released in the atmosphere affect the agricultural productivity directly through injury to grains, leaves or indirectly. For example NO_2 causes discoloration by damaging the tissue of plants .Similarly SO, which leads to formation of acid rain have severe effects on soil and plants which further lead to plant mortality (Augustaitis *et al.*, 2010). Therefore suitable steps must be taken to deal with stubble burning to meet the increasing food demand.

Effects on the economic development:

Stubble burning not only effects the environment and health but air pollution also hampers the growth of country's economy. Ghosh *et al.* (2019) reported that air pollution effects cost the economy of India about 4.5 to 7.7 % of its GDP in 2018 and when he projected for 2060 there shows an increase in percentage by 15%. It has been observed that due to increase in air pollution tourist inflow in Delhi have also shown decline.

Effect on climate: Due to emissions from stubble fires climate is adversely affected as there is release of greenhouses gases like CH_4 and CO_2, which further leads to global warming. (Bellarby *et al.*, 2008) reported that about 17 to 32 % of total greenhouse gas emissions are assisted by agricultural sector in the world. Open burning is still considered as source of black carbon, a climate pollutant which contributes to climate change, air pollution and increased melting of snow and ice. Figure 2 shows the effect of stubble burning in Delhi which further degrades the air quality.

Impact of stubble burning on environment:

A large number of toxic pollutants are released into the atmosphere due to open burning of stubble. Many harmful gases are associated with this burning like, Carbon Monoxide, Methane, Carcinogenic Polycyclic hydrocarbons and VOCs. These harmful gases either build clouds of ash or produce into smog which is formed due to increase in amount of smoke present in the atmosphere.

Stubble burning. These harmful gases have an ability to travel thousands of kilometres which leads to increasing in air pollution in the cities nearby making the air quality more worse. With the onset of winter, burning becomes prevalent in the Northern India mainly in Punjab, Haryana and western Uttar Pradesh. Each year farmers of Punjab burn about million metric tons of crop residues (Kedia, 2020) and this crop residue burning is one of the major contributor for causing air pollution as emits Greenhouse gases.

According to (Kumar *et al.*, 2015) in Table 3 these particulates are released in the atmosphere in large quantities. Further they also added that concentration of organic pollutants was also found to be high which consists of toxic heavy metals like Iron and Zinc (Reddy *et al.*, 2019). Burning of crop residue not only degrades the air quality but it actually destroys the nutrient value of the soil which in how results in decrease in soil fertility causing loss in moisture in the soil. Chaterjee (2018) reported that burning 1 ton stubble may cause the loss of 5.5 kg nitrogen, 2.3 kg phosphorus, 25 kg Potassium and 1.2 kg Sulphur, in addition to organic carbon.

Human Health and Well Being: Researchers have shown that burning of stubble or any agriculture residue is a major health hazard. Stubble burning releases fine particulate matter ($PM_{2.5}$), which is an air pollutant and majorly its concerns the people's health when the concentration or levels of $PM_{2.5}$ is very high. These particles get trapped inside the lungs and increase the risk of lung cancer by 36% (Kedia, 2020). The gaseous emissions which are released due to burning pose risk to the health ranging from skin and eyes irritation to severe cardiovascular , neurological and respiratory diseases, asthma, chronic bronchitis and decreased lung function, COPD (Chronic Obstructive Pulmonary Disease), emphysema, etc. (Abdurrahman, 2020). Due to prolonged exposure of pollution leads to increase in mortality rates. Even the pregnant women and infants are prone to many dangerous consequences due to pollutants released by the stubble burning (Singh *et al*., 2018). Other effects of exposure to burning or pollution caused by burning include Stoke, tuberculosis, lung cancer, a cardiac arrest and infections in respiratory system (Abdurrahman, 2020). Simpson (2019) estimated that economic cost of being exposed to air pollution from stubble burning is nearly Rs. 2 lakh crore annually. These air quality standards (Table 4) are set by the individual countries to protect the public health of their citizens. Though Indian AQI standard are less stringent as compared to WHO. Air quality degradation results in increase in respiratory problems like asthma, cough, bronchitis, eye and skin diseases. Stubble burning sometimes also causes poor visibility which further leads to increase of road accidents (Sidhu, 2015).

Impacts on Economic growth: Air pollution negatively affects a nation's economy and its adverse effects on health and the environment. Due to the rise in air pollution over the past few years, Delhi has seen a 20–25% decline in visitors visiting the city. In 2018, the cost of air pollution to India's economy ranged from 4.5 to 7.7% of GDP, and when extrapolated to 2060, the figure increased to around 15%. Air pollution also reduces workers' productivity in other areas by making them ill and difficult to see. The Indian government estimated that managing air pollution and providing for its well-being would cost around $14 billion annually.

Management practices: Farmers can manage the crop residues very effectively. An holistic approach is required to tackle this problem from the base by adopting various precautionary and preventive methods or techniques. The techniques are incorporating the stubble in to the soil, generating fuel from husk (Biofuel production), Composting, bio char, Fodder (Abdurrahman, 2020). Instead of burning of the stubble this can be used in different ways like mushroom cultivation, biomass energy, packing materials and in industrial production also. In ancient times when the agriculture produce was less or limited, some old methods were adopted by the farmers instead of burning the fields like stubble mostly used as fodder. Rice straw had been used to bind clay in built up wall construction and in the manufacturing of fired brick, for packing the materials, Bedding for livestock, poultry for built up litter system. But now these methods are considered as insignificant in front of new technologies or modernization. Technologies like making pellets out of stubble replace the coal in industries. These pellets can be widely used for heating, industrial furnace, hot water boiler, life stove etc. Fuel from pellets have high efficiency and are easy to store they can also solve the problem of environment as replacing coal will be beneficial for environment (Verma, 2014). Agriculture waste or we can say stubble can generate energy via combustion, gasification, or methanation (Shafie, 2016). This stubble can be combusted mixing up with the other biomass or can be combusted directly also to generate heat and electricity (Kumar *et al.,* 2015). Composting is also one of the methods which proved to be essential in the management of stubble. A very popular method of composting is vermi-composting that produces compost with the use of earthworms which is known to improve the productivity of soil (Singh *et al.*, 2018). Stubble composting can be done in two stages in which anaerobic process is followed by aerobic process for 40 days (Gummert *et al*, 2020). In a study conducted by (Ravindra *et al.,* 2018), they founded that stubble from millet, sugarcane, wheat, pulse etc. generates valuable vermi-composting when mixed with Cow dung. It was also reported by (Zhao *et al.*, 2019) that rice straw decomposition restores the fertility of the soil. There are some other approaches which can be considered as other alternatives for the management of stubble which includes production of bio-lubricants, pulp manufacturing, production of Nano silica, Paper manufacturing (Zhang *et al.*, 2017). Further this Nano silica can be used in solar cells, cosmetics and Nano medicines.

Conclusion

Burning of stubble is mostly taken as an easiest and cost effective alternative. Therefore Haryana, Punjab, Uttrakhand and Uttar Pradesh states should adopt or initiate new technologies. Stubble burning is one of the major environmental hazards so it is extremely important to understand the causes situations as why farmers burn the stubble. Alternative approaches can be taken to solve the problem of stubble burning by encouraging and making the farmers aware by trainings, workshops, or through Kisan camps etc. While adopting these new technologies of agriculture conservation it can help in improving the soil health, quality, reducing pollution and enhancing the sustainability.

Management of stubble burning: Following strategies for the management of stubble burning are appropriate to adopt

1. The foremost step should be spread awareness among the farmers to enlighten them about the environmental concerns, economic benefits by managing the stubble.
2. Government can provide stubble collecting machinery to farmers on rent or subsidy basis.
3. All the pulp, paper, biomass, construction and power industries should be forced by the government to use stubble as raw materials.
4. Biomass fuel can be set up to generate fuel.
5. Some packaging industries can be contacted to collect the stubble for packaging the boxes. 6. Machine like happy seeder can be used by the farmers.
7. Farmers should be encouraged for diversification of crops.

Table 1 : Crop residues produced by major crops (Arvanitoyannis and Phonbumrung 2006)

Source	Composition
Rice	Husk, Bran
Wheat	Bran, Straw
Maize	Stover, husk, Skins
Millet	Stover
Sugarcane	Sugarcane tops

Table 2 : Source: Revised National Ambient Air Quality Standards, CPCB, 2009

Sr. No.	Pollutants	Time Weighted Average	Concentration in Ambient S. Air		Methods of Measurement
			Industrial, Residential Rural and other Areas	Ecologically Sensitive Area (notified by Central Government)	
01	Sulphur Dioxide (SO_2), µg/m^3	Annual* 24 Hrs**	50 80	20 80	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
02	Nitrogen Dioxide (NO_2) µg/m^3	Annual* 24 Hrs**	40 80	30 80	1. Modified Jacob & Hochheiser (Na-Arsenite) 2. Chemiluminescence
03	Particulate Matter (Size <10µm) PM_{10} µg/m3	Annual* 24 Hrs**	60 100	60 100	1. Gravimetric 2. TOEM 3. Beta attenuation
04	Particulate Matter (Size <2.5µm) $PM_{2.5}$ µg/m3	Annual* 24 Hrs**	40 40	60 60	1. Gravimetric 2. TOEM 3. Beta attenuation
05	Ozone (O_3), µg/m	8hours** 1hours**	100 180	100 180	1. UV photometric 2. Chemiluminescence 3. Chemical Method
06	Lead (Pb), µg/m^3	Annual 24 hr**	0.50 1.0	0.50 1.0	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
07	Carbon Monoxide (CO), m^3	08Hours** 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 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.

Table 3: Particulates releasing in air

Particulars	Range
$P.M_{2.5}$ M	146-221 $^{\mu gm-3}$
$P.M._{10}$	300 $^{\mu gm-3}$
NO_2 and NH_3	40–50 $^{\mu gm-3}$

Table 4: IND-AQI category and range (CBCB)

AQI category	AQI range	Possible health impacts
Good	0 – 50	Minimal Impact
Satisfactory	51 – 100	Minor breathing discomfort to sensitive people
Moderate	101 – 200	Breathing discomfort to the people with lungs, asthma and heart diseases
Poor	201 – 300	Breathing discomfort to most people on prolonged exposure
Very Poor	301 – 400	Respiratory illness on prolonged exposure

Fig. 1 : Stubble burning, a common Agricultural practice

A B

Fig. 2 : Pollution in Delhi before and during stubble burning periods; (A): Image of New Delhi during July, 2019. (B): Image of New Delhi during November, 2019

Acknowledgement

The authors acknowledge with thanks the Principal, Regional Institute of Education ((NCERT) Bhubaneswar for extending necessary support and facilities for the present study and Prof. R.C. Mohanty, Emeritus Scientist Utkal University, Bhubaneswar for his encouragement and technical advice.

Declaration of Competing Interest

The authors declare no competing interests.

References

Abdurrahman, M.I., Chaki, S. and Saini, G. (2020). Stubble burning: Effects on health & environment, regulations and management practices. *Environ. Pract*., 2: 100011.

Augustaitis, A., Ðopauskienë, D. and Bauþienë, I. (2010). Direct and indirect effects of regional air pollution on tree crown defoliation. *Baltic For.,* 16(1):13. https://www.balticforestry.mi.lt/bf.

Bellarby, J., Foereid, B., Hastings, A.F.S.J. and Smith, P. (2008). Cool farming: climate impacts of agriculture and mitigation potential. *Greenpeace Int*. 44. http://eprints.lancs.ac.uk/ 68831/1/1111

Chawala, P. and Sandhu, S.A.H. (2020). Stubble burn area estimation and its impact on ambient air quality of Patila and Ludhiana district, Punjab, India., https://doi.org/10.1016 /j.heliyon.2019.e03095

Fasching, R.A. (2001). Ecological Sciences – Agronomy Technical note., Natural resources conservation service., *Agronomy Technical Note* No. 150.16.

Ghosh, P., Sharma, S., Khanna, I., Datta, A., Suresh, R., Kundu, S., Goel, A. and Datt, D. (2019). Scoping study for South Asia air pollution. Energy Resour. Inst. 153. https://www.gov.uk/dfid-research┐ outputs/scoping-study-for-south-asia-air-pollution.

Gummert, M., Hung, N.V. Pauline, C. and Douthwaite, B. (2020). *Sustainable rice straw management*. Springer International Publishing https://doi.org/10.1007/978-3-030-32373-8.

Hesammi, E., Talebi, B.A. and Hesammi, A. (2014). A review on the burning of crop residue on the soil properties. (1): *WALIA Journal.,* 30(1): 192-194.

Kumar, P., Kumar, S. and Joshi, L. (2015). The extent and management of crop stubble. In: Socioeconomic and environmental implications of agricultural residue burning. *Briefs Env. Sci*. Springer, India, New Delhi, pp. 13–34.

Kumar, P. and Kumar, S. (2015). The extent and management of crop stubble, 10.1007/978-81-322-2014-52.

Kedia, S., Pandey, R. and Malhotra, A. (2020). *The impact of stubble burning and poor air quality in India during the time of COVID- 19.* The Energy and resources Institute.

Parmod, K., Surender, K., Laxmi, J. (2015). Socioeconomic and Environmental Implications of agricultural residue burning: A case study of Punjab, India. *Environ. Sci. Technol*., DOI 10.1007/978-81-322-2014-56

Phonbumrung, T. and Khemsawas, C. (1988). Agricultural Crop Residue; Proceedings of the *Sixth Meeting of Regional Working Group on Grazing and Feed Resources for Southeast Asia*; Legaspi, Philippines. 5–9 October 1998; pp. 183-187.

Pranay, R.J., Nidhi, D., Harshal, A.A., Kesha, R., Kachakayala, R. and Chethan, S. (2019). Stubble burning in Punjab: A review.

Pyali, C. (2018). Impact of practice of stubble burning in environment. A Socio Legal Study, Munich, GRIN Verlag, https://www.grin.com/document/437147.

Ravindra, K., Singh, T. and Mor, S. (2018). Emissions of air pollutants from primary crop residue burning in India and their mitigation strategies for cleaner emissions. *J.Clean. Prod.,* 208: 261-273.

Sidhu, R., Bansal, M., Bath, G.S. and Garg, R. (2015). Impact of stubble burning on the ambient air quality. *Int. J. Mech. Prod. Eng.,* 3(10) :46–50.

Singh, J., Singhal, N., Singhal, S., Sharma, M., Agarwal, and Arora, S. (2018). Environmental implications of rice and wheat stubble burning in North-Western States of India. *Advances in Health and Environment Safety* DOI: 10.1007/978-981-10-7122-5_6.

Singh, P.R., Chanduka, L. and Dhir, A. (2015). Impacts of stubble burning on ambient air quality of a critically polluted area–Mandi Gobindgarh : 10.4172/2375-4397.1000135**.**

Simpson, D. (2019). *Air pollution from India's stubble burning has a toll on health and the economy*. International Food Policy Research Institute.

Singh, Y., Singh, D. and Tripathi, R.P. (2019). Crop residue management in rice-wheat cropping system. *International Crop Science Congress.* National Academy of Agricultural Sciences New Delhi https://doi.org/10.1007/978-1-4020-9875-810

Shafie, S.M. (2016). A review on paddy residue based power generation: Energy, environment and economic perspective. Renew. *Sust. Energ. Rev*., 59(2): 1089-1100.

Verma, S.S. (2014). Technologies for stubble use. *J. Agri. and Life Sci.,* SSN 2375-4214 (Print), 2375- 4222.

Yadav, S., Koli, P., Mina, U. and Devi, S. (2017). Crop residue burning and air pollution. ISSN: 2321-0001.

Zhang, L., Zhang, Y., Li, R., Wang, S. and Chai, F. (2017). Emission characterization, environmental impact, and control measure of $PM_{2.5}$ emitted from agricultural crop residue burning in China. *J. Clean. Prod*., 12: 149**-**635.

Zhang, L., Liu, Y. and Lu, H. (2019). Contributions of open crop straw burning emissions to $PM_{2.5}$ concentrations in China. *Environmental Research Letters* 11 (1): 014014.