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Rice Crop Residue burning and alternative measures by India: A Review

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Abstract: **This review paper aims to underline the impact of burning rice straw on environment and numerous surrogate measures taken by the Indian government to overcome the problem of air pollution. India is the second-largest producer of rice in the world. Around, 23 million ton which makes 62.4% of the total rice straw generated, is set ablaze in the fields of north-western states of India annually. Straw burning releases harmful chemicals that causes decline in air quality and soil infertility. It causes not only health hazards but also contributes massively to reach higher altitudes of global warming. Moreover, the alternatives to crop burning are less effective and costly. Several measures have been taken by Government of India to diminish this hazardous procedure by introducing biogas plants, composting, and production of bio-char. India recently developed Pusa decomposer, a cost-effective, farmer-friendly compost made up of a mixture of microorganisms to convert rice straw into manure. This recently developed technique by Indian Agricultural Research Institute (IARI) can prove to be successful in plummeting the greenhouse effect and other harmful gas emissions in Delhi and other states.**

Index Terms: alternatives for crop burning, crop burning hazards, north-western India, rice straw burning, pusa decomposer.

I. INTRODUCTION

India is the second- largest producer of rice in the world, with 43.86 million hectares of land under rice cultivation and productivity of 2390 kg/ha as recorded in the year 2016 (From burning to buying, Nederland Report,2019). The major rice cultivating states in India are Uttar Pradesh, Punjab, and Haryana, southern states like Tamil Nadu and north eastern states like Sikkim. There was a noticeable increase in area under rice cultivation by 142% and rice production increased five times from 1950- 51 to 2015-16. The rice crop residue generated is around 23 million tons i.e., 62.4% of the total crop residue generated annually in Indian sub-continent (National Policy for Management of Crop Residue, NPMCR). According to IARI 80% of rice crop residue is burnt in India annually. This contributes to 26.89% of rice crop residue burning in the whole world as surveyed by authors Suresh Kumar and D.K Sharma, 2011. Slash and burn method is majorly used in north-western states and the capital city of India which adds to its air pollution and makes it the fifth most polluted city in the world. Soil infertility is caused due to burning of essential soil nutrients like nitrogen, phosphorous, potassium, and sulphur during the crop burning (Loan, 2018). Carbon dioxide and carbon mono- oxide along with black carbon released from crop burning engenders irreversible damage to the atmosphere resulting in global warming and respiratory diseases (Abdurrahman,2020). This article focuses on various alternatives like bio- composting, biomass based power plants which are introduced globally to mitigate the risks induced to the environment. Moreover, many countries give subsidy and incentives to farmers, familiarize them with new machinery and encourage farmers to follow less harmful alternatives of disposing the crop waste (Kumar, 2011). Indian Agricultural Research Institute (IARI), recently managed to find a promising eco-friendly alternative called ‘PUSA DECOMPOSER’ which includes the use of cocktail of micro-organisms for fermentation of the rice residue and then converting it to manure. This new alternative is said to be farmer friendly as it is free of cost.

This manuscript is a detailed review of rice crop burning predicament and introduction of various alternatives to promote residue management and soil incorporation to the agrarian society of the world.

II. RICE CROP BURNING IN INDIA

Crop residue burning is prevalent in India and other Asian countries like Thailand, Myanmar, Bangladesh, Indonesia, etc. India being the lead harvester of rice after China generates a high amount of rice straw. The Contribution of rice residue burning in total crop burning is 43% whereas, of wheat is around 21%, sugarcane is about 19% and oilseed is 5% (Bhuvaneshwari S., 2019). Other crop residues from wheat, sugarcane, and bamboo are used as fodder and fuels but rice crop residue is not nutritious enough to feed animals as they contain high amount of silica (Dobermann&Fairhurst, 2016)

Farmers in India tend to harvest three crops in a year. Cultivation of rice crop requires heavy irrigation and hence, it is not suitable to be grown in the summer season. Whereas, the wheat yield assist better if sown before the last week of November (Kumar,2011). It's strenuous for farmers to rotate crops within such a short span. One of the major causes of rice straw burning in India is the use of combine harvesters as stated by IARI 2012. Labor shortage, economical and less tedious attributes of combine harvesters has increased its use and demand in agriculture since last decade (Gupta, 2012),70- 90% of rice crops are being harvested using harvesters presently in India (Gajri,2002). Use of machinery like 'happy seeder', leaves behind around 40 to 50 cm of stubble after harvesting (Singh B., 2011). Thus it becomes costlier, time-consuming and labor-intensive to remove crop stubble from the fields and prepare it for the next harvest. Using alternatives like bio- composting and soil incorporation has not proved to be beneficial for the farmers because they are highly labor-intensive and time-consuming thus, leaving them with the current best option i.e., crop burning (Sidhu,2005).Demand for rice straw and other crop residues as fodder are continuously declining due to the reduction in live-stock population over the last few decades (GoI., 2009; GoI 2012).Therefore, due to the above-stated reasons rice crop burning is preferred by farmers over residue management. This has been augmenting atmospheric pollution and soil infertility over many decades which have caused irreparable damage to the environment and ecosystem.

III. COMPOSITION OF STUBBLE BURNING EMISSION

Crop burning produces a huge amount of toxic gases resulting in detrimental impact on the environment and human health. The emission from stubble combustion contains large amount of carbon dioxide, carbon mono- oxide, nitrous oxide, methane, sulphur dioxide and smoke particles that vary in size depending on the phase of burning (Ordou&Agronovski,2019). Aerosols produced as a result of crop burning are predominantly black carbon and organic carbon. Black carbon strongly absorbs solar radiation whereas organic carbon scatters solar radiation, the latter being the principal component of emission. A part of organic Carbon known as brown carbon is also formed while crop burning, it has stronger light absorbing capacity than black carbon (Laskin,2015) Stubble combustion emission also comprises ionic species such as chloride, calcium and magnesium ions and salts such as sulphates, oxalates, etc. as mentioned by Saarikoski (2007).

Approximately 4.86 Mt of CO_2, 3.4 Mt of CO, 0.14 Mt of NO_x, and 1.28 Mt of PM (Saggu,2018) are produced from the combustion of 63 Mt of crop waste (Kumar, 2015) Polyhalogenated organic compounds (PCDDS), Peroxyacetyl nitrate (PAN), polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs) and polychlorinated dibenzofurans (PCDFs), these pollutants are carcinogenic and cause irreparable damage to human health (Singh,2018).The Green House Gases (GHGs) in the Indian region are mainly contributed by burning of large amount of rice and wheat crops (Awasthi,2011).

IV. IMPACT OF RICE STRAW BURNING ON ENVIRONMENT

Burning of rice stubble in open fields generates a tremendous amount of noxious gases, and particulate matter (PM) contributes to global warming and respiratory diseases in humans. PM25 in Delhi increased by 78% in 2011, during the rice and wheat burning period (Carlsen,1992) .A study conducted by Singh (2015)& Kumar (2015) concluded that stubble burning contributes approximately, 100- 200 µg/m3 of PM10 to the air pollution of the city. The Air Quality Index (AQI) shows severe increase during the rice and wheat harvesting seasons. In November 2019, Delhi set an all-time high value of 487 AQI, followed by Greater Noida with 480 AQI (Mohd. Isa Abdurrahman, 2020)

70% Carbon inside the stubble is converted to carbon dioxide, 7% to carbon monoxide and 6.6% to methane due to burning (Yadav,2019). These harmful gases and aerosols produced, affects air quality making it unsafe for habitat. Open field burning not only affects human health but also affects the soil quality, burning of its essential nutrients like nitrogen, phosphorus and potassium as well as other useful microorganisms (Yadav, 2019) Agricultural productivity is also affected by air pollutants like nitrous and sulphur oxides. Ozone formed at lower levels by reaction between nitrogen oxide and organic compounds in presence of sunlight, causes disruption of plant metabolism.

India particularly is exposed to a high level of PM25, which is more hazardous compared to other pollutants. It is estimated that about 600, 000 people in India die prematurely due to exposure to such noxious gases, every year (Sachin, D.&Lelieveld, 2015). The exposure to pollutants affects skin, eyes and respiratory functioning in humans, even leading to cancer and permanent lung diseases (Ghosh,2019). It also leads to chronic diseases like tuberculosis, lung cancer, cardiac arrest and infections in children (Bernal,1996).The dust released after crop burning blurs vision and hence, results in road side accidents 19.

Agricultural sector mainly contributes 17% to 32% of total greenhouse gas emissions in the world (Kumar,2018).It also in turns affects the crop yields due to climate change. The economy sector also faces a decline in development due to increase in air pollution. Delhi's AQI is daunting for tourists and also counterproductive to India's economy. Alternatives and measures introduced by India to overcome the dangerous consequences of air pollution cost millions of rupees annually (Kumar,2015).

V. RICE STRAW MANAGEMENT PRACTICES

A. Composting

Composting is an organic process in which the organic matter of stubble is utilized by micro-organisms and earthworms to cvert the dry matter into soil nutrients (Bernal, 1996; Qian, 2013) Conversion of rice stubble into compost seems to be a potential solution to overcome open field burning. Agricultural residue is rich in nutrients and hence, their compost improves soil fertility (Romasanta, 2017). Crop yield can be increased by 4-9% by conversion of crop waste into compost (Sood, 2015).Various techniques have been introduced for composting, like vermi-composting (Abdurrahman,2020)mechanized windrow composting (Gummert,2020), co-composting livestock and dairy manure with rice straw, etc. (Qian, 2013). The process of bio- composting involves two stages, anaerobic and aerobic, and each stage takes about 40 days to be achieved (Gummert, 2020; Kumar,2015)The aerobic phase is degradation which requires high temperature and accurate pH to activate the micro-organisms. This stage helps breaking down sugars and acids (Bhuvaneshwari, 2019; Chandra, 2012) and it prolongs for weeks or even a month. Thus, bio- composting is a fruitful but tedious task for farmers following crop rotation twice a year. A few farmers, aware of crop burning hazards carry out composting and other such organic procedures to improve their crop yield and reduce air pollution caused by open field burning.

B. Rice straw as bio-fuels

The ligno-cellulosic compositions of plants are difficult to decompose and hence, can be used as a raw material for bio-fuels. Plant biomass is pre-treated by selective micro-organisms for degradation and is converted into monomers and sugars, serving as an effective bio-fuel (Chandra, 2012; Bhuvaneshwari, 2019). Biomass can be converted into biogas by anaerobic digesters. Biogas mainly comprises of methane gas and a nutrient rich residue. The monomers generated by anaerobic digesters are treated to obtain fatty acids (acetate, formate) and finally converted into carbon dioxide and methane by useful bacteria (Holm-Nielsen, 2009). The demand of fuel in India can be fulfilled by bio-fuels by up to 17% (Hiloidhari,2015).This method has proved to be a viable alternative if followed efficiently. With energy demands increasing in the world bio-fuels is a better option as they leave less carbon traces compared to fossil fuels (M., I., Abdurrahman, 2020). There are 56 biogas plants in India majorly in Maharashtra, Karnataka and Kerala. Introducing small bio gas plants in rural areas is a progressive step taken by Indian Government. There are around five million small biogas plants installed by Ministry of New and Renewable Energy (MNRE), certified by IIT, Indian Agricultural Research Institute. For each house, they generate around 4000 m^3 of biogas from 10 tons of residue (Talapatra et al,1948). This initiative reduced crop burning to some extent.

C. Rice straw as animal fodder:

Owing to its lower nutritional value, rice straw is not used as animal fodder. Rice straw is ligno-cellulosic and is not readily digested and can cause livestock health issues. Only 7 percent of the total ricestraw stock produced is used as animal fodder, according to a study by Kumar (2015) whereas 45 percent of wheat straw is used as animal fodder. Just 0.02 to 0.16 percent of the phosphorous in rice straw is inefficient for livestock. The content of silica in rice straw is higher than lignin and is therefore not properly metabolized. Rice straw also differs from other straws in having a high (1–2 percent) content of oxalates.

D. Soil incorporation

Various experiments have demonstrated that soil incorporation is a safer alternative to removal of crop residues. The procedure is to blend the crop stubble into the soil three weeks before cultivation, it not only increases soil fertility and provides essential nutrients, but also increases soil organic carbon by 14-29 percent (Singh, 1996). It offers cost-saving equipment and less labour in the long term. Along with soil benefits such as cooling effect, increased moisture, carbon source and erosion protection, soil integration has various disadvantages such as crop infestation, nutrient immobilization and phyto-toxin formation (Mohd Isa Abdurrahman,2020).The National Policy for Management of Crop Residue (NPMCR) suggests that methods such as soil incorporation and composting should be promoted in India to not only reduce air pollution due to stubble burning but also increase soil fertility (S.Bhuvaneshwari, 2019.,NPMCR)

VI. INITIATIVES BY INDIAN GOVERNMENT

Indian Government introduced numerous laws to alleviate the hazards caused due to open field burning of crops like The Section 144 of Civil Procedure Code (CPC) to ban burning of rice crop; The Air Prevention and Control of Pollution Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995; and The National Environment Appellate Authority Act, 1997. The states of Rajasthan, Uttar Pradesh, Haryana and Punjab have implied the National Green Tribunal (NGT) to limit the crop residue burning as mentioned by Loan Kumar, (2015); S. Bhuvaneshwari, (2019). Other stringent measures taken by the Government are installing biogas plants in remote villages and popularizing bio – compost methods. Several schemes and policies proposed by the Government also played a beneficiary role in reducing crop burning practices in India. Schemes like The Rashtriya Krishi Vikas Yojana (RKVY), State Plan Scheme of Additional Central Assistance. A program called the National Policy for Management of Crop Residue (NPMCR) has recently been established by the Ministry of Agriculture of India. It aims to encourage crop residue management technology, avoid soil nutrient losses, produce new equipment and provide discounts and incentives for the procurement of happy seeders, turbo seeders, shredders and bailing machines. NPMCR also intends to track crop residues using the National Remote Sensing Agency (NRSA).

Similarly, another initiative by The National Green Tribunal Act aims to spread awareness among the farmers to curb crop burning. The implementation of such systems and ventures has effectively reduced the open combustion of crop stubble. It has been observed that the use of end products of crops are not utilized in other manufactures due to lack of awareness and social consciousness among farmers. Management practices like production of bio char, compost and biogas has proved to be three key technical solutions to overcome open field burning hazards (S. Bhuvaneshwari, 2019)

VII. PUSA DECOMPOSER

In the end of September 2020, Indian Agricultural Research Institute (IARI) announced the development of PUSA DECOMPOSER, a microbial capsule to decompose paddy crop residue. As reported by the head of the Microbiology Division, IARI., Mrs K. Annapurna, along with Chief Minister Shri. Arvind Kejriwal had visited and sprayed the microbial decomposer on the fields of farmer Prakash Singh of Hiranki village, Najafgarh block, Delhi. Just 15 days later they found that 90 percent of the paddy residue had decomposed as reported in Mongabay by Usha Rai.

The IARI and Punjab Agriculture University (PAU) in Ludhiana have been working on the IARI solution, which comes in the form of four capsules, each costing Rs 5 or Rs 20. It is so inexpensive and disintegrates stubble so efficiently that it can be used by all farmers without caring about costs or depriving the soil by burning its nutrients. Livleen Shukla, principal scientist of the Microbiology Division in Pusa, says that only four capsules are required to turn a hectare of farm waste into usable compost. The net cost per acre is approximately ₹ 300 which includes the cost of producing the concoction with jaggery, gram, mixing the capsules in large water containers and the cost of spraying labour. The fields preserve some moisture during decomposition of agricultural waste, and the soil is enriched, minimizing the use of fertilizer. Another advantage of the capsule containing crop-friendly fungi is that it does not have any side effects. Eight companies working with bio-products have been granted the Pusa Decomposer license. The Delhi government declared this year that the spray will be used across Delhi on 800 hectares of farmland. Environment Minister Prakash Javadekar then confirmed that it would also be used in Punjab and Haryana on 100 hectares of land and on 10,000 hectares of land in Uttar Pradesh.

CONCLUSION

This review article focuses on the hazardous outcomes of crop residue burning and various alternatives to curtail the harmful consequences. Rice crop residue burning has been contributing to major air pollution in Delhi and other northern states in India. The problems caused by excessive release of particulate matter have also been discussed. A concerning deterioration of air quality has been recorded in recent years. Farmers in India tend to burn crops due to the fact that it’s inexpensive, time friendly and less strenuous. The management of crop waste is a huge task in India and other Asian countries, which is so far the biggest contributor of air pollution. The Indian government is continuously on guard to curtail crop residue burning in a sustainable way and also to annihilate the dire risk factors of pollution.

The review article also mentions the effective implementation of techniques like bio- composting, soil incorporation, Pusa Decomposer and various other schemes introduced by Indian Government. Biogas plants are installed in a vast number of villages in some north eastern states in India to support the farmers. The Indian Agricultural Research Institute (IARI) is constantly promoting research and various innovative measures to manage crop residue. It is also working on educating the farmers about the alternative measures to be implemented.

The Indian Agricultural Research Institute (IARI) is taking tremendous efforts in keeping the pollution caused by the burning of crops in control and introducing policies and schemes for a promising future for agrarian society of India.

REFERENCES

Abdurrahman, M.,I., Chaki, S., Saini, G., (2020). Stubble burning: Effects on health and environment, regulations and management practices.India, Elseveir.

Awasthi, A., Agarwal R., Mittal,SK., Singh, N., Singh, K., Gupta, P.K,(2011). Study of size and mass distribution of particulate matter due to crop residue burning with seasonal variation in rural India in Punjab, India.

Bernal, M.P., Navarro, A.F., Roig, A., Cegarra, J., Garcia, D., (1996). Carbon and Nitrogen transformation during composting of sweet sorghum bagasse.

Bhuvaneshwari, S., Hettiarachchi, H., Meegoda., J., (2019). Crop residue burning in India: Policy challenges and potential solutions. International Journal of Environmental Research and Public Health.

Carlsen E, Giwercmann, A, Keiding, N., Shakkebaek, N.E, (1992). Evidence for decreasing quality of semen during past 50 years. India. BMJ.

Chandra, R, Takeuchi, H, Hasegawa, T., (2012), Methane production of ligno-cellulosic agricultural crop wastes . A review in context to second generation of bio fuel production. Renew. Sustain. Rev.

Dobermann, A., Fairhurst, T., (2016). Effect of waste water Irrigation on growth and yield of rice crop and uptake and accumulation of nutrient and heavy metals in soil. Vol.4, International Rice Research Institute (IRRI).

From Burning To Buying: Creating a circular production chain out of left over crop' Residue from Indian Farmland. Final Report.Utrecht, Nederland,2019.

Gajri. P.R., Ghuman, B.S.,Singh, S.,Mishra, R.D., Yadav., D.S and Singh, H. (2002). Tillage and Residue Management practices in rice- wheat system in Indo- Gigantic Plains- A diagnostic survey.

Ghosh, P., Sharma.,S., Khanna., I., Datta, A.,Suresh, R., Kundu, S., Goel, A., Ddatt, D., (2019). Scoping study for South Asia Air Pollution.

Ghude, S.D., Chate, D.M., Jena, C., (2015). Prematurity mortality rate in India due to PM2.5 and ozone exposure. Geophysical Research Letters. Vol. 43, Issue 9.

GoI,(2011).Livestock census. New Delhi: Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India.

GoI, (2012). Livestock census. New Delhi. Department of Animal Husbandry Dairying and Fisheries , ministry of Agriculture and Farmers Welfare, Government of India.

Gummert, M., Hung, N.V., Pauline , C., Douthwaite, B., (2020).Sustainable Rice Straw Management Springer, International Publishing.

Gupta, P.K.; Sahai, S.; Singh, N.; Dixit, C.K.; Singh, D.P.; Sharma, C., (2012), Residue burning in rice- wheat cropping system: Causes and implications.

Hiloidhari, M., Das.,Baruah, D.C., (2014). Bioenergy potential from crop residue biomass in India. Renew. Sust. Energy.

Holm- Nielsen , J.B.; Al Seidi, T.; Oleskowizc- popiel , P.,(2009). The future of anaerobic digestion and biogas utilization. Bioresources. Technol.

Kumar, P. Kumar, S and Joshi, L. (2015).Socio-economic and environmental implications of agricultural residue burning. Barakhamba, New Delhi. Springer.

Kumar, P.; Kumar, S.; Joshi, L., (2018).The extend and management of crop residue stubble.

Kumar, R., Singh, T., Mor, S., (2018). Emissions of air pollutants from primary crop residue burning in India and their mitigation strategies for cleaner emissions. J. Clean. Prod.

Kumar, S., Sharma, D.K., Singh, D., Biswas, H., Kumar, P., and Sharma, V., (2019). Estimating loss of ecosystem services due to paddy straw burning in north- west India.

Laskin, A., Laskin, J., Nizkorodov , S.A., (2015). Chemistry of atmospheric brown Carbon .

Lelieveld, J., Evans, J.S., Fnais, M., Giannadaki, D., Pozzer, A., (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature ,525.

Loan, S. K.., Jat, H.S.;Yadav, A.K., Sindhu, H.S., Jat, M.L., Choudhary, M., Kiran, J.P., Sharma, P.C., (2018). Burning issues of Paddy Residue management in north west states of India. Renew, Sustain, Energy Rev .

National Policy For Management of Crop Residue (NPMCR). available at http://agricoop.gov.in/

Ordou, E., Agranovski, I.E., (2019).Contribution of fine particles to air emission at different phases of biomass burning. Atmos.

Rai, U., (2019). A microbial spray could be the game changer against crop residue burning. Mongabay Series: Environment and Health.

Romasanta , R.R., Sander, B.O. Gaihre, Y.K, Alberto, M.C, Gummert, M., Quilty, J.,Nguyen, V.H., Castalone, A.G., Balingbing, C., Sandro, J., Correa, T., Wassmann, R., (2017). How does burning of rice straw affect CH4 and N2O emissions? A comparative experiment of different on-field straw management practices.

Saarikoski , S., Sillanpaa. M., Sofiev, M., Timonen.,H., Saarnio, K., Teinali, K., Karpinen., A., Kukkonen. J., Hillamo, R., (2007). Chemical composition of aerosols during a major biomass burning episode over northern Europe in spring 2006.

Saggu, G.S., Mittal, S.K., Agarwal, R., Beig, G., (2018). Epidemiological study on respiratory health of school children of rural sites of Malwa region (India) during post harvest stubble burning events. M.A.P.A.N.

Sidhu, B.S., & Beri, V. (2005).Experience with managing rice residues in intensive rice- wheat cropping system in Punjab.

Singh, B., (2011). Effect of rice mulch on irrigated wheat growth, yield and water productivity.

Singh, J., (2018). Paddy and Wheat stubble blazing in Haryana and Punjab States of India: A menace for environmental Health. Environmental Quality Management.

Singh Y. Singh D, Tripathi, RP.,(1996). Crop Residue management in rice- wheat cropping system. International Crop Science Congress.National Academy of Agricultural Sciences, New Delhi.

Sood , J. Not a waste until wasted , Down to Earth 2011. www.downtoearth.org

Talapatra et al (1948). Rice straw as livestock feed by M.G. Jackson.

Qian, X., Shen, G., Wang, Z., Guo, C., Liu,Y., Lei, Z., Zhang, Z. (2013). Co- composting of livestock manure with rice straw: Characterization and establishment of maturity evaluation system, Elseveir.

Yadav, R.S, (2019). Stubble Burning: A problem for the environment, agriculture and humans. Blog https://www.downtoearth.org.in/

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