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Controlling pollution by managing crop residue: A solution driven approach

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Abstract
Purpose: Usage of technology is not new in agriculture, it has also increased the agricultural efficiency in terms of higher yield, less time, energy & money saving, but a gigantic challenge has been emerged globally i.e. air pollution due to CRB (Crop residue burning). Contaminated molecule of CRB expands in the air and degrades the air quality. In India Polluted air quality has become a burgeoning issue in metro cities, Delhi is the capital of India and one of the most polluted city (ranked in top five polluted cities in the world, Jakarta post, November 4, 2017).
Design/Methodology/approach: Field study has been adopted for this research, personal observation method has been used to collect the information from three agriculture dominated districts (Bathinda, Mansa and Sangrur) of Punjab state. In this paper researcher has done a cost-benefit analysis for farmers if they use baler (agriculture implement) rather than burning the crop. Various villagers and farmers have been surveyed for collecting the information about the practices which are followed by farmers starting from harvesting of crop to managing the crop residue.
Findings: In north India, Punjab is ranked first in rice production. Punjab is also ahead in CRB and spreading air pollution. The most affected areas are cities of Haryana state, Punjab state, Delhi (Capital of India) and nearby region. In this paper we have calculated the cost of baling the residue of rice (rather than burning), and found that balling is a profitable affaire and can decrease the level of pollution also.
Practical Implication: State and centre government can take action for the awareness of farmers and push them for the usage of baler for managing the crop residue. Also usage of crop residue as raw material should increase in industries.
Originality/Value: This research has been done to contribute towards novelty by safe guarding the precious environment for the future generation and reduce the number of diseases caused by air pollution.

Keywords: harvesting, stubble burning, air pollution, health issue, bio mass, energy potential

1. Introduction

India is an agriculture dominated country, where more than half of the population is dependent upon agriculture or allied activities. Worldwide India has second rank in farm output and contributes approximately 15.4% in GDP (gross domestic product) (Kumar, 2013) [35]. Despite of it, India is having good agriculture land and Punjab is the most prominent state in India from agricultural point of view (Singh *et al*., 2008) [45]. Total area of Punjab is 50,362 Km^2 out of which 83% land is used for agriculture purpose (Kumar, 2013) [35]. To fulfil the food requirement of growing Indian population, Indian farmers have to cultivate more and more crops in a short span of time and produce more yields. In north India two main crops are cultivated, one is paddy and another is wheat (Singh *et al*., 2008) [45]. Paddy is largely produced in Punjab under RWS (Rice and wheat system). Seeds of wheat are generally sowed in the month of October in India due to seasonality, the time period between paddy harvesting and sowing wheat seed is only 30-45 days, which is too short (Hegde, 2010). Due to shortage of time between two crops, availability of labour is always paucity, due to high demand and less supply of labour, labourer charges higher prices to cut the yield of rice (Hegde, 2010). To get rid of this labour problem and to decrease the cost of harvesting, now-a-days farmer prefer to harvest their crops by machine (Combine harvester is an agriculture implement used for crop harvesting), which is an easier and comparatively less time consuming (Kumar, 2013; Garg, 2008) [35]. Farmers generally try to complete the work of paddy harvesting, warehousing, packaging, selling and agriculture land preparation before sowing the seeds of wheat. There is one major drawback of harvesting the crops by machine (Combine harvester), that the left over (Residue) is in huge volume in paddy fields in comparison of manual harvesting. In manual harvesting, crops are harvested from the base, on the other hand when combine harvester is used, crops are harvested 50-60 cm. above the ground and left over stubble is huge (Jain *et al*., 2013) [12]. 80-90 percent of paddy crop residue is burnt, which causes a large amount of air pollution and leads to health issues, whereas 40-60 percents of wheat crop residues are used for making fodder for animal food and in some rural area the straw residue of wheat crop is mixed with mud for making mud houses and chulahs (an instrument used for cooking food, made of mud and straw residue of wheat). Hence wheat residue is used for multipurpose but paddy residue is majorly burnt (Singh & Hussain, 2002; Thakur, 2003; Singh *et al*., 2008) [45]. In this paper we have mainly focused on the season after paddy harvesting i.e September to November.
(Umair irfan, nov 25, 2017, in a news in vox. Com (American news and opinion website owned by vox media) United Airlines canceled its flights due to poor air quality in India. Visibility on roads was so bad that cars crashed in a row on highways and trains delayed and canceled. Toxic chemicals and airborne particles have chocked the 19 million residents in Delhi (Capital of India), its like smoking 50 cigarettes a day. Hospitals also reported an increase of 20% in patients due to pollution related diseases. The smog

was so terrible that United States installed air filters in their India based offices for their staff. The Lancet Commission on pollution and health reported 9 million premature deaths had taken place in 2015 due to air pollution, out of which more than 2.5 million are from India. As per WHO survey of 1600 countries worldwide, Delhi is the worst one. In India approximately 1.5 million people kills every year due to air pollution.

1.1 India: as an agricultural country

The main role of agriculture is to fulfil the food requirements of human beings, animals, birds and many more located all over the world. Every country has their traditional and unique food and agriculture values. India is also having a unique crop system, as it is much dependent on monsoon (Kumar, 2013) [35]. Indian Crop season has two sessions one is called as Khariff (this is the crop in which seeds are sowed with the first rain of the monsoon and harvested till the beginning of winter season from June to October, crops are paddy, soybean, bajra, jowar etc.) and another is called as Rabi (this is the crop in which seeds are sowed with the beginning of the winter season and harvested in spring, from October to march, crop ares wheat, oat, maize etc.) (Singh *et al*., 2008) [45]. Rice (Oryza sativa L) and Wheat (Triticum aestivum L) are major demandable crops as food item among Indian population. After green revolution in 1961, a new era has been emerged in Indian agriculture, it has changed the picture of Indian economy, from an importer of agriculture products India became an exporter of agriculture products (Garg, 2008). India ranked as seventh largest exporter in terms of agriculture products. Punjab is one of the best states in terms of land quality, availability of water, weather and many more other aspects of agriculture. The growth rate was reflected through the increase in per hectare production of food grains yield rate (Kumar, 2013) [35].

In India most of the times farming is depends upon monsoon, climate also varies from state to states (Singh & Hussain, 2002) [45]. Crop rotation system is used in farming to maintain the nutrients of soil and provide sufficient amount of water for crops growth (Kumar, 2013) [35]. Rice is a demandable grain in food items in India. Rice or paddy require large amount of water during early stage of plantation. In north India monsoon used to start in the month of July and pre monsoon used to knock in the month of June, this is a best period for sowing paddy seeds, and wheat seeds are sowed in the month of October-November (Benbi *et al*., 2006). To maintain the gap between these two crops, crop rotation is necessary for giving accurate percentage of water and minerals to crop and take large amount of yield. The same strategy for increasing agriculture production is followed in Punjab (Kumar, 2013) [35]. Both the crop requires intensive water and minerals, farmers are required to grow short period crops during two sessions, so that soil nutrients can be maintained. By crop rotation system, an agriculture mechanics can be built up for taking multi crops during a year (Panigrahy *et al*., 1997).

1.2 Punjab: An introduction

Punjab's land is considered as one of the most fertile region on earth. Punjab is famously called as "Granary of India" or "India's propagate basket in agriculture" (Kumar, 2013) [35]. It produces 20% of wheat and 9% of rice among the total production of rice and wheat in India (Singh *et al*., 2008) [45]. Punjab is the creamiest layer of India in terms of agriculture. It contributes not only at national level in production of food grains, but also plays a vital role in export to international countries (Garg, 2008). Punjab is 2nd in rice production worldwide after Thailand (Yang at. el., 2008) [55]. According to Gross State Domestic Product 2010-2011 agriculture sector is important sector in term of state employment and economic growth, as it contributes 22% in state GDP. Earlier, traditional system of farming were used, which were majorly depends upon natural sources like rain, manual harvesting etc., but now a day's agriculture done by new and innovative technology, having low risk of production loss and high agriculture income. Application of appropriate technology and polices of government helps to increase the agriculture production (Ruby at.el., 2015).

Crop rotation cycle runs properly only when both the crops of Khariff and Rabi are sowed and harvested on appropriate time. Due to Shortage of time between Kharif harvesting and Rabi seed sowing, farmers give priority to burn stubble of rice rather than disposing off in an environmental friendly way (Sidhu & Beri, 2005; Mandal, 2004). Biomass burning is common globally to dispose off the agriculture waste and it has adverse effect on the air quality and increase the health hazards worldwide (Yang *et al*., 2008) [11]. Paddy wastage (stubbles) mainly burnt after the harvesting period of crop during the period of October-November each year in Indo-Gangetic Pains(IGP- is a 630 million acre plain fertile land in northern region of Indian subcontinent), which has shown astonishing impact of greenhouse gases, which are produced by burning of crops (Badarinath *et al*., 2009a). As per estimation the burning of stubble of rice produced by Punjab is approximately 20 Million tonnes. (Mukherjee, 2016)

2. Review of selected literature

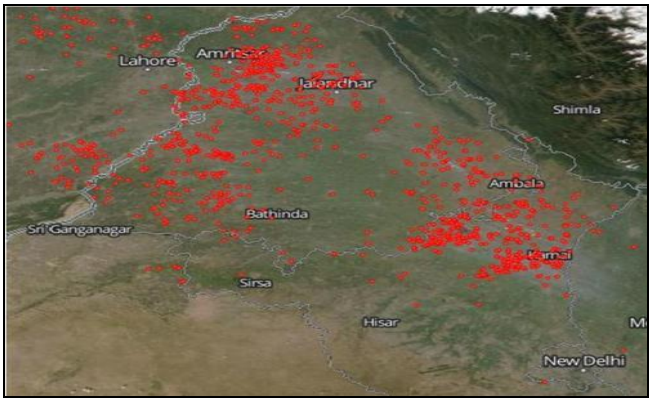
Burning of biomass has a significant impact on atmosphere, various poisonous gases are released in the air and thin particles create a thick layer in the environment. Due to this thick layer of particles, sun rays are not properly reached to earth and particles remain in the air (Venkataraman *et al.*, 2006; Sahai *et al.*, 2007). These thin particles enter in human body at the time of breathing and became the reason of lot many diseases. During the burning phase of crop residue, the emission of suspended particulate and greenhouse gases like compound of carbon, Carbon Monoxide (CO), Methane (CH_4), Nitrogen, Dinitrogen oxide (N_2O) hydrocarbon and sulphur Dioxide (SO_2) increases (Yevich and logan, 2003; Kumar, 2013) [35]. Hence, from last one decade this problem is becoming a gigantic issue for the Indian environmentalists (Badrinath *et al*., 2006, Singh *et al*., 2008) [45]. In overall India, Punjab solely contributes 20 million tonnes of paddy straw wastage (Kumar, 2013) [35]. Wheat straw is mostly used for cattle feed, whereas paddy straw cannot used for this purpose because of large silica content in it (Jain *et al*., 2013) [12]. As per the air quality records the burning content of farm wastage is increasing every year. Collection and utilization of paddy straw is a costly and time consuming affaire in comparison to burn the residue, and farmers generally opt for the easiest option (ENVIS Centre: Punjab Status of Environment & Related Issues; Gadde, 2009; Kumar, 2013) [19, 35]. These burning residues of crop create pollution in air. By the Air Pollution control Act, 1981- any substance it may be solid, liquid, gas or even noise present in

concentration harms to living organism or property of environment mainly called "Air Pollutants" (Ruby at. El., 2015). The WHO threshold for safe air is 25 micrograms per cubic meter of suspended particles, as per table no. 1 it has been showed that the level of particulates in the air per cubic meter. In none of the month the level of particulate is less than the approved limit. In the month of September to December the level was the highest, in fact in the season of CRB i.e. October-November the average level of PM is approximately 9-10 times of the safe level of PM. The maximum level shows that in the month of October-November it is upto 35-40 times of the safe level.

Table 1: Particulate air pollution in Delhi during 2015

Months	Average PM microgram µg/m³	Maximum PM maximum µg/m³
January	71	381
February	62	252
March	74	395
April	55	283
May	33	239
June	33	122
July	50	167
August	105	433
September	236	976
October	249	552
November	184	457
December	139	402

***Source*:** Journal of environment pollution and human health, 2016, 4(2), pp 24-41



***Source*:** NASA image depicting fires on agricultural lands in Punjab and Haryana, on October 11, 2016

Fig 1: Area of paddy stubble burning in Punjab.

The images shown in fig.1 delineates the scale of fire in Punjab and Haryana, image recorded by NASA in October, 2016. Each red dot represent the fire area on farmland, it can be easily detected by remote sensing technology. Kharif harvesting session is main spot area of fire on land. According to Punjab government health related issues due to air pollution in rural area are approximately 76.09 million annually (Ruby *et al*., 2015). According to expert's new technique are formed for straw management. Government take action against farmers if they find fire in their fields, approximately Rupees 1500-2000 is fined on per hectare land and jail for 6 months (Agriculture policy of Punjab, 2013). Government provide subsidies to purchase instruments and machines for stubble cutting, also run programs like workshop, seminars and holding camp to create awareness among the farmers, that how to resolve the issue of crop residue, still the utilization of residue is too low among the farmers. Government use social media for awaking the farmer to protect environment from CRB.

Stubble burning demonstrates various 'on the field' and 'off the field' impacts and raise social economic issue also (Kumar, 2013) [35]. Due to stubble burring, on the field impacts causes loss of soil neutrality. During crop cultivation plants absorb organic nutrients from the soil but the burning of crop residue soil losses its macronutrients like NPK (Nitrogen, Phosphorus, Potassium) (Ruby *et al*., 2015), also the micronutrients are released in the air and creates a thick layer of smog in the atmosphere (Garg, 2008). The off field effect of stubble burning cause degradation of atmosphere and living organism health (Mandal, 2004). During this period air quality degrades, as harmful gases are released in the air. Human being faces lot many health related problems like lungs, eyes and skin disease, also having adverse effect on working capacity of human being (Sidhu & Beri, 2005). In table no.2 it has been showed that India is on second number in terms of death rate due to air pollution after China. India is one of the most polluted country in the world (*The Times of India, 9 sep. 2016*).

Table 2: countries with highest death due to air pollution in 2013

Countries	No. of people killed due to air pollution
China	16,25,164
India	14,03,136
Bangladesh	1,54,898
Pakistan	1,56,191
Ukraine	49,078
Combodia	19,595

***Source*:** The Times of India, 9 sep. 2016

Although Bathinda, Mansa and Sangrur has showed decline in CRB on yearly basis. Farmers are becoming more aware about the increasing level of pollution and health issues arising due to burning of crop residue. But still it is an area of major concern, because the rate of decline is not that considerable which can improve the air quality. Table 3 represents the data of 2014 and 2015, the area burn in these three districts, which shows a decrease. In Punjab, Sangrur is one district which had highest rate of crop residue burn. Now a days from year 2014 to 2015 the rate of CRB has been reduced by approximately 11%, rest two districts also shows that there is a decrease in the residue burning area, in Bathinda. Government run Programme like Rashtriya Krishi Vikas Yojna, under it farmers have to pay fine Rs 1,000 per acre if they are burn their field crop residue. By this the percentages of burning field decrease every year.

Table 3: District wise distribution of area burnt in Punjab in 2014 and 2015 (Area is in hectare)

District	Burnt Area in 2014	Burnt Area in 2015	Change in burnt area 2014-2015	% of burnt area changed with respect to 2014
Bathinda	98.31	77.49	-20.82	-21.17
Mansa	59.79	41.88	-17.91	-29.96
Sangrur	227.21	202.83	-24.38	-10.73

***Source*:** Kaur & Rani 2016

2.1 Problem statement

A developing country like India, where the infrastructure, technology, modernisation and many other things are in

developing stage neither they are in backward stage nor in fully developed stage, due to this intermediate stage of development a lot many problems are faced and air pollution is one of them, which is very critical form the aspect of human health. Due to development, this kind of pollution is spreading and we do not have advanced technologies to cope up with these kind of situations. Generally probability of fire in farmlands began in the starting phase of October month (panigrahy & Sharma, 1997). Paddy stubble burning results are more injurious to human beings and environment as compared to other crop residue. Now- a- days the burning probability of paddy wastage is 80% and wheat straw having more than 50% (panigrahy & Sharma, 1997). Burning of farm wastage stubble stimulate macronutrients (which are absorbed by crops from the soil during their growing phase) in the atmosphere. Stubble contains N (Nitrogen 25%), P (Phosphorus 25%) and K (Potassium 75%), after burning of crop residue it creates harmful compounds, which are released in atmosphere and make the air quality poisonous. on the other hand burning of crop residue also degrade the land quality. 1 ton burning of stubble approximately forfeits 5.5 Kg N (Nitrogen), 2.3 Kg P (Phosphorus), 1.2 Kg S (Sulphur), 25 Kg Potassium oxide, and 400 Kg. of organic carbon(Hindustan Times, 12 September 2018; Streets et.al., 2003). the percentage of these nutrients may vary on the basis of type of crop residue and land quality.

During this period visibility on road are also very low and it become a main cause of accidents (Yang at. El, 2008) [11]. As per Delhi (Capital of India) high court, the air quality of Delhi and nearby state degrading day by day and directly point out Punjab and Haryana government for this. They said rice straw burning is the main cause of degradation of Air Quality of Delhi (Press Trust of India, 2015). Ground reports suggests, that the two state governments are working on this but the major challenges lie in the viable alternative solution to get rid of paddy residue in short period of time and with cost effective mechanism. Burning of farm wastage penetrates some moisture and microbes in the soil which directly hits the properties of soil. In this paper we have done a cost-benefit analysis for the farmers, if they did not burn the CRB and use baler to manage the paddy residue.

3. Research methodology

3.1 Statement of Objective:

Due to increasing level of air pollution in the month of September to November, it become a big concern for the authorities and for the residents. The main reason of pollution is CRB, in the above mentioned months in neighbouring states. Poisonous air quality posing a threat for the health of the human beings. The main aim of this paper is to documents the CRB practices and provide the solution of this problem by the use of baler.

1. To document the current practices of crop burning
2. To provide cost-benefit analysis if farmers use baler method for managing rice residue

3.2 Study Area

For this paper both primary and secondary data is collected. Primary data is mainly collected by the survey of villagers and rural area respondents, majorly three district of Punjab state i.e. Bathinda, Mansa and Sangrur has been covered for this study, as these cities have larger area under RWS production. This paper represents that how much pollution is emitted by stubble burning of crops, major problems arises by the burning of rice crop residue. Here government of India needs to play a major role to stops the burning of crops residue, to protect the environment.

Bathinda. Bathinda is located in South West region of Punjab and is a part of the Indo-gangetic alluvial plains. Climate of bathinda is semi-arid, having variation between summer and winter temperature. In North India bathinda is the largest food grain producer for rice and wheat (Bhattacharya & neel, 2017). Figure no. 2 delineates the fire in one of the field in Bhatinda.

***Source*:** Photo clicked by researcher on September 25, 2018 at 7.45pm

Fig 2: Road side view of Wheat stubbles burn at Gulabghar distt. Bathinda

Mansa: Wheat and rice are cultivated in Mansa. The most import thing about Mansa, that it is the home of the largest thermal power plant of Punjab i.e. called as TSPL. TSPL (Talwandi sabo power plant) produced 1980(3×660) Mega Watt electricity which makes Punjab self-independent in terms of energy resources. Figure no. 3 shows the fire in one of the farm in Mansa.

***Source*:** Photo clicked by researcher on September26, 2018 at 8.00 pm.

Fig 3: Road site view of Wheat stubble burn at village Gurne Khurd distt. Mansa

Sangrur: In Sangrur most famous cultivation crop is rice. One of the most branded rice of India i.e. India gate basmati rice is produced, sold and exported from sangrur only.

3.3 Information collection

Field study has been adopted for this paper, personal observation method has been used to collect the information in three agriculture dominated districts (Bathinda, Mansa and Sangrur) of Punjab state. Punjab government give subsidy to farmers for purchasing agricultural implements, to reduce agriculture farm waste. Still the purchase of these kind of machines by farmers is too low. Baler is one such kind of agriculture implement used for baling crop residues.

In this paper researcher has done a profit and cost analysis for farmers if they use baler rather than burning the crop. Various villagers and farmers have been surveyed for collecting the information about the practices which are followed by farmers starting from harvesting of crop to managing the crop residue. Also information is collected about the costing of various implements used after harvesting for the purpose of balling of crop residue. On the basis of price information cost-benefit analysis has been done by the researcher.

4. Cost-benefit analysis

4.1 Implements used in harvesting and baling

Combine harvester is an agriculture implement used to harvest the crop, but as mentioned above it cut the crop 50-60cm above the ground (Refer figure 4).

***Source*:** https://teara.govt.nz/en/photograph/18401/combine-harvester-at-work

Fig 4: Image of Combine Harvester

Cutter is used to cut the crop residue (Straw) which is left by combine harvester. (Refer figure 5)

***Source*:** https://www.google.com

Fig 5: Image of Cutter

Rake is a farm implement, used to collect the crop straw in sequenced row. (Refer figure 6)

***Source*:** https://en.wiktionary.org/wiki/rake

Fig 6: Image of Rake

Baler is a farm machinery used to compress the raked crop into compact bales (square or circle) easy to transport to industries. (Refer figure 7)

***Source*:** https://energyresources24.com/global-agriculture-and-livestock-baler-market-2018-john-deere-american-baler-co-international-baler-mchale/1388/

Fig 7: Image of Baler

4.2 Profit and Cost analysis of using Baler

The cost and profit analysis included the estimation of cost of baling and transporting the baled material to the industries, it included cost of agriculture implements, diesel expense, manpower expense, rope cost and transportation cost.

Production of Baled material

A baler can produce 5 tons of baled material in 1 hour, hence if a baler works for 15 hours a day then one day production will be 15*5 = 75 tons. If we run the baler for 45 days then the total baled production will be 75*45 = 3,375 tons baled material.

Cost of agriculture equipments

Combine harvester: the cost of combine harvester is not included in the calculation as whether farmer bale the crop or burn the same they have to harvest the same, hence cost of harvester is not included.

Tractor: cost of tractor is also not included, as for agriculture it is suppose that farmers generally have tractor, so it is not an additional requirement for baling residue, only the maintenance cost of tractor has been included in final calculation.

Cutter: cutter is an agriculture implement used to cut the crop residue and its cost is around 30,000 Rs.

Raker: The average cost of a raker is approximately 3.5 lac Rs., and government provides 50% subsidy on this implement, hence the cost of raker will be 1,75,000 Rs. after deducting subsidy. It also attracts maintenance cost of Rs. 15,000, hence total cost would be 1, 90,000 Rs.

Baler: The average cost of a Baler is approximately 14 lac Rs., and government provides 80% subsidy on this implement, hence the cost of baler will be 2,80,000 Rs. after deducting subsidy. It also attracts maintenance cost of Rs. 40,000, hence total cost would be 3, 20,000 Rs.

Diesel Expenses

For running a baler, a tractor of 50-55 HP (Horse power)

requires 5 liter of diesel every hour, hence diesel requirement would be 15*5 = 75 Ltr. For a day. For a raker, a tractor of 30-35 HP is required, and the diesel requirement is 2.5 liter every hour. If a baler and raker works for 15 hours a day then total diesel consumption will be 15 x 7.5 = 112.5 Ltr. The price of diesel is approximately 65 rupees/liter. Hence the per day diesel cost would be 112.5 x 65 Rs. = Rs 7,312.5. Hence total cost of diesel for 45 days would be 7,312.5*45 = 3, 29,062.5

Manpower expense

For operating a raker 2 operators are required, whom 11,000 Rs. is paid to each of the operator, hence total cost of rake operator would be 22,000 Rs. For running a baler, 2 operator required to whom 22,500 Rs. is paid to each operator, hence total cost of baler operator would be 22,500*2= 45,000. In all these operations one helper is also required which cost around 10,000 Rs. For full season. Hence the total expense of manpower would be 22,000+ 45,000 + 10,000 = 77,000 Rs.

Rope expense

-For 1 ton baled material 800 gm rope is required. Rope price is Rs. 150/Kg. For a total production of baled material of 3,375 tone, 2,700kg (3,375*800/1,000) rope is required and total cost would be 2,700*150 = 4,05,000 Rs.

Transportation cost

As per the field study we came to know that the cost of transportation would be Rs.300 per ton. Hence for 3,375 tons of material it will be 3,375*300 = 10, 12,500 Rs.

Selling Price

Again as per the field study we came to know that a tone of baled material can be sold at Rs. 1,400/ton, hence the total price which framers can get out of their baled material is 3,375*1,400 = 47,25,000 Rs.

Table 4: Profit and cost analysis

Type of expense	Final Cost
Cost of agriculture equipments	
Combine Harvester	Nil
Tractor	Nil
Tractor Maintenance cost	6,000
Baler cost is 1400000 (80% subsidy) (www.khetigaadi.com)	2,80,000
Baler maintenance cost	40,000
Rake cost is 350000 (50% subsidy) (www.khetigaadi.com)	1,75,000
Rake maintenance cost	15,000
Cutter cost is 30000 (www.khetigaadi.com)	30,000
Manpower Costing	
Baler Operator, per person cost 22500 (2 Nos.), hence 22500*2	45,000
Rake Operator, per person cost 11000 (2 Nos.), hence 11000*2	22,000
Helper, per person cost 10000 (1 Nos.)	10,000
Diesel cost	
For Baler 50-55 HP tractor (consumption 5 Lt. /hour* cost of diesel 65Rs. /Liter* No. Of days), hence 5*15*65*45	2,19,375
For Raker 30-35 HP tractor (Consumption 2.5 Lt. /hour* cost of diesel 65Rs. /Liter* No. Of days)	1,09,687.5
Rope costing	
For 1 ton material 800 gm rope is required (Rs. 150 per Kg.), hence 3375 ton* 800/1000= 2700Kg, 2700*150=405000	4,05,000
Transportation cost	
Rs. 300 per ton material, hence 3375*300	10,12,500
Total Expense of Baling (A)	23,69,562.5 Rs.
Selling price (1400 Rs. per ton), hence 3375*1400 (B)	47,25,000 Rs.
Profit/Loss (B-A) (47,25,000-25,29,712.5)	23,55,437.5 Rs.

5. Interpretation and Discussion

No doubt disposing the crop residue by baler method is time taking and require manpower, but it's one of the best practices which can be applied to earn profit and reduce the air pollution. By the above calculation it is clear a huge profit can be earned, if the implements are used wisely and collectively by a group of farmers. By the use of balers pollution can be controlled, in which biomass can be used as a source of bio fuel. Biomass of agriculture waste further goes to power plant and paper industries, where it can be used as raw material.

Talwandi sabo power plant, located in Mansa (a district of Punjab) uses this kind of bio fuel, which is transported from nearby district. The bio waste is used as a raw material in this electricity plant and supplied 1980 Mega Watt electricity to Punjab state.

For this study data has been collected by the researchers, by Using personal observation and survey method.

The straw balers are prominent over manual collection of crop residues. Annual availability of crop residue in India is 523.4 Metric Ton, out of which 127.3 Metric Ton has being burnt, which creates huge amount of poisonous air. The stubble left behind by the combine harvesters is raked and baled to reduce the transportation, handling and storage costs. These bales offers a cost effective mean of power generation by controlled burning at biomass-based power plants. Besides producing power it also provides a solution against SMOG caused by burning of crop stubble. This process offers an extra income to farmers and preserves the essential nutrients of soil. Biomass based power generation produce decentralized power, which reduces transmission loss due to wide variety of crop residue available throughout the country.

SMOG SCENARIO– *Biomass burning*

Figure-8(a) Paddy Harvesting | 8(b) Crop residue by Using combine | 8(c) CRB (Crop residue burning) | 8(d) SMOG

Fig 8: depicts how the smog is created and released in the air.

Baling Scenario

Figure- 9(a) Combine Harvesting, 9(b) Crop residue by using combine, 9(c) using raker for collection of residue, 9(d) using baler, 9(e) Baled residue, 9(f) baled material used in electricity plants

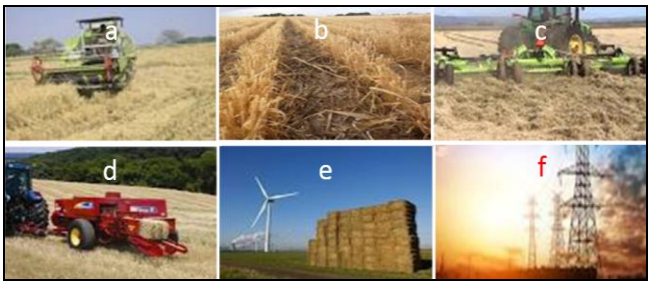


Fig 9: represents crop stubble can be used for producing energy in power plants.

More than 10% of the Power shortage problem can be mitigated by the power generation from surplus biomass in India (Agriculture Policy of Punjab, 2013). By this balers techniques Air Quality index of Punjab can be improved. Government run programs for farmers to known new techniques in farming. Farmer also shows interest in it because it gives extra income to farmers. Industries needs to come forward to take part in protecting our environment by purchase biomass of agricultural waste. This biomass is mainly used to generate electricity and in some paper mill. By this we can also save our non-renewable resources which generally used as a raw material in industries to generate electricity (like coal). Earlier in paper mills, plant stems are used as raw material to make paper but with the generation of idea of using paddy residue as raw material, the use of plants has been reduced and also helps in saving our ecological balance and protects the environment. Even Farmers are need not to purchase baling equipments like cutter, baler and rake, as some industries have their own agriculture implements and they provide these implements to farmers on rent or ask famers to sell there baled material to them (industries who provide implements), so that baled material can be used as raw material. This idea proves as a win-win situation for all, farmer, industries and environment.

6. Conclusion

After green revolution agriculture growth has been expedited. Due to seasonality and dependence on monsoon, mainly two type of crops are cultivated in India. With the start of winter season paddy crop is harvested and wheat crop is sowed, due to crunch of time there is always a huge demand of labours. To tackle the problem of labour crunch, farmers have started harvesting the paddy crop by the use of machines (combine harvester) from last two decade. By the use of machinery in harvesting huge amount of crop residue remains in the fields, to handle this residue quickly and easily farmers started to burn the residue and this has become a major reason of worst air quality, sometimes the PM level goes up to 20 times in the air from the permissible limit. Hence government of India and industries come forward and started various programmes to spread awareness among the farmers, that how to deal with huge crop residue and what are the adverse effect of CRB. Government provides various kind of subsidy, so that farmers can purchase the agriculture implements to deal with crop residue. Even Industries are coming forward, they purchase the implements like baler, cutter, raker and provide the same to the farmers so that CRB can be stopped and bio waste material can be used in the industries. Mechanisation in collection of straw and baling contributes reduction in greenhouse gases.

Crop wastage is generally used in power plants and paper mills, but there is urgent need to develop mechanism so that this kind of raw material can be used in more industries. Converting bio wastage of crops in to different types of bio-energy will rise the economy growth of country by generating an another source of clean energy and reduce the air pollution.

Data provided by Punjab government showed a drop of 37,602 cases of CRB post the paddy harvest between 2016 and 2017. There were 80,879 cases of CRB in 2016 and 43,817 in 2017. In years ahead it can be expected that the cases of CRB will reduce and gradually all the farmers will start disposing the crop wastage in environmental friendly manner. In fact Punjab government is very particular about the farmers who burnt their farms and fined them heavily (Hindustan times, Delhi, 13th sep 2018)

7. References

1. Abrol IP, Bronson KF, Duxbury JM, Gupta RK. Analysis of long-term soil fertility experiments in rice-wheat crop-ping systems. Rice-Wheat Consortium Paper Series 6. RWC and CIMMYT, New Delhi, India, 2000.
2. Andreae MO. Biomass burning: Its history, use, and distribution and its impact on environmental quality and global climate. In: Levine, J.S. (Ed.), Global Biomass Burning, Atmospheric, Climatic, and Biospheric Implications. MIT Press, Cambridge, MA, 1991, pp. 3-21.
3. Andreae MO, Merlet P. Emission of Trace Gases and Aerosols from Biomass Burning. Global Biogeochem. Cycles. 2001; 15:955-966.
4. Bacon PE, Cooper JL. Effect of rice stubble and fertil-izer management on wheat growth after rice. Field Crops Res. 1985a; 10:229-240.

5. Badarinath KVS, Kiran Chand TR, Krishna Prasad V. Agriculture Crop Residue Burning In The Indo-Gangetic Plains: A Study Using IRS-P6 Awifs Satellite Data. Curr. Sci. 2006; 91:1085-1089.
6. Badarinath KVS, Kharol SK, Sharma AR. Long-range transport of aerosols from agriculture crop residue burning in Indo-Gangetic Plains—A study using LIDAR, ground measurements and satellite data, J Atmos. Sol. Terr. Phys. 2009; 71:112-120.
7. Battle M, Bender M, Sowers T, Tans PP, Butler JH, Elkins JW. *et al*. Atmospheric gas concentrations over the past century measured in air from fin at the south pole. Nature. 1996; 383:231-235.
8. Cao GL, Zhang XY, Wang YQ, Zheng FC. Estimation of Emissions from Field Burning of Crop Straw in China. Chin. Sci. Bull. 2008; 53:784-790.
9. Dhammapala R, Claiborn C, Corkill J, Gullett B. Particulate emissions from wheat and Kentucky bluegrass stubble burning in eastern Washington and northern Idaho. Atmospheric Environment. 2006; 40:1007-1015.
10. Dormaar JF, Carefoot JM. Implications of crop residue management and conservation tillage on soil organic matter. Can. J Plant Sci. 1996; 76:627-634.
11. Duan F, Liu X, Yu T, Cachier H. Identification and estimate of biomass burning contribution to the urban aerosol organic carbon concentrations in Beijing. Atmospheric Environment. 2004; 38:1275-1282.
12. Emission of Air Pollutants from Crop Residue Burning in India by Niveta Jain*, Arti Bhatia, Himanshu Pathak (Centrefor Environment Science and Climate Resilient Agriculture, Indian Agricultural Research Institute, New Delhi- 110012, India).
13. Gadde B, Menke C, Wassmann R. Possible energy utilization of rice straw in Thailand: seasonal and spatial variations in straw availability as well as potential reduction in greenhouse gas emissions. In: GMSARN International Conference on Sustainable Development: Challenges and Opportunities for GMS. GMSARN Secretariat, AIT, Pattaya, Thailand, 2007.
14. Gadde B, Bonnet S, Menke C, Garivait S. Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines, Environ. Pollut. 2009; 157:1554-1558.
15. Gadde B, Christoph MC, Wassmann R. Rice Straw as a Renewable Energy Source in India, Thailand, and the Philippines: Overall Potential and Limitations for Energy Contribution and Greenhouse Gas Mitigation. Biomass Bioenergy. 2009; 33:1532-1546.
16. Gupta RK, Narsh RK, Hobbs PR, Jiaguo Z, Ladha JK. Sustainability of Post-green Revolution Agriculture: The Rice-wheat Cropping Systems of the Indo-Gangetic Plains and China- Improving the Productivity and Sustainability of Rice-wheat Systems: Issues and Impact, ASA Special Publication, Wisconsin USA, 2003, 65.
17. Gupta PK, Sahai S, Singh N, Dixit CK, Singh DP, Sharma C. *et al*. Residue burning in rice–wheat cropping system: causes and implications. Current Science. 2004; 87:1713-1717.
18. Hays MD, Fine PM, Geron CD, Kleeman MJ, Gullett, BK. Open burning of agricultural biomass: physical and chemical properties of particle-phase emissions. Atmospheric Environment. 2005; 39:6747-6764.
19. Hrynchuk L. Rice straw diversion plan. In: McGuire, Terry (Ed.). California Air Resources Board, California, 1998, p. 23.
20. Indian standard methods for measurement of air pollution.
21. IS. 5182 (Part VI), Nitrogen oxides, Indian standard methods for measurement of air pollution, 1974.
22. IS 5182 (Part XIV), Guidelines for planning the sampling of atmosphere, 1974.
23. Jain Niveta, Bhatia Arti, Pathak Himanshu. Emission of Air Pollutants from Crop Residue Burning in India. Aerosol and Air Quality Research. 2014; 14:422-430.
24. Jenkins BM, Bhatnagar AP. On the electric power potential from paddy straw in the Punjab and the optimal size of the power generation station. Bio resource Technology. 1991; 37:35-41.
25. Korenaga T, Liu X, Huang Z. The influence of moisture content on polycyclic aromatic hydrocarbons emission during rice straw burning. Chemosphere –Global Change Science. 2001; 3:117-122.
26. Koppmann R, Czapiewski KV, Reid JS. A review of biomass burning emissions, part I: gaseous emissions of carbon monoxide, methane, volatile organic compounds, and nitrogen containing compounds. Atmospheric Chemistry and Physics Discussions. 2005; 5:10455-10516.
27. Lemieux PM, Lutes CC, Santoianni DA. Emissions of organic air toxics from open burning: a comprehensive review. Progress in Energy and Combustion Science. 2004; 30(1):1-32.
28. Li X, Wang S, Duan LJ, Li Hao C, Chen Y, Yang L. *et al*. Particulate and trace gas emissions from open burning of wheat straw and corn stover in China. Environmental Science & Technology. 2007; 41:6052-6058.
29. Mehta H. Bioconversion of Different Wastes for Energy Options, Sardar Patel Renewable Energy Research Institute Vallabh Vidyanagar, ppt, 2004.
30. Mittal SK, Susheel K, Singh N, Agarwal R, Awasthi A, Gupta PK. Ambient Air Quality during Wheat and Rice Crop Stubble Burning Episodes in Patiala. Atmos. Environ. 2009; 43:238-244.
31. Mohanraj R, Azeez PA. Health effects of airborne particulate matter and the Indian scenario. Current Science. 2004; 87(6):741-748.
32. Nguyen BC, Putaud JP, Mihalopoulos N, Bonsang B. CH4 and CO emissions from rice straw burning in South East Asia. Environmental Monitoring & Assessment. 1994; 31:131-137.
33. Ogawa M, Yoshida N. Nitrous oxide emission from the burning of agricultural residue. Atmospheric Environment. 2005; 39:3421-3429.
34. Oppenheimer C, Tsanev VI, Allen AG, Mcgonigle Andrew JS, Cardoso Arnaldo A, Wiatr A. *et al*. Paterlini W, Dias Cristine de Mello. NO2 emissions from agricultural burning in Sao Paulo, Brazil. Environmental Science & Technology. 2004; 38:4557-4561.
35. Pandey JS, Kumar R, Devotta S. Health risks of NO2, SPM and SO2 in Delhi (India). Atmospheric Environment. 2005; 39(36):6868-6874.
36. Pathak BS. Crop Residue to Energy, In Environment and Agriculture, Chadha, K.L. and Swaminathan, M.S. (Eds.), Malhotra Publishing House, New Delhi, 2006,

p. 854-869.
37. Pathak H, Singh R, Bhatia A, Jain N. Recycling of Rice Straw to Improve Wheat Yield and Soil Fertility and Reduce Atmospheric Pollution. Paddy Water Environ. 2006; 4:111-117.
38. Powel JM, Unger PW. Alternatives to crop residues as soil amendments. In: Renard, C. (Ed.) Crop residues in sustainable mixed crop/livestock farming systems. ICRISAT, India and ILRI, Kenya. 1997, p. 215-239.
39. Punia M, Nautiyal VP, Kant Y. Identifying biomass burned patches of agriculture residue using satellite remote sensing data. Current Science. 2008; 94(9):1185-1190.
40. Roetter RP, Kalra N, Van Keulen H, Hoanh CT, Van Laar HH. (Eds.), Indian Agricultural Research Institute, New Delhi, India, & International Rice Research Institute, Los Banos, Wagningen University and Research Centre, Wagningen, 2008, p. 161-189.
41. RWC-CIMMYT. Addressing Resource Conservation Issues in Rice-Wheat Systems of South Asia: A Resource Book. Rice-Wheat Consortium for the Indo-Gangetic Plains-International Maize and Wheat Improvement Centre, New Delhi, India.
42. Sahai S, Sharma C, Singh DP, Dixit CK, Singh N, Sharma P. *et al*. A study for development of emission factors for trace gases and carbonaceous particulate species from in situ burning of wheat straw in agricultural fields in India. Atmospheric Environment. 2007; 41(39):9173-9186.
43. Schwartz J. Particulate air pollution and chronic respiratory disease. Environmental Research. 1993; 62(1):7-13.
44. Sharma MP, Bali SV. Effect of rice residue manage-ment in wheat yield and soil properties in rice-wheat cropping sys-tem. Indian J Agric. Sci. 1998; 68:695-696.
45. Singh Y, Singh D, Tripathi RP. Crop residue managementin rice–wheat cropping system. In: Abstracts of Poster Sessions. Second International Crop Science Congress. National Academy of Agricultural Sciences, New Delhi, India, 1996, p 43.
46. Singh Y, Singh B. Efficient Management of Primary Nutrients in the Rice-Wheat System. In: Kataki, P.K. (Ed.). The Rice-Wheat Cropping Systems of South Asia: Efficient Production Management. Food Products Press, New York, USA, 2001, pp. 23-85.
47. Staniforth AR. Straw for fuel, feed and fertilizer? Farming Press, Ipswich, England, 1982.
48. Streets DG. Yarber KF, Woo JH, Carmichael GR. Biomass burning in Asia: annual and seasonal estimates and atmospheric emissions. Global Biogeochemical Cycles. 2003; 17(4):1099-1118
49. Turn SQ, Jenkins BM, Chow JC, Pritchett LC, Campbell D, Cahill T. *et al*. Elemental characterization of particulate matter emitted from biomass burning: wind tunnel derived source profiles for herbaceous and wood fuels. Journal of Geophysical Research. 1997; 102(D3):3683-3699.
50. US EPA. Emission Factor: Documentation for AP-42, Open Burning. In: Office of Air Quality Planning and Standards and Office of Air and Radiation (Ed.), AP-42 Database. U.S. Environmental Protection Agency, North Carolina, 1992, p. 34.
51. Venkataraman C, Habib G, Kadamba D, Shrivastava M, Leon JF, Crouzille B. *et al*. Emissions from Open Biomass Burning in India: Integrating the Inventory Approach with Higher Solution Moderate Resolution Imaging Spectroradiometer (MODIS) Active Fire and Land Count Data. Global Biogeochem. Cycles 20: GB2013–20, 2006.
52. Verma TS, Bhagat RM. Impact of rice straw management practices on yield, nitrogen uptake and soil properties in a wheat rice rotation in northern India. Fert Res. 1992; 33:97-106
53. Walia SS, Brar SS, Kler DS. Effect of management of crop residues on soil properties in rice–wheat cropping system. Env-iron Ecol. 1995; 13:503-507.
54. Wang Q, Shao M, Liua Y, William K, Paul G, Lia X. *et al*. Impact of Biomass Burning on urban Air Quality Estimated by Organic Tracers: Guangzhou and Beijing as Cases. Atmos. Environ. 2007; 41:8380-8390.
55. Yang S, He H, Lu S, Chen D, Zhu J. Quantification of crop residue burning in the field and its influence on ambient air quality in Suqian, China. Atmospheric Environment. 2008; 42(9):1961-1969.
56. Yevich R, Logan JA. An Assessment of Biofuels use and Burning of Agricultural Waste in the Developing World. Global Biogeochem. Cycles, 2003, 17. Doi: 10.1029/2002GB001952.
57. Yoshinori M, Kanno T. Emission of trace gases resulting from rice straw burning. Soil Sci Plant Nutr. 1997; 43:849-854.
58. Zhang H, Hu D, Chen J, Ye X, Wang SX, Hao J. *et al*. Particle Size Distribution and Polycyclic Aromatic Hydrocarbons Emissions from Agricultural Crop Residue Burning. Environ. Sci. Technol. 2011; 45:5477-5482
59. www.khetigaadi.com, (Cost of all the agriculture implements (New Holland Company brand), accessed on 20/2/2019
60. https://www.vox.com/energy-and-environment/2017/11/22/16666808/india-air-pollution-new-delhi accesed on 18 march 2019