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Recycling of Rice Straw to Form Pulp in Order to Prevent Rice Straw Burning

Sarthak Panwar[1*], Khushi Panwar[2]
[1,2]*Student, New Delhi, India*

***Abstract*: Approximately 39 million tons of rice straw are burnt annually by Indian farmers, as there is no economically viable alternative for its waste disposal. Due to its low bulk density and high volume, the fastest, easiest, and most cost-effective solution is to simply burn it. However, as this causes large emissions of greenhouse gases (methane and nitrous oxide), rice straw burning is an extremely dangerous procedure. Not only does it pollute the environment- giving rise to smog in urban settlements- and cause global warming, but it also induces respiratory illnesses such as bronchitis and asthma. For these reasons, the Indian government had made it illegal to burn rice straw (and other residues). Farmers face the threat of fines and "red entries"- marks on their records that make it difficult to get loans or subsidiaries. According to government regulations, deploying combine harvesters without the installation of the Super Straw Management System (SMS). These rules are difficult to adhere to for small farmers with less capital as they cannot afford the SMS. Hence, we propose a different solution. Using rice straw to make pulp (which is further bleached to make paper), farmers have a convenient method of waste disposal, as well as, an additional source of income. The procedure detailed in this paper uses easily accessible materials and requires minimal effort.**

***Keywords*: Methane, nitrous oxide, rice straw, global warming, respiratory illness, bronchitis, asthma.**

1. Introduction

Annually, 104.8 million tons of rice are grown in India. Approximately 23% of all agricultural residue in India is rice straw.[1] Farming requires approximately 43.86 million hectares of land, 90% of which is owned by Marginal, Small, or medium farmers (based on land ownership). This contributes to the relatively low production value of 2390 kg/ha of Indian paddy farming. Compared to countries such as China which boasts productivity of 6710 kg/ha or Vietnam with 5573 kg/ha, India is far behind ineffective utilization of land and technology. [2]

A prevalent and harmful procedure used by Indian paddy farmers is rice straw burning. During the harvesting process, the rice grains are separated from the rice straw. This leaves the rice straw either scattered on the field or piled up, depending on the method of harvest (manual or machine). The ratio of the waste rice straw to the actually valuable rice grain can be as high as 1.4: 1 for certain varieties of rice.[3] On average, this equates to the formation of 1.5 tons of rice straw for every 1 ton of rice.[4]

Rice straw has a low bulk density which can range from 162.0 kg/m^3 to 194.5 kg/m^3. The bulk density of rice straw is always lower than that of rice husk, which can range from 331.6 kg/m3 to 380.5 kg/m^3.[5] This makes the transportation and storage of rice straw expensive as it occupies a lot of volumes.[6] Rice straw is also highly resistant to decay due to a high silicon dioxide content [7]. The chemical composition of rice straw is 10% to 17% ash, which is basically comprised of silica (SO2) as ash is 75% silica.[8] Due to these reasons, rice straw is also not a viable option for feedstock. Another possible option could have been the usage of rice straw as a potential biofuel. However, due to its low calorific value (the HHV of rice straw is just found in the ranges of 14.08 to 15.09 MJ kg^{-1}) and its volatile nature, rice straw does not make great fuel without extensive pre-treatment which is very cost-intensive.[9] Hence, the most common method to get rid of this residue is via burning.

The burning of rice straw has many harmful effects on the environment. This can most clearly be seen by the rise of air pollution during the burning season. In India, a total of 352 Mega tonnes of stubble is produced, 34% of which is rice straw.[10] The burning season is October-November, its hazardous effects can be seen through satellite imagery which can monitor the Atmospheric Brown Cloud or the AQI index.

Delhi NCR is a landlocked city (bordered by the small Aravalli Mountain range, which is surrounded by the agricultural states of Punjab and Haryana. The effect of rice straw burning can be seen as the AQI of Delhi severely shoots up. The average AQI, as measured from the first of January to the 4th of November, had been 195 in the year 2019.[11] This value is considered "unhealthy" by the AQI Index.[12] However, during the burning season, this value rose to a peak of 487 in Delhi.[13] For values of 301 and above, the air quality is "hazardous".

The effect of stubble burning is also visible from space. NASA's Aqua satellite passed over the Indo-Gangetic Plain (focusing on Punjab and Haryana) on 4th November 2010, its MODIS sensor (Moderate Resolution Imaging Spectrometer) observed "numerous small fires and a large smoke plume lingering downwards".[14] More recently on November 5th, 2015, the Suomi NPP satellite passed over the region of Punjab and used the VIIRS (Visible Infrared Imaging Radiometer Suite) to monitor the widespread locations where active burning

*Corresponding author: sarthakpanwar03@gmail.com

of stubble was taking place. [15] The image is given below, with the red spots marking the fire.

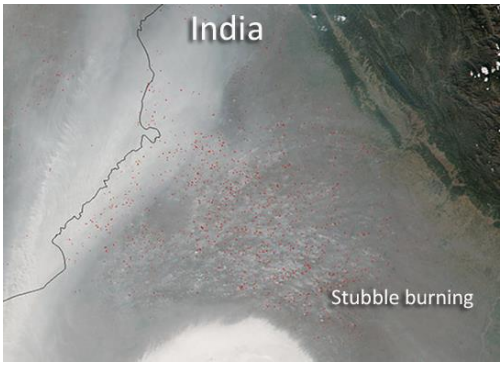

Fig. 1. Stubble burning

The haze caused by the burning of rice straw is actually photochemical smog. Along with greenhouse gases such as nitrogen oxides (NOx), methane (CH4), sulfur oxides (SOx), and carbon oxides (CO and CO2), it also releases VOCs (Volatile Organic Compounds).[16] Just 1 ton of rice straw releases 3.2 kgs of non-methane hydrocarbons.[17] These hydrocarbons can potentially react with NO2 (in sunlight) to form ozone-

an oxidant.[18] This makes it even more dangerous. Stubble burning is the primary cause of hydrocarbons in the air. In the Sacramento Valley Air Basin in October 1975, 38.7% of the hydrocarbons present in the air were found to have been released from the burning of stubble. [19]

There are more subtle and long-term effects of burning rice straw. The burning releases heat into the soil; burning a field with 8 to 9 tons of rice straw per hectare can raise the soil temperature up to 630 degrees Celsius.[9] While the soil does not burn, this leads to tremendous damage as the microbes in the soil cannot withstand the high temperature and die.

Open-air burning is considered to be the major practice for the removal of rice straw. This, in turn, pollutes the air resulting in asthma, bronchitis, and cancer.

Recent studies have shown that air pollution (caused by the burning of rice straw) plays a role in the exacerbation of asthma. In 2000, a study conducted in Japan linked the increase in asthma attacks in children when the rice straw is burnt [20].

Open-air burning of rice straw results in incomplete combustion which in turn releases harmful gasses into the atmosphere like carbon monoxide (CO), volatile organic compounds (VOC), and carcinogenic polycyclic aromatic hydrocarbons [21]-[23]. The VOCs emitted cause eye, nose, and throat irritation, shortness of breath, headaches, fatigue, nausea, dizziness, and skin problems. VOC are considered to be carcinogenic and may cause cancer [24], [25].

VOCs, especially formaldehyde, are released by the burning of rice straw. The International Agency for Research on Cancer concluded that formaldehyde was a carcinogen in 2006.[26] Rats and mice were shown to develop nasal squamous cell carcinomas due to the inhalation of formaldehyde and in humans a strong correlation between exposure to formaldehyde and developing site-specific respiratory neoplasms.[27]

Furthermore, the incomplete combustion caused by the open-air burning of rice straw can also cause cancer due to the emissions of carbon monoxide and carcinogenic hydrocarbons [28]. The harmful particles released are trapped inside the lungs which can cause cancer, disorders, and even death in certain extreme cases. Exposure to these toxic gases for a long period of time can cause cardiovascular mortality.

It was observed that “Rice Millers’ Syndrome” among the rice mill workers in Malaysia exhibited clinical, hematological, and radiological findings [29]. In 2016, a test showed a stagnation of pulmonary functions and some respiratory morbidities [30]. Acute bronchitis and possibly other respiratory diseases can be caused by the emission of small particles which are released when agricultural residue is burnt [31].

Many documents reported that the disclosure of dust from the rice straw burning can result in pulmonary fibrosis [32]. The respiratory morbidity of rice mill workers was very high it was documented that 40.73% had obstructive and restrictive respiratory morbidity [33]. The way to do this is simply to download the template and replace (copy-paste) the content with your own material.

2. Materials and Method

A. Materials

All chemicals used during the experiment were procured from the laboratory at DPS International, Saket.

Table 1
Materials

S.No.	Materials
1	Rice Straw
2	Beaker
3	Forceps
4	Filter Paper
5	Measuring Cylinder
6	White Tile
7	Funnel
8	Distilled Water
9	Ruler
10	Water Bath
11	Stopwatch
12	weighing scale
13	Hydrochloric Acid

B. Method

The process of making pulp from the rice straw followed six simple steps. First, we started by taking 40 rice straw pieces and cutting them into 10 cm each. We then rinsed the rice straw with distilled water. Next, after drying the rice straw we crushed and ground it in order to convert it into small pieces and powder.

We then used different concentrations of Hydrochloric acid and Sodium Hydroxide acid (0.5mol/dm^3, 1.0mol/dm^3, 1.5mol/dm^3) and poured a fixed amount of volume (110cm^3) using a measuring cylinder into the beaker containing the crushed rice straw (The volume of acid remains constant throughout the experiment). Then we left the rice straw in the water bath for 1 hour at a temperature of 90 C (The temperature is kept constant throughout the experiment). After leaving the mixture of rice straw and the acid for one hour we filter the

mixture in order to separate the rice straw from the acid using filter paper, a funnel, and a beaker.

Following this we removed the rice straw which gets stuck to the filter paper after filtration on a white tile using forceps. We then shaped the pulp created into a rectangle and left it out under the sun to dry. We followed these steps in order to make pulp which could be used further to make paper.

Table 2
Experimental values

Acid Used: Hydrochloric Acid (HCl)	Temperature: 90 C	
Initial Concentration: 1.5 mol/dm^3	Total Time Taken: 60 minutes/1 hour	
The volume of HCl: 150 cm^3		
Initial Weight/grams	Final Weight/ grams	Weight of Rice Straw/ grams
98.74	100.72	1.98

The temperature, weight of the rice straw, and the volume of hydrochloric acid were kept constant throughout the experiment. The same acid was used and the experiment was repeated three times for accurate results.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

3. Conclusion

Burning Rice Straw has been a significant problem in many places, especially in India. Rice Straw burning contributes to global warming and produces smog, making it a health hazard. As it can cause many respiratory diseases such as bronchitis and asthma. This paper provides a simple solution to the problem by converting this residue (rice straw) into paper and thus saving resources. Overall, the pulp created from the experiment can be bleached to create a paper that is non-toxic, beneficial to the environment, and relatively cheap to produce. We hope to see more ideas in the field to improve the product by using the latest technology and a good investment.

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