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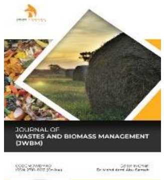

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RESEARCH ARTICLE

ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS OF 'BRIQUETTING PLANT AND BRIQUETTES'

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ABSTRACT

Brick Kilns and crop residue firing are the two common sources of air, water, and soil pollution in rural India. Brick kilns emit huge carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), black carbon, particulate matter (PM) while crop residue firing resulting in heat penetration of 1 cm into the soil and temperature elevations of up to 33.8-42.2 °C which kills the bacterial and fungal populations critical for fertile soil. These substances & harmful gases contribute to the greenhouse effect and global warming. The aim of this study was to understand environmental, social and economic impacts of 'briquetting plant & briquettes'. The results show that crop residue conversion into briquettes and use of these briquettes into brick kilns helped to reduce the carbon footprint and other harmful greenhouse gases by reducing CO2 emissions by 8.22 million kg, CO emissions by 0.34 million kg, NOx emissions by 0.028 million kg, SO2 emissions by 0.007 million kg, and particulate matter emissions by 0.065 million kg. It has also increased the farmer's average income by 11.81%, briquette manufacturers earned 35% net profit, the brick kiln reduced labor costs by 13%, increased brick production by 8%, and overall earnings of brick kiln increased by 18%.

KEYWORDS

Brick Kilns, Air Pollution, Water Pollution, Soil Pollution, Briquettes, Crop Residue Firing, Biomass, Agricultural waste, Waste Management

1. INTRODUCTION

There are many sources of renewable energy such as wind, water, solar, and agricultural and biomass wastes. This research focuses on agricultural wastes and biomass for renewable energy (Singh and Kumari, 2021; OAS, Ch-1: Renewable Energy Overview, 2021; Ghiani and Pisano, 2018; Sorgulu and Dincer, 2018; Powell, 2011; Singh and Kumari, 2021; Perea-Moreno, et al., 2019; IRENA, 2016; Patil and Deshmukh, 2015; Drożyner et al., 2013; Hall, 1991). The briquettes are also known as clean source of energy. The recent organic matter which has been derived from animals and plants such as dung, shavings, wood or forestry process or agricultural plant residues, and human, animal or any industrial wastes are known as Biomass (Kılkıs et al., 2018; Nzotcha and Kenfack, 2019). These biomasses decompose in nature themselves to their elementary molecules with releases of heat. Hence, the release of energy from the conversion of biomass into useful energy replicates natural processes at a faster rate and this kind of energy recovered from biomass is known as a type of renewable energy (Hall, 1991; Schuck, 2006). Waste is defined as "anything that does not create value" (Singh and Kumari, 2021). Waste is everywhere; we just need to understand it and make it useful. In an article, it claimed that 1.6 billion tons of food are lost or goes to waste each year, which costs $1.2 trillion (BCG, 2020). This loss or waste is approximately one-third of all the food produced globally and contributes to 8% of global greenhouse gas emissions.

Indian farmers burn their crop residues and other biomass wastes due to cost effectiveness. Farmers burn their agricultural & biomass waste (crop residues) which is a cost-effective way to clean the fields, but it leads to air pollution as it releases obnoxious and greenhouse gases (Singh and Kumari, 2021; Trivedi, 2020; Lokeshwari and Swamy, 2010). Agricultural & biomass wastes are available everywhere and is very harmful to the environment while it decomposes as it produces many harmful greenhouse gases into the environment. These wastes should be processed and be used for mankind's purposes. This research proposed a briquetting plant to recycle agricultural and biomass wastes (specially crop residues) into briquettes that are used in many industries such as ceramic, chemical, paper, textile, and many other industries where boilers are used, as well as in Brick Kilns as co-firing with black coal (Chen, et al., 2009). As per an internal survey with brickfield owners, they normally use a 9:1 ratio of briquettes and black coal. The briquetting plant was started on April 2018 at Kanasi, Farrukhabad, UP, India, with the objectives as below:

a) Create wealth from agricultural wastes for farmers.
b) Protect the environment from various harmful gases emitted during brick kiln's operation, crop residue firing by farmers.

These were major environmental problems in the Farrukhabad area, including most of the other rural parts of India.

"The objective of the research was to assess the impact of 'briquettes manufacturing plant and use of briquettes' on brick kiln's operation, biomass firing activities, and environment."

1.

2. LITERATURE REVIEW

Some scientists proposed a briquetting plant for the management of agricultural and biomass waste (Chen et al., 2009). Few others have proposed direct solutions from biomass wastes like proposed the preparation steps and techniques for activation of rice husk ash as one of the most used agro waste ash and its applications in engineering fields (Nguyen et al., 2019). Ash is considered for wastewater treatment, as an

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additive for the cement industry, and alkali-activated materials, as an additive for production of glass, silicate, pure silica, silicon carbide, refractory materials, as filler in thermoplastics and rubbers, reinforcing agent, and adsorbent in polymer composites etc. Authors also studied conversion of biomass and agricultural waste (Upadhyay and Harshwardhan, 2017). Agricultural substances are those substances that are produced on earth with the change of seasons. The waste generated from crops has a good potential to convert into energy in the related energy sector. Increasing human needs attract industrialization globally, which results in an increase in pollution.

According to UPPCB, a huge number of brick kilns are available in Uttar Pradesh, India, which are prime sources of air, water and soil pollution in rural areas (UPPCB, 2020). There were many authors and agencies such as proposed emission calculation from brick kilns. The emission of CO, SO_2, Particulate Matter (PM) was calculated in the excel sheet and the final value was shown just for understanding purposes (Guttikunda et al., 2012; De-Sarker and Kundu, 1996; Zhang, et al., 1999; Roden et al., 2009; Rajarathnam, et al., 2014; Maithel, et al., 2014; Suresh, Kumar et al., 2016). A number of researchers found that emission of individual air pollutants from brickfields (brick kilns) varied notably during a firing batch (7 days) and among different types of kilns (Skinder et al., 2014; Le, 2010).

It was found that the average emission factors per one thousand (1000) bricks were 0.52–5.9 kg of SO2, 6.35–12.3 kg of CO, and 0.64–1.4 kg of particulate matter (PM). A single brick kiln (brickfield) with a circular chimney normally bakes 1 million bricks in a single round (one time) and in the season, it bakes an average 5-6 rounds of bricks which comes out to be 6 million bricks per brickfield in the district of Farrukhabad, UP. According to in a joint report by the Shakti Sustainable Energy foundation and the Centre for Science and Environment (CSE), burning one tonne of crop residue emits approximately 58 kg of CO, 1,400 kg of CO2, 4.9 kg of NOx, 11 kg of particulate matter (PM), and 1.2 kg of SO2.Considering these high-level emissions of harmful gases, agricultural wastes and crop residue burning has become a major environmental problem in India (Trivedi, 2020). Uttar Pradesh produces the highest biomass/agro residues (about 135 million tons) as per a report by the Center for science and environment 2020. This creates an opportunity to use biomass/agricultural residues for making briquettes, which helps to minimize the emissions & protects the environment from harmful gases after crop residue burns in fields.

3. Briquetting Plant and its Supply Chain, Briquettes and Benefits

3.1 Briquetting Plant and Its Supply Chain

Briquettes are binder less technology which does not use any type of adhesive or binder that makes it perfect substitute to charcoal, Kerosene oil, and black coal for domestic and industrial purpose. Figure 1 shows the framework of briquette supply chain for sustainability that starts from collection/reception of agricultural wastes (crop residues/biomass) from the point of its generation, processing it at briquetting plant and manufacturing the briquettes, storage, distribution to point of use (brick kilns, boilers, ceramic industies, and forges & foundries, etc. through agents or directl deliveries. The use of briquettes in brick kiln is very much useful as it help to reduce smoke, improves the productivity & finally produced a quality product (brick). Material flows from left to right and cash flows from right to left. This creates a win-win situation between farmer & briquetting plant owner, briquetting plant owner & brick kiln owner, brick kiln owner & brick users.

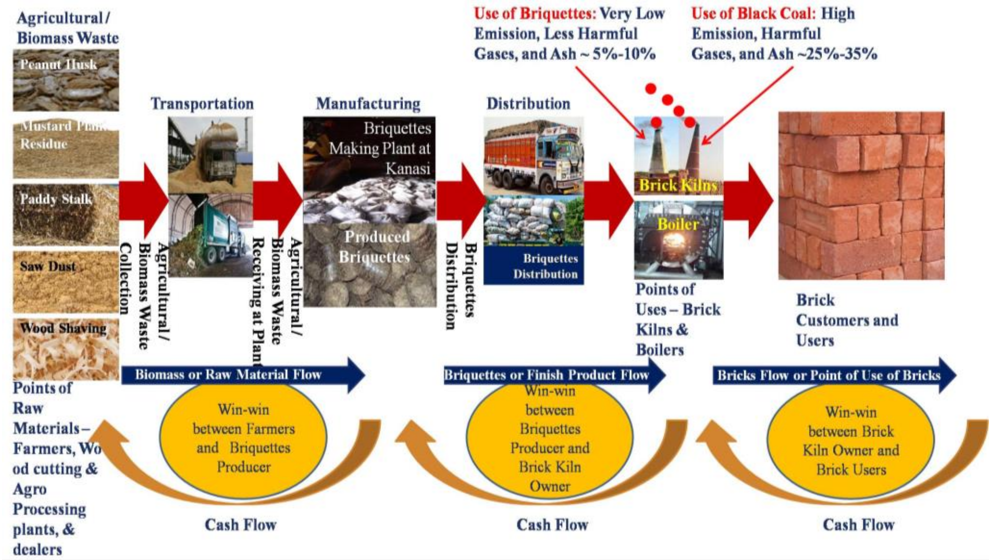

Figure 1: Briquette Supply Chain for Sustainability

3.2 Benefits Of Briquettes and Applications

Briquettes are easy to transport, renewable source of energy, smokeless or very less smoke, cheaper, and more efficient as its heating value (Calorific Value) is around 3000-4000 kcal/kg and hence briquettes can generate more intense heat than other fuels. They also have lower ash content (2-10% compared to 20-40% in coal). Application of briquettes in boilers, brick kilns (brickfields), forges & foundries, ceramic units, cooking, and residential heating. A photo of briquetting machine, different types of briquettes and burning briquettes are shown in the Figure 2.

Figure 2: Briquetting Machine, Different types of Briquettes and Burining Briquettes

4. Problems Identified and Their Respective Solutions

4.1 Problems

Brickfields (brick kilns) contribute to the air, water and soil pollution in Rural India as shown in Figure 3. Apart from brick kilns, many factories & industries burning coal for their heat needs are also the biggest contributor to the atmospheric damage. Brickfields, industries, and biomass burning emit harmful gases such as CO, CO2, SO2, and black carbon, which are widely dispersed in the atmosphere and are major contributors to the greenhouse effect. Ultimate results could be seen in the form of acid rain, melting of glaciers, and various kinds of diseases like skin diseases, respiratory diseases, breathing problems, cancer etc.

Figure 3: Brick Kilns Using Black Coal

Brickfields are known for causing ambient air pollution in rural areas and high air pollution levels in the atmosphere have shown significant negative consequences as they create severe occupational health hazards and adversely affect the surrounding environment too (Bobak, 2000; Joshi and Dudani, 2008; Pawar et al., 2010; Aslam et al., 1994; Pope et al., 2002; Callen, et al., 2009; Koskela et al., 2005). In research, it was found that black coal combustion is the main source of airborne particles which are giving rise to air borne particles.

According to the air quality index (AQI), the air quality was severely polluted during the operational phase of brick kilns, but it was relatively clean during the non-operational phase of brick kilns. The production of bricks degrades the environment by emitting large amounts of particles and gaseous pollutants (Skinder et al., 2014; Burntley et al., 2007). As per research by the Indian Agricultural Research Institute (IARI), in 2008-09 India had generated 620 million tonnes of crop residue in 2008-09 and out of this, about 16% was burnt and of this, 60% was paddy straw and 22% was wheat straw. Uttar Pradesh (India) produces 135 million tonnes of agricultural & biomass waste yearly.

As per the report from www.downtoearth.org.in, residue burning negatively impacts the soil health apart from humans & animals. Few snaps of burning & burnt field are shown in Figure-4 as below.

Figure 4: Burning and Burnt Snaps of Wheat Stalk in field

It loses 2.3 kg of phosphorous, 5.5 kg of nitrogen, 1.2 kg of sulphur, and 25 kg of potassium in the soil. Also, according to the Centre for Sustainable Agriculture, heat from burning straw penetrates 1 cm into the soil and elevates the temperature to 33.8-42.2 ° C, which kills the bacterial and fungal populations critical for a fertile soil.

4.2 Solutions

To get rid of or diminish the above issues, biomass (cross) residues must be processed through proper channels (Kaczyński et al., 2019). The solution proposed was the briquettes manufacturing plant as it creates wealth, protects the environment through minimizing emissions and hence such plants must be started at a micro-level (at every Gram-Panchayat) for sustainability (Singh and Kumari, 2021; Chen et al., 2009). This plant is also termed as an agricultural/biomass waste management plant as this plant helps to compress and convert agricultural & biomass (Crop residues) wastes into briquettes without using any adhesive or binder (Singh and Kumari, 2021). Inside snaps of briquetting plant has shown in Figure 5.

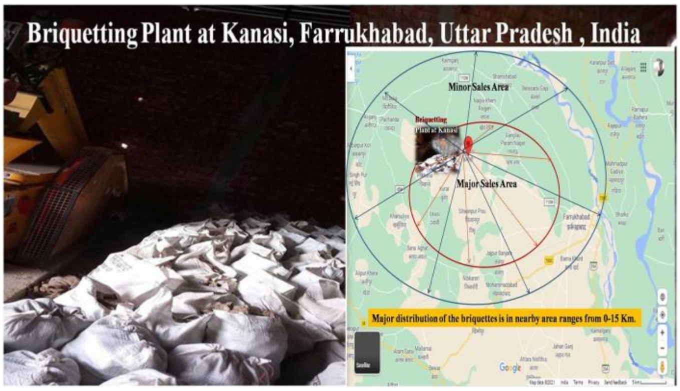

Figure 5: Briquetting Plant at Kanasi, Farrukhabad, UP, India

These briquettes can be used in industries (where boilers are placed) and brick kilns as co-firing to reduce emission levels (Basu et al., 2011).

Air pollution control equipment consisting of baffle arrangement inside the chimney with a gas bypass system may be installed in the chimney to arrest pollution (Skinder et al., 2014). Utilization of fly-ash for brick manufacture through cost effective technology will save the precious topsoil required for agricultural production. Development of a green belt around the brick kilns may be an effective mitigation mechanism for fugitive emissions. At the same time, environmental awareness programs should be organized. In the absence of effective air quality management, air pollutant concentrations will increase in the future, so enforcement of air quality standards is necessary.

Briquettes are a renewable source of energy, environmentally friendly, easily accessible and available, less expensive, pollution-free because they are sulfur-free, have a high calorific value, and are easy to manage from toxic gases and produce less ash content as compared to black coal. Briquettes could be used in Brickfields (Brick Kilns) and industries where boilers are used. Investigators has proposed a solution to agricultural & biomass wastes to briquettes which are consumed in industries and brickfields as a renewable source of energy as a replacement for black coal which is used for heat production purposes in brick kilns (Singh and Kumari, 2021; Dodic et al., 2012).

"Because the author has established an agricultural and biomass waste management project at Kanasi, district of Farrukhabad, Uttar Pradesh, and thus, this research has proposed this plant as a solution."

5. Research Methodology

5.1 Research Design

The research design was based on the impacts of a briquetting plant and was analytical and descriptive based on a previously established plant. The brief research design is shown in the figure-6 below:

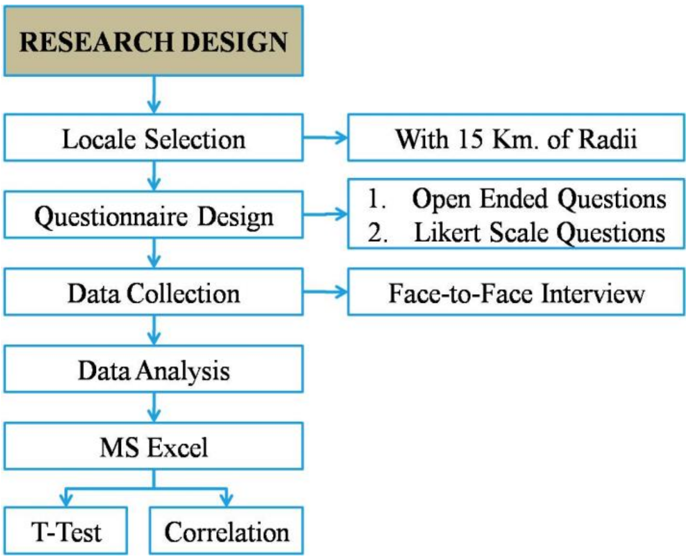

Figure 6: Research Design

It requires a clear specification of who (briquetting plant), what (impacts), when (before April 2018, in 2018 and in 2021), why (issues/problems discovered), and how (survey-questionnaire, F2F Interview) the research would have been conducted.

5.2 Research Location

The research was conducted within a 15-kilometer radius of the briquetting plant in terms of brick kilns and farmers who are directly involved with the plant. Brick kilns that buy and use briquettes, as well as farmers who supply agricultural/biomass waste to briquetting plants, are being studied.

5.3 Data Collection

5.3.1 Sample Size and Sampling

There were 30 brick kilns within the defined range (15 km), and only 15 of them are currently (until April 2021) using briquettes, and all of them are purchasing briquettes in full or partial quantities from the Kanasi briquetting plant. Farmers & dealers of biomass supply are close to 700. Random sampling was used and selected all the brick kilns and farmers & dealers. Please keep in mind that dealers are also farmers, but they have cutters and other necessary machinery and equipment to provide biomass supply.

5.4 DATA ANALYSIS AND TOOLS

The data was analyzed using MS Excel 2010.

6. RESULTS DISCUSSION

For any research, data analysis is crucial, and the end goal of the analysis should be to produce the desired outcomes. The discussion of the results is an important aspect of any analytical report. The purpose of this section is to summaries the obtained data using statistical procedures and to show the analyzed data in graphical, table, and/or other appropriate formats. The current study looked at the effects of already-existing briquetting facilities, analyzing and deriving conclusions from the financial and operational state of brick kilns, the financial state of farmers, and ultimately, the management of greenhouse gas emissions following crop/biomass firing by farmers.

The findings are summarized under the headings below:

- Analysis of brick kilns in terms of the use of firing material to bake raw bricks
- Research models
- Testing of hypotheses
- Data Analysis
  - Data reliability (internal consistency) check
  - T-test
  - Correlation

6.1 Analysis Of Open-Ended Questions

Open ended questions were summarized and streamlined to obtain conclusions.

6.1.1 The impact of using briquettes on brick kiln operation

Figure 7 has shown the results of the analysis which says that by using briquettes at brick kilns, the average brick's production has increased by 8%, average labour reduction by about 13% and overall average earning of the brick kiln has increased by 18%.

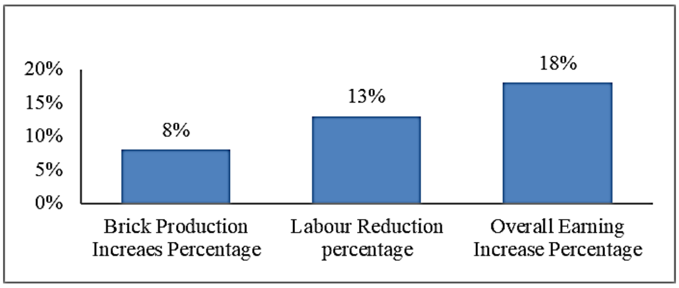

Figure 7: Impacts of Briquettes at Brick Kiln's Operation

6.1.2 The earning of farmers - before 2018, in 2018 and in 2021

Figure 8 has shown the average farmer's earning trends before 2018, during 2018 and in 2021. The results are motivating and encouraging as most of the farmers used to burn or dispose-off their crop residues (agricultural wastes) before 2018 and after the briquetting plant establishment, most of the farmers are selling their crop wastes and making wealth for themselves. The calculations were carried out using standard bigha as per government of India which is 27000 Square Foot.

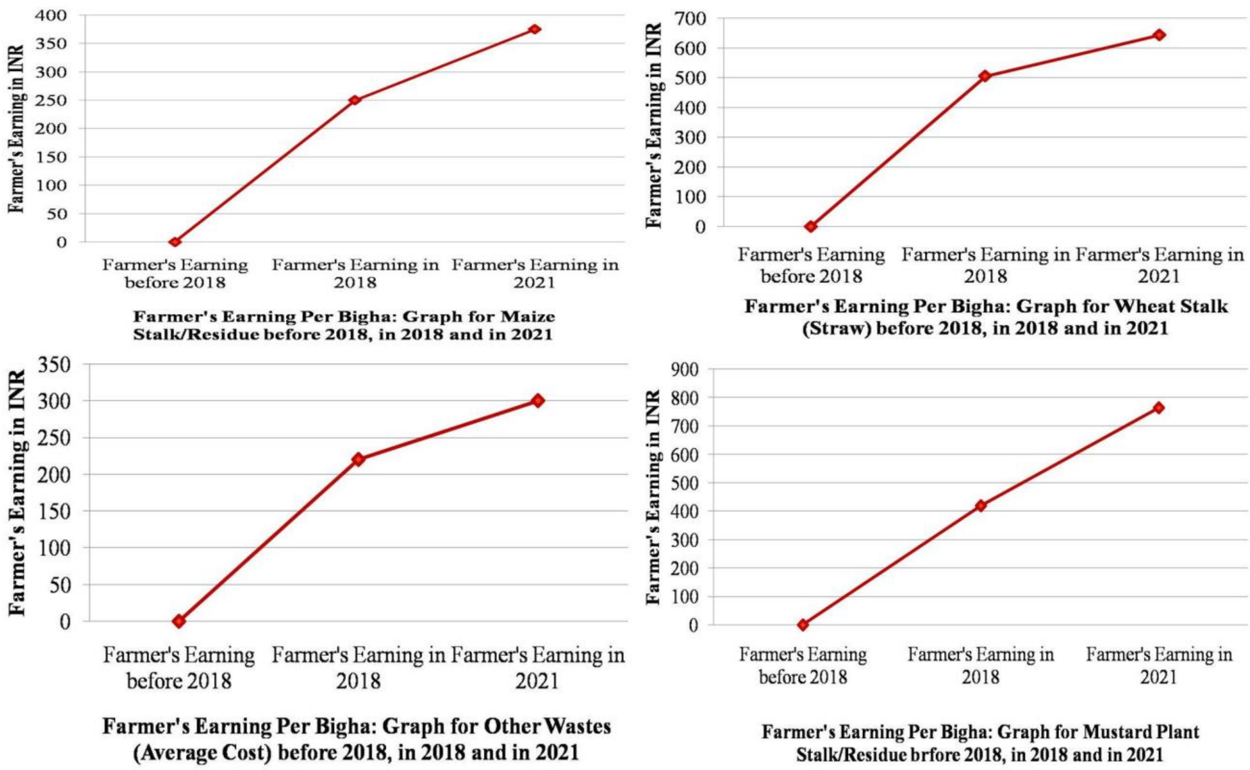

Figure 8: Farmer's Earning Trends per Bigha per Crop Residue (Agricultural Waste) Wise

The current year's (as on April 2021) average earning of the farmer is 4689 rupees as shown in Table-1. The point to be noted that this earning is only for single crop, in case farmer sow double or triple time, the average earning would increase accordingly. "The average crop per year per farmer comes out to be 1.7 and hence the final average earning comes out to be (as per Table-1) 4689*1.7 which is 7971 rupees."

Table 1: Average earning (In Rupees) of farmers as on April 2021

Waste Material Production	Agri. Waste Price	Waste Material Generation Per Bigha in Quintal	Farmer's Earning in 2021 (In Rupees)	Average Agricultural Land per Farmer (In Bigha)	Average Earning (In Rupees) of Farmers as on April 2021
Mustard Plant Stalk/Residue	255	3	765	9	6885
Wheat Stalk	280	2.3	644	9	5796
Maize Plant Stalk/Residue	150	2.5	375	9	3375
Other Wastes (Average Cost)	150	2	300	9	2700
*Average Earning (In Rupees) of Farmers as on April 2021					4689

*Handling cost assumed to be zero as farmer handles their own and transport is handled by the plant in most of the cases.

Research data suggests that the average earning from the main crop/s is/are 7500 per *bigha* and average earning per farmer is 67500 rupees per annum. The average income of the farmer has increased by 11.81 percent by selling the agricultural waste to the briquetting plant. The calculation is provided as below for increase in average farmer's income:

Extra Earning per Farmer per Annum / Average Annual Earning per Farmer per Annum)*100 = (7971/67500)*100 = 11.81%.

6.1.3 Briquetting Plant's Financials

Table 2: Briquetting Plant's Revenue and Earning Metrics

S No.	Particulars	Cost (Per Quintal-100Kgs) in INR
1	Average Raw Material (Biomass Waste) Price per Quintal	215
2	Labour Cost, Power Cost, Other miscellaneous Costs Per Q.	65
3	Handling Cost - warehousing + Loading (Per Quintal)	20
4	Transportation Cost (Per Quintal)	20
5	Marketing, Sales and Other Over Head Costs (Per Quintal)	22
6	Total Cost per Quintal (100Kg)	342
7	Revenue or Selling Price without GST Price per Quintal	460
8	Final Revenue or Final Selling Price per Quintal @ 5% GST	483
9	Earning Per Quintal (100Kg) Including GST	141
10	Net Profit per Quintal (100Kg) = Revenue – Cost	118
Profit percentage		**Percentage**
11	Profit Percentage = (Net Profit / Cost)*100	35

Table 2 has shown the various calculations in table format where profit percentage comes out 35% which is to be considered good when people have lost so many jobs in past 2-3 years in India.

6.1.4 The Trends of Agricultural (Biomass) Wastes Material Cost Per Quintal (100kg) At Briquetting Plant

The result of the research shows that the price of various raw materials (agricultural wastes) was increasing continuously as shown in Figure-9 below. This increase also has the impact of wood price has increased due to funeral of dead bodies in India due to Covid-19.

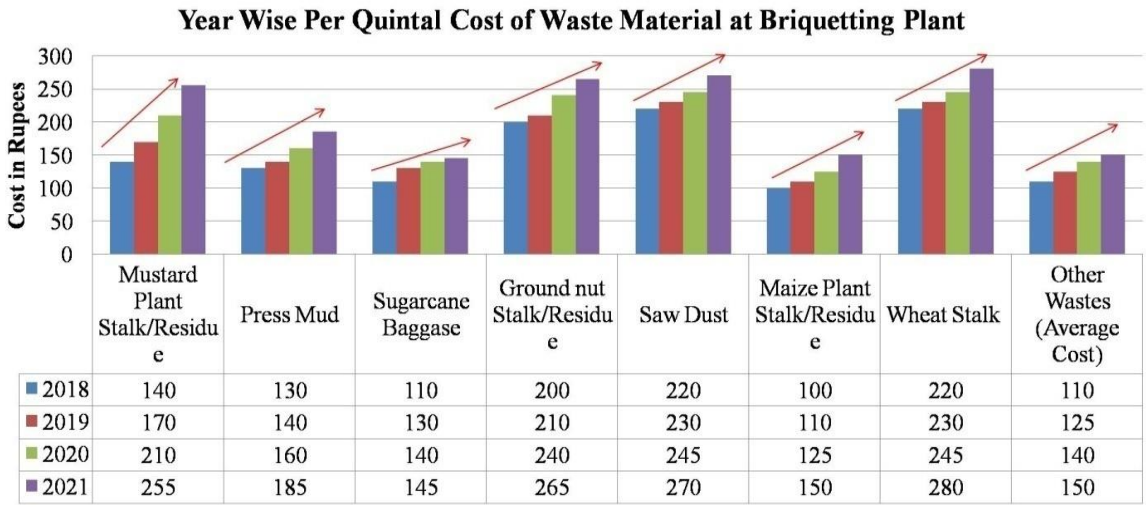

Figure 9: The trends of agricultural waste material cost per quintal (100Kg) at Bkt. Plant

6.1.5 The Emission and Control Data and Analysis

The Table 3 has shown the emission calculations based on the research paper by Trivedi and the results were very much encouraging. The final bar charts have shown in Figure-10 and Figure 11 which clearly show the year wise control of pollution of 'CO, NO_x, SO_2, PM Discharge (emission)', and 'CO_2 emission' respectively. This pollution control would have been much more if plant was running at its full pace. Covid-19 has affected the briquettes manufacturing operation since March 2019.

Table 3: Year Wise Emission Control Data through Avoiding Burning (Firing) of Agricultural (Crop Residues) by the Farmers

Substances/ Gases	Burning (Firing) One Tonne Crop Residue Release Gases & PM in Kg [Ref: (Trivedi, 2020) CSE]	Year Wise Emission Control through Avoiding Burning (Firing) of Agricultural Wastes (Crop Residues)								
		2018		2019		2020		2021 (Until April, 30)		Grand Total (In Killograms)
		Agricultural Stalk Residue Processed (In Tonnes)	Substances/ Gases Emission Control (In Kgs)	Agricultural Stalk Residue Processed (In Tonnes)	Substances/ Gases Emission Control (In Kgs)	Agricultural Stalk Residue Processed (In Tonnes)	Substances/ Gases Emission Control (In Kgs)	Agricultural Stalk Residue Processed (In Tonnes)	Substances/ Gases Emission Control (In Kgs)	
CO2	1400		2016000		2520000		1764000		1915200	8215200
CO	58		83520		104400		73080		79344	340344
Nox	4.9		7056		8820		6174		6703.2	28753.2
SO2	1.2	1440	1728	1800	2160	1260	1512	1368	1641.6	7041.6
Particulate Matter (PM)	11		15840		19800		13860		15048	64548
Total										8655886.8

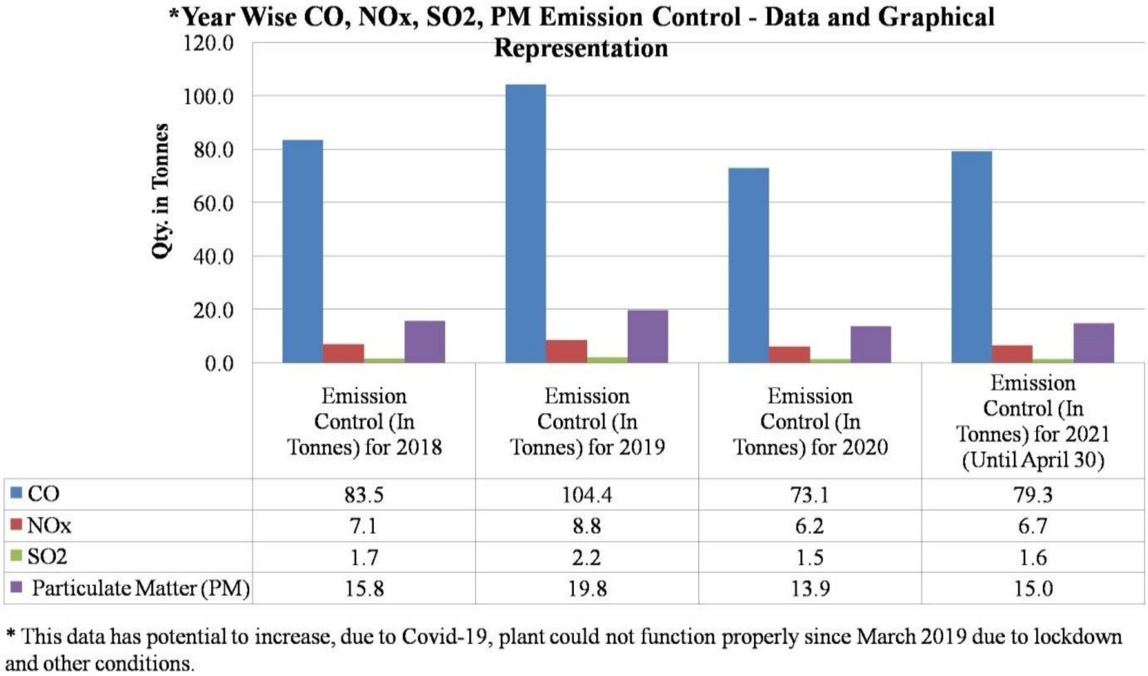

Figure 10: Bar Chart – Year Wise CO, NO_x, SO_2, PM Discharge (Emission) Control

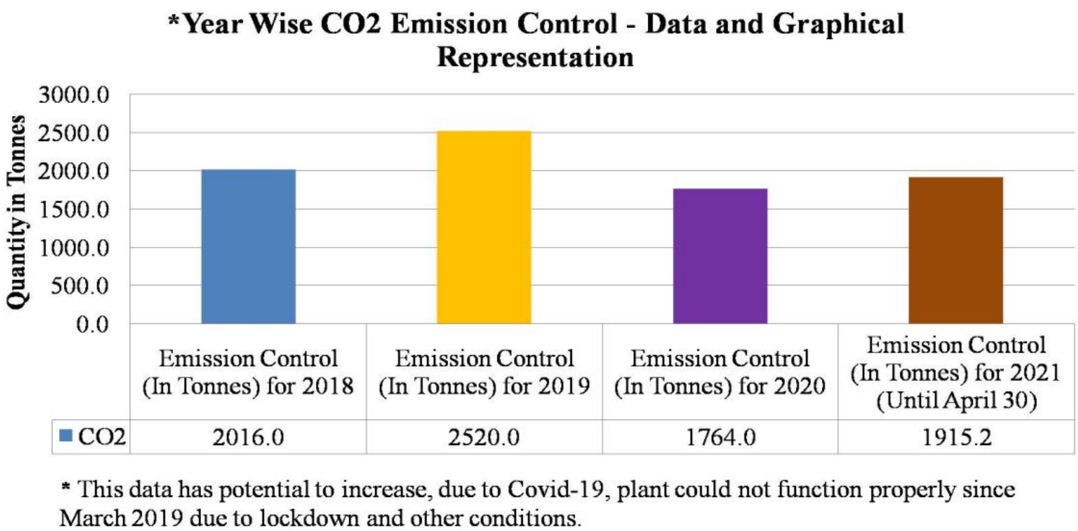

Figure 11: Bar Chart – Year Wise CO_2 Discharge (Emission) Control

6.2 Research Model

The research model is straightforward and easy to comprehend. This model claims that there are environmental, social and economic impacts of 'briquetting plant & briquettes use in brick kilns ' The t-test and correlation methods are used to test and show this.

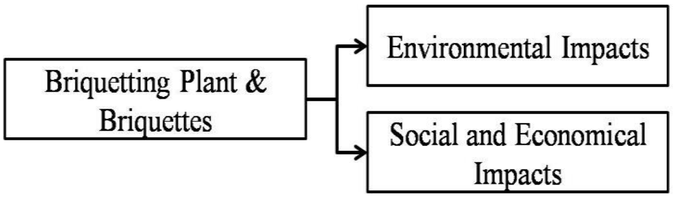

Figure 13: Research Model – Environmental and Social & Economic Impacts of 'Briquetting Plant & Briquettes'

6.3 Testing Of Research Hypotheses

Proposed research hypotheses derived from the research model as below:

Null Hypothesis (H_0a): There is no impact on environment of briquetting plant & briquettes use in brick kilns.

Alternate Hypothesis (H_1a): There is impact on environment of briquetting plant & briquettes use in brick kilns.

Null Hypothesis (H_0b): There is no social and economic impact of briquetting plant & briquettes use in brick kilns.

Alternate Hypothesis (H_1b): There is no social and economic impact of briquetting plant & briquettes use in brick kilns.

6.4 Data analysis – cronbach 's alpha test for data reliability, t-test, and correlation

6.4.1 Cronbach 's alpha test

Cronbach's alpha (or coefficient alpha) is a measure of reliability or internal consistency established by Lee Cronbach in 1951 (Lavrakas, 2008). Consistency is also known as "reliability." Cronbach's alpha tests are used to determine the reliability of multiple-question Likert scale surveys. Cronbach's alpha tests are used to determine the reliability of multiple-question Likert scale surveys. These questions assess latent variables, or variables that are unseen or unobservable, such as a person's conscientiousness, neurosis, or transparency. In real life, these are extremely difficult to quantify. Cronbach's alpha determines how closely a group of test items are associated. The formula for cronbach's alpha is as below:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Where:

N = the number of items

$\bar{c}$ = average covariance between item-pairs

$\bar{v}$ = average variance

For dichotomous questions (i.e., questions with two possible answers) or Likert scale questions, a general rule of thumb is shown in table-5 below:

Cronbach's alpha (α) value and the data reliability (internal consistency) level explained as below:

If $\alpha > 0.9$ then internal consistency is excellent; If $0.9 > \alpha > 0.8$, then internal consistency is good; If $0.8 > \alpha > 0.7$, then internal consistency is acceptable, while, if $0.7 > \alpha > 0.6$, then the internal consistency is questionable; If $0.6 > \alpha > 0.5$, then internal consistency will be poor; If $0.5 > \alpha$, then it is unacceptable.

The final calculated value of α is 0.927, which is more than 0.9, i.e. the reliability or internal consistency of data is excellent. Hence, the data collected and streamlined was consistent for further analysis & tests.

6.4.2 T-TEST

Table 6: Result of t-test: This table shows the final results of the t-test based on hypothesis for the research model.

Predictor	p - Value	Significance Level (0.01)	Null Hypothesis – Accepted or Rejected?	Final Result on Hypothesis
Environmental Impact	0.000	0.01	Reject H_0a	Since H_0a rejected and hence H_1a was accepted. There is impact on environment of briquetting plant & briquettes use in brick kilns.
Social and Economic Impacts	0.000	0.01	Reject H_0b	Since H_0b rejected and hence H_1b was accepted. There is no social and economic impact of briquetting plant & briquettes use in brick kilns.

Note: Decision at 95% and 99%-level of significance, p-value < 0.05, and/or p value < 0.01, then, Reject the null hypothesis (H_0) and accept the alternate hypothesis (H_1)

As per table-6, the final results of t-test show that the null hypotheses (H_0a, H_0b) were rejected and alternate hypotheses (H_1a, H_1b) were accepted, which shows that there is a positive close relationship between 'environment, society and economy' and briquetting plant & briquettes use in brick kilns.

6.4.3 Correlation

Results of Correlation - Correlation results are derived from the research model as below:

I. The value of the correlation between environment and briquetting plant & briquettes use in brick kilns = 0.74

II. The value of the correlation between society & economy and briquetting plant & briquettes use in brick kilns = 0.69

The results show that there is a high (strong) correlation between "environment, society & economy" and briquetting plant & briquettes use in brick kilns. The correlation results explain that:

1) There will be a better & clean environment if briquetting plant & briquettes use in brick kilns and crop residues are converted into the briquettes instead of firing.

2) There will be positive social & economic impacts if briquetting plant & briquettes use in brick kilns and crop residues are converted into the briquettes instead of firing.

7. Conclusion

This study has opened up a new way of thinking about generating money from crop residues or other agricultural wastes in rural India by using a briquetting plant and use of briquettes in brick kilns. It also provides a comprehensive grasp of agricultural and biomass waste management, as well as the briquette supply chain, in order to ensure long-term sustainability. This plant benefits farmers by earning additional income from wastes, as well as contributing to environmental protection by reducing dangerous gases and substances and preventing the burning of crop wastes. The project has benefited not only farmers, but all stakeholders in the briquettes supply chain, including farmers, manufacturers, and brick kiln owners. This also benefited brick users, as the price of bricks was reduced significantly due to lower input costs. In the last three years, farmer's average income has climbed by 11.81

percent, briquettes manufacture has earned a net profit of 35 percent, brick kiln (brickfield) has cut labour costs by 13 percent, improved brick production by 8%, and overall earnings have increased by 18 percent. In addition, the briquetting factory has helped to reduce carbon emissions and other damaging greenhouse gases. Since its start on April 8, 2018, the plant has reduced CO_2 emissions by 8.22 million kg, CO emissions by 0.34 million kg, NO_x emissions by 0.028 million kg, SO_2 emissions by 0.007 million kg, and particulate matter (PM) emissions by 0.065 million kg.

8. Recommendation

The recommendation is always an important aspect of any research effort, and the stakeholders should take it carefully. To think about society and the environment, decision makers, politicians and bureaucrats in governments (state and federal), capitalists/industrialists, social influencers, and farmers could be potential stake holders in this research. They must raise awareness and support such projects and plants in order to make the environment more livable.

A. The following are two major proposals for governments and capitalists:
1. This study clearly demonstrates that this type of waste management project (Briquetting Plants) should be initiated and supported by individuals, businesses, and the federal and state governments in order to produce a healthy environment and boost rural economies.

2. It was discovered throughout the investigation that wet wastes or other biomass wastes that cannot be turned into briquettes or pellets can be used for composting or other purposes, and that burning of agricultural wastes should be avoided as much as possible.

B. The following is a significant guideline for farmers:

1. Combine harvesters should not be used to harvest paddy (rice) or wheat. Farmers should revert to historical harvesting processes, particularly for wheat and paddy (rice), such as machinery such as the Brush Cutter, Reaper, Reaper Binder Machine, and Danraanti, Hasiya, and others for manual or hand cutting. Thrashers should be used to smash and remove seeds, as well as to collect straw for cattle. This advised approach will increase the amount of straw available to cattle while also protecting the environment by preventing it from being burned.

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