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ORIGINAL RESEARCH PAPER

Environmental Science

ENVIRONMENTAL BENEFITS OF USING SELECTED AGRICULTURAL BIOMASS AND COW DUNG AS ALTERNATIVE FUELS IN CEMENT PRODUCTION BY USING GREEN CHEMISTRY

KEY WORDS: Alternative fuels, agricultural biomass, almond shell, bagasse, coffee husk, and olive husk.

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ABSTRACT

Introduction-Cement manufacturing is a major industry in creation of national infrastructures that requires a lot of cash, consumes energy and is vital. In cement kilns of cement, the utilization of alternative fuels is also defined by the wide term "environmental protection," because it saves not only main sources of power, but also garbage that would otherwise have to be discarded of on garbage removal locations or burned in particularly made burning kilns. The most frequent types of biomass presently utilized in the cement industry include palm nut shells, bagasse, hazelnut shells, coffee pods, maize stover, coconut husks, and rice husk.

Material and methods-The research looks at the possibility of using 6 agricultural biomasses like alternative fuels in cement kilns: almond shell, coffee husk, olive husk, bagasse, cow dung and rice husk. In this research, the Aspen Plus program is utilized to simulate a furnace of cement using the principle of power and mass balance and identified chemical reaction stoichiometry. Agricultural biomasses were evaluated as furnace model of alternative fuel for the present research.

Result- A cement kiln processes model was built and validated using factory and research data. Agricultural biomasses were chosen like alternative fuels in the furnace model. The model was conducted with various alternative fuel substitution rates. The findings indicate that the chosen biomasses are able of lowering both energy requirements and emissions of carbon dioxide.

Conclusion-It is concluded from the research that agriculture biomasses are one of the best alternative fuel among all alternative fuels which can reduce greenhouse gas emissions and has less adverse impacts on environment, use of biomasses in cement manufacturing process will reduce the carbon dioxide emissions which is generated through cement industry. These 6 types of agriculture biomasses were environmentally friendly and cost-effective.

1. INTRODUCTION

Cement manufacturing is a major industry in creation of national infrastructures that requires a lot of cash, consumes energy and is vital. While a restricted share of world output has increased, the international cement industry in recent years has grown at an increased rate contrasted to the regionalneed. Cement production companies have been compelled to relocate to nations with less stringent ecological laws as a result of efforts to preserve the ecosystem in emerging nations, especially Europe. This has created a trend for financial success and ecological regulation, along with continuously increasing actual costs.

The worldwide Cement manufacturing has now surpassed 2.8 billion tonnes per year, with nearly 4 billion tonnes per year expected in the future. Significant growth is projected in China and India, as well as in the Middle East and North Africa[1].

Alternative fuels, often referred as " non-conventional," " non-traditional," and "modern" fuels, are any substances that may be utilized as fuels in place of traditional fuels such as fossil fuels (natural gas, coal, and petroleum). Bio-alcohol (CH_3OH, C_2H_5OH, C_4H_9OH), biodiesel, vegetable oil, RDF (refuse-derived fuel) and other biomass resources are some of the most well-recognized alternative fuels.

Extremely waste products have some thermal efficiency and can thus be used like an alternative fuel source for heat production in the cement sector. Cement producers have been leaning toward widely accessible alternative fuels as a result of raisingpressure from environmental organizations and a promise to sustainable cement production. For the last thirty years, alternative fuels have been used commercially in the cement sector. Nearly hundredpercent alternative fuels at the precalciner were gained at preliminary phage in calciner lines. The utilization of alternative fuels in rotating furnaces is even in the early stages, as producers face challenges related to the environment, social issues, and quality of products[2,3]. The utilization of alternative fuels in cement kilns of cement is also defined by the wide term "environmental protection," because it saves not only main sources of power, but also garbage that would otherwise have to be discarded of on garbage removal locations or burned in particularly made burning kilns. The utilization of alternative fuels produced from garbage could decrease the amount of garbage that needs to be discarded up to fifty percent. Both burning facilities and garbage removal locations have the potential to have substantial detrimental effects on environmental constituents. It is important to remember that obtaining main sources of energy has an adverse effect on the environment.

Agricultural biomass is being used to generate electricity in a growing number of rural developing nations, including Malaysia, Thailand, and India[4]. Agricultural biomass made for 0.25 percent of the heat power replacements used in the cement sector worldwide in 2001[5]. The percentage of furnace fuel substituted by agricultural biomass is around five percent, and it is steadily rising [6]. The most frequent types of biomass presently utilized in the cement industry includepalm nut shells, bagasse, hazelnut shells, coffee pods, maize stover, coconut husks, and rice husk. Most agricultural biomasses have a modest thermal efficiency of 14 to 21 MJ kg-1[7], making them acceptable for use in both cement kilns and calciners. According to study, agricultural biomass can replace 20% of the heat energy in cement without requiring significant capital expenditure[8].

Agricultural biomass is regarded as a carbon dioxide neutral fuel because the carbon dioxide used throughout their lifetime is almost equal to the carbon dioxide released after burning[9]. Various studies have shown that cofiring agricultural biomass reduces NO_x, SO_x, and certain heavy metal emissions [10]. The inconsistency of biomass availability and the volatility of certain biomasses' thermal efficiency may limit their usage as an alternative fuel[11].

One of the most difficult aspects of adopting alternative fuels is ensuring that pollutant emissions and clinker quality remain within permissible limits. Using alternate fuels in the system of furnace may result in a lesser temperature of flame, lowering clinker quality. Furthermore, adding alternative fuel should not decrease clinker output on a daily basis, since this may negate the energy savings. According to the rule of thumb, alternative fuels may replace twenty percent of total heat energy requirements. Due to many limitations, this may not be true in a real plant. It was updated by combining a unit operation block to fire alternative fuels to forecast the result of adopting the chosen alternative fuels.

2. Material and methods

2.1 Selection of Agricultural Biomass

There are many studies on co-firing agricultural biomass with coal in the research, however few look at the effect of doing so in cement furnaces. The research looks at the possibility of using 6 agricultural biomasseslike alternative fuels in cement kilns: almond shell, coffee husk, olive husk,bagasse,cow dung and rice husk. The biomasses were chosen for their accessibility, global use, and insufficient disposal options.

The leftover bagasse from the sugar cane industry is usually utilized by the same facility for heat and power production. The burning leftovers, on the other hand, must be discarded in landfills, which may represent an ecological risk. By burning bagasse in a cement furnace, all burning waste is contained inside the clinker, improving cement quality[12].

The hull (or rice husk) is the paddy grain's outermost coating, accounting for approximately 20% of the paddy's weight [13]. During the milling process, it is removed from the rice grains and is usually burnt as trash, disposed of in landfills, or utilized as animal fodder.

2.2 Elemental analysis of selected biomass

Before using any alternative fuel in the cement business, the manufacturer must assess the alternative fuel's effect on clinker emission and quality. The chemical makeup of several agricultural biomasses, as well as their combustion properties, were studied.

2.3 Principle of model

In this research, the Aspen Plus program is utilized to simulate a furnace of cement using theprinciple of power and mass balance andidentified chemical reaction stoichiometry. Taking various duties of the procedure, like breakdown of fuel, burning, isolation, refrigeration, and chemical reactions, several unit operating blocks were utilized. All burning in the present model was done on the basis of an energy balance. The burning of traditional and alternative fuels took conducted in 2 Aspen Plus operating units. RYIELD and RGIBBS were the 2 type, which represent decomposition and burning, accordingly. The RGIBBS reactor block was directly supplied stoichiometric air. The RGIBBS reactor block received direct decay heat from the RYIELD reactor.

2.4 Modified Kiln Model

The suggested furnace model of alternative fuel was built to mimic a 2200-ton manufacturing kiln using alternative fuels. Agricultural biomasses were evaluated as furnace model of alternative fuel for the present research. According on data gathered from a local cement factory, the kiln's energy demand was estimated to equal forty percent of the overall energy demand. For the sake of convenience, ten percent more air was permitted in the kiln's combustion area. Alternative fuels were fed at a rate ranging from five percent to twenty five percent of the overallheat energy needed in the kiln. The constructed-in calculator block in Aspen Plus was used to figure out the mass flow rate. The output findings were examined in conditions of clinker components and air emissions.

3. RESULT

A cement kiln processes model was built and validated using factory and research data. The model was updated to allow for the use of alternatefuels.6 agricultural biomasses were chosen as alternative fuels in the furnace model. The model was conducted with various alternative fuel substitution rates. The concentrations of contaminants in the exhaust gases, as well as the clinker quality, were investigated.

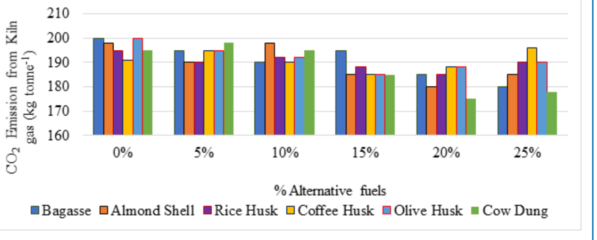

Figure1. Total emission of carbon di-oxide from kiln (kg/ tonne21 clinker).

The overall emissions of carbon dioxide from the clinker manufacturing process are determined by the fuel used and the quality of the raw feed used. For every tonnes of clinker, about 970 kg of carbon dioxide is generated. In acalciner and preheater furnaceprocedure, the preheater tower absorbs approximately seventy five percent of the carbon dioxide produced by calcination and fuel burning. This means that the furnace is responsible for approximately two hundred kg of carbon dioxide every tonne of clinker produced. The simulation outcomes in terms of emission of carbon dioxide and carbon mono-oxide from a furnaceprocedure while firing alternative fuels in a constant proportion are shown in Figures 1 and 2. All of the alternative fuels tested were shown to be capable of reducing carbon dioxide emissions from the furnace to some degree. Cow dung was shown to decrease carbon dioxide by approximately 5.2% percent among the alternative fuels tested, whereas other fuels reduced carbon dioxide by around0.09- 1.75%. Cow dung was determined to be the finest choice among the chosen agricultural biomasses in regards of carbon mono-oxide emission from the furnace. Cow dung substitutes for twenty five percent of thermal energy, resulting in a decrease in carbon mono-oxide emissions.

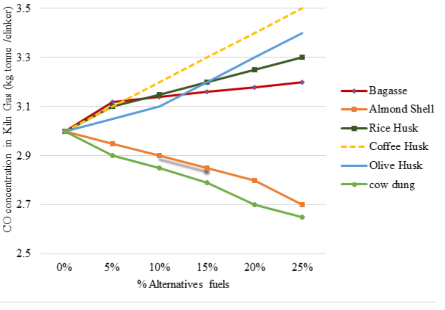

Figure 2. Emission of carbon mono-oxide from kiln (kg/ tonne21 clinker).

Theextra air, feed rate,fuel type in the combustion region, andtemperature of flame all affect the % ofSOX and NOXin the furnace gas. Manufacturing of cement is responsible for 1- 9 kg of NOX emissions per tonne. The NOX content in the furnace gas is shown in Figure 3. In terms of NOX emissions, the findings indicate that a thermal replacement of up to thirteen percent for every alternative fuel is acceptable. In fact, substituting almond shell for up to twenty five percent of the furnace gas will maintain the NOX content below the standard. Figure 4shows that utilizing any of the agricultural biomass resulted in a constant decrease of SOX in the furnace gas, which is consistent with previous findings. It's worth noting that the global acceptable limit for SOX emissions is 200-500 mg Nm23, and the model findings showed that it was less than 110 mg Nm23. This emission rate is permitted.

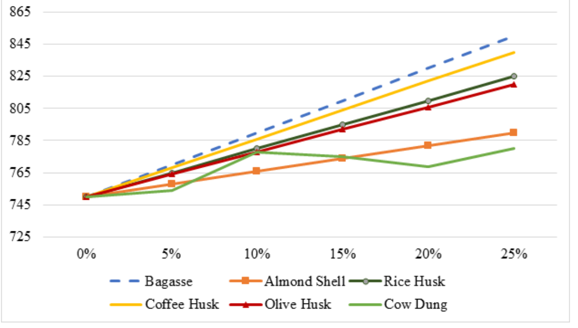

Figure 3. Concentration of NOX in the kiln gas (mg m23).

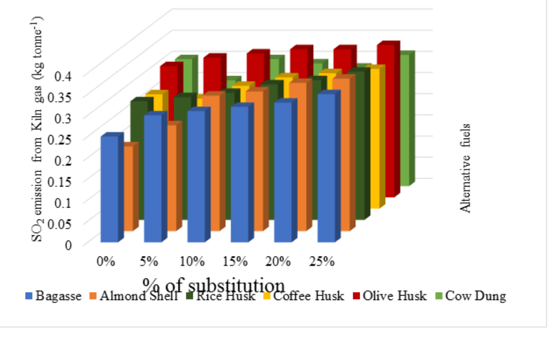

Figure 4.Total sulphur di-oxide emission from calciner (kg/tonne21 clinker).

Clinker production may be harmed as a result of utilizing alternative fuels in the furnaceprocedure, and the cost savings obtained from using other fuels may be lost as a result of the decreased output. Besides rice husk, the outcomes in Figure 5show that all of the other alternative fuels investigated in this research may reduce clinker formation. The simulated kiln capability was 2200 tonnes per day, and if the capability was increased to 2196 tonnes per day. Another kiln characteristic that influences clinker quality is the temperature of the flame in the kiln.Reduced flame temperatures may cause clinker to crystallize quickly, changing the proportion of constituents in the clinker. Because no appropriate sensor exists to detecttemperatureof flame, temperatures of furnace gas are often employed to assess the furnace's atmosphere. The temperature of the furnace gas ranges from 1710 to 2110 degrees Celsius. Figure 6 depicts the modeled furnace gas temperature when various alternative fuels are used. Apart from almond shell, cow dung, all of the alternative fuels were made to keep the furnace gas temperature within the allowed range.

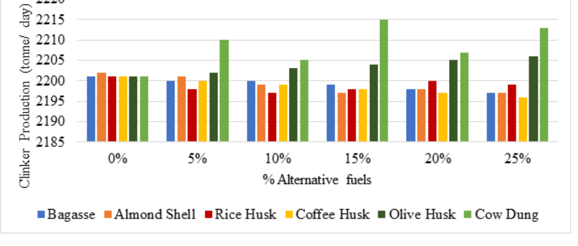

Figure 5.Everyday clinkerconstruction from model out comes (tonne/day)

Free lime is an essential characteristic in clinker manufacturing since it is utilized to determine how the clinker is burned. The right amount of free lime is important for monitoring the furnace operation and achieving significant heat energy reductions. The free lime data produced by the experiment is shown in Figure 7. The results indicate that simply using rice husk decreases the amount of free calcium oxide (lime) in the clinker. Raising in free calcium oxide (lime) owing to the utilize of other farming biomasses are not significant and are unlikely to have an impact on clinker quality.

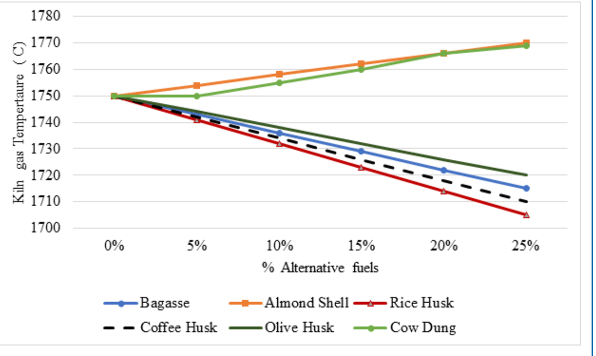

Figure 6.Temperature of outlet gas (K)

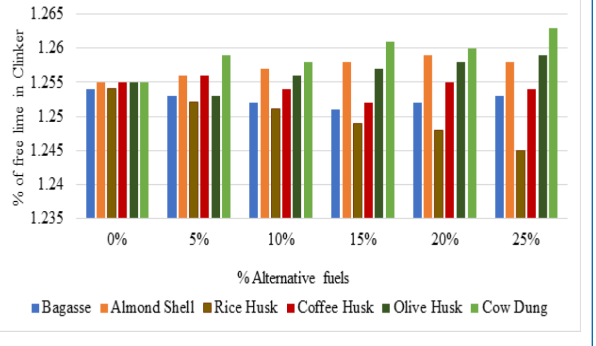

Figure 7.FreeCaO (lime) %, exist in the clinker.

The furnace model was utilized to evaluate the energy efficiency obtained, with replacement rates for alternative fuels of twenty, fifteen, fifteen, twelve percent, and 13.5 percent for rice husk, olive husk, coffee husk, almond shell, and bagasse, correspondingly. The contaminant emission limits, and necessary daily clinker output established those percentage values. The quantity of overall fuel input in the procedure was decreased after the replacement rate was fixed until the model generated outcomes that agreed with all of the cut-off points. Alternative fuel which is substituted results in an increase in energy efficiency. The simulation's outcomes are reported in fig. 8, 9 and 10.

The findings in fig. 9 and 10 indicate that the chosen biomasses are capable of lowering both energy requirements and emissions of carbon dioxide. Coffee husk may be substituted for 12% of the time, improving energy efficiency by three percent and reducing emissions of carbon dioxide by 1.4 percent. Almond shell may reduce emissions of carbon dioxide by 3.5 percent while decreasing total clinker output and lowering flame temperature. Based on the modeling findings, it was discovered that substituting rice husk for fifteen percent of the heat energy may improve overall clinker output by approximately three tonnes per day2. In addition, it lowers energy consumption and emissions of carbon dioxide by approximately 2.4 and 1.5 percent, correspondingly. When rice husk was used as an alternative fuel, the furnace gas temperature was discovered to be minimum, which may be a problem for the excellence problem of clinker. Bagasse may be utilized to generate up to twenty percent of overall heat energy, reducing emissions of carbon dioxide by one percent and increasing energy efficiency by2.5 percent. Olive husk has the ability to increase energy efficiency by 2.5 percent while reducing emissions of carbon dioxide by0.9 percent.

3.1 Model outcomes for energy efficiency (Fig. 8-10)

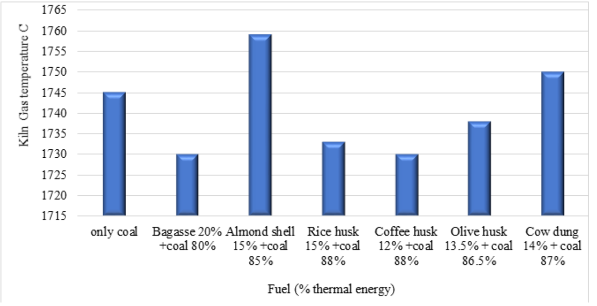

Figure 8. Temperature of kiln gas, in°C (model outcomes)

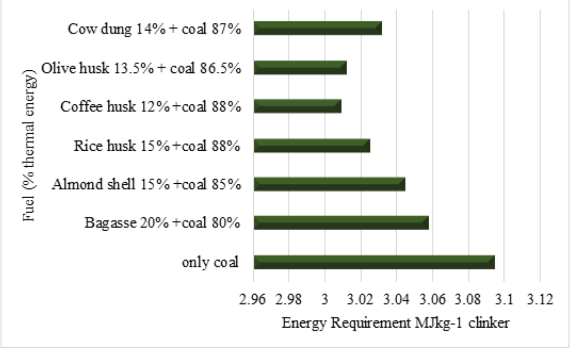

Figure 9. Energy Requirement MJkg-1 clinker (model outcomes)

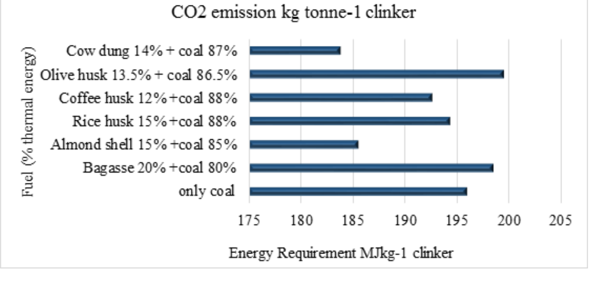

Figure 10. CO2 emission kg tonne-1 (model outcomes)

3.1 Environmental advantages of alternative fuels using in cement industry

Alternative fuels have received a lot of interest in latest years due to their capability to reduce the quantity of GHGs (greenhouse gases) emitted into the environment. The development of alternative shipping fuels is a critical aim since shipping accounts for fifty percent of GHGs (greenhouse-gas) emissions in certain regions. Unlike biofuels, fossil fuels discharge previously held carbon dioxide into the environment, raising the total quantity of carbon in the environment.

The majority of alternative fuels have a significant capability to reduce carbon dioxide emissions into the environment. The impact of a fuel on carbon emissions is determined by a number of variables, including how it fires, the substance it is made of, and the quantity of fuel it takes to make or purify it.

There are two basic beneficial factors of alternative fuel.

- **Decrease pollution**

Alternative fuels reduce hazardous**exhaust** emissions (like CO, SO_2, particles and CO_2) and ozone-generating emissions significantly.

- **Protect against climate change**

According to a broadlyaccepted scientific hypothesis, combustingfuelsof fossils triggers temperatures in the increase in planet's environment to increase (climate change). Despite the fact that climate change stays a hypothesis, severalpersons around the world consider that discoveringresources of fresher fuel is a crucialmovein the direction ofenhancing the excellence of ecosystem.

- **The most suitable alternative fuel and its impacts on environment**

Biomass:- It was the most suitable alternative fuel among all alternative fuel. The environmental impacts of biomass are given below.

- **Biomass is a renewable energy source**

Energy of the biomass has the advantage of being a sustainable form of energy that cannot be exhausted. Plants are the origin of the biomass, which implies that for as long as plants persist on our planet, biomass will be available as a renewable source of energy.

- **Biomass prevents global warming by decreasing greenhouse gases (GHG)**

Biomass aids in the decrease of emissions of greenhouse gases, which have a larger effect on global warming. When compared to fossil fuels, emissions of biomass are far lower. When it relates to emissions of carbon, the main difference between biomass and fossil fuels is that throughout the biomass energy generation, entire carbon dioxide that has been taken by the plant for its development is released back into the environment. While carbondioxide generated by fossil fuels is emitted into the air, it contributes to global warming.

- **Clean the environment**

Biomass energy contributes to the clean-up of our surroundings. With an ever-increasing global population comes an ever-increasing amount of trash that must be thrown away. Numerous chunks of garbage wind up in supplies of water, harming environments and jeopardizing health of human being. This garbage may be valorized and converted intoother supplies, energy, andbiofertilizers.

- **Biomass is broadly obtainable resource of energy**

Biomass is a commonly accessible source of energy. Farming, forestry, fishery, aquaculture, algae, and trash are all sources. Several energy experts believe that when the financial and ecological features of energy resources are studied,one of the best choices is biomass.

3. DISCUSSION

This study concluded that almond shell, olive husk, rice husk, coffee husk, cow dung and bagasse may substitute for 15 percent, 13.5 percent, 15 percent, 12 percent, 14 percent and 20 percent of thermal energy, respectively. Despite a modest decrease in overall clinker generation, coffee husk was shown to improve approximately three percent of energy efficiency over the reference scenario of hundred percent coal combustion. Rice husk, on the other hand, has the potential to boost daily output while reducing emissions of carbon dioxide by 2.4 percent. For all chosen alternative fuels, emissions of NO_x were found to be greater than the reference scenario and may be maintained within the regulatory limit by decreasing the replacement rate. All 6 agricultural biomasses produced less sulfur dioxide, whereas the other alternative fuels, with the exception of cow dung, produced more carbon mono-oxide. Only rice husk has the capacity to decrease the quantity of free lime in the clinker, according to the outcomes.

Selim T et al. (2010) discussed in their research that cement is a high-capital, energy intensive and important industry of national framework building. In latest years, the international cement business has risen at a growing amount than other requirements, but it represents a modest percentage of global production. In development nations, efforts to safeguard the public, and especially in Europe, drove cement production companies to relocate to under harsh ecological rules. This has led to a pattern in corporate accomplishment and ecological protection together with steadily growing actual costs [14]. A study done by Saini et al. (2015) on the use of alternative fuels in cement kiln at Dalla Cement Factory in Uttar Pradesh in India. Accordingly, it is assuming that Indian cement industry has been doing rigorous efforts to increase the thermal substitution rate (TSR) 20 to 30% by utilization of alternative fuels by 2020 [15].

An evaluation on clinker manufacturing was done by Zhang CY et al. (2018) stated that the manufacture of clinker is the major sources of carbon di-oxide emissions from commercial processes and accounts for roughly half of the entire carbon di-oxide emissions from commercial processes. Moreover, little study did not address the effect of the changing socio-financial growth of environment on procedure-associated carbon di-oxide emissions from worldwide cement manufacturing [16].

A similar study on biomass was carried out by Zeidabadi ZA et. al. 2018. According to them cement is a necessary component of urbanism, and its manufacturing accounts for the majority of global carbon dioxide emissions. The usage of chemicals effective for the replacement of material that causes greenhouse gas emissions, particularly carbon dioxide , may help to decrease climate change, which is produced by the release of GHGs (greenhouse gases)into the atmosphere. Ash of agricultural waste is one of these resources, which has been shown to be appropriate for partly replacing Portland cement in concrete production and may help to reduce cement manufacturing's environmental effect.Overall, it was determined that rice husk and bagasse biochars are good replacements for concrete and may be utilized without damaging the environment. [17].

CONCLUSION

In this research 6 types of agriculture biomass were taken, and they were capable of lowering both energy requirements and emissions of carbon dioxide. The 6 agricultural biomasses were coffee husk, almond shell, rice husk, bagasse, cow dung and olive husk. The findings of the research showed that the agriculture biomasses are one of the best alternative fuel among all alternative fuels which can reduce greenhouse gas emissions and has less adverse impacts on environment, use of biomasses in cement manufacturing process will reduce the carbon dioxide emissions which is generated through cement industry. The 6 types of agriculture biomasses used in this study were environmentally friendly and cost-effective.

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