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Controlling of CO_2 emission in buildings: An overview

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Abstract
Normally buildings generate nearly 40% of annual global CO_2 emissions throughout the world. Of the total emissions, building operations are responsible for 28% annually, while building materials and construction (typically referred to as embodied carbon) are responsible for an additional 11% annually. For every 1.0 Ton of cement produced, 0.8 Ton of CO_2 was emitted. Also, depletion of natural resources could be caused by excessive use of conventional aggregates (granite, gravel etc.) and their quarrying could lead to environmental issues. Three construction materials such as concrete, steel, and aluminum are responsible for 23% of total global emissions. Direct and indirect emissions from building operations is about 9 GT in 2020, after having risen an average 1% per year since 2010. In 2020 a drop in buildings sector CO_2 emissions resulted primarily from lower activity in the services sector. Despite the expected rebound in emissions in 2021 being moderated by continued power sector decarbonization, buildings remain off track to achieve carbon neutrality by 2050. To meet this target, all new buildings and 20% of the existing building stock would need to be zero-carbon-ready as soon as 2030. Agricultural residues have recently been adopted in concrete in different forms, some of which are as geopolymer reinforcement, replacement of aggregates and replacement of cement. An overview on studies carried out on selected agricultural residues used as partial substitution for cement in mortar and concrete is presented in this paper.

Keywords: CO_2, buildings, partial replacement, mortar, agricultural residues, concrete

Introduction
The rapid growth in urbanization and construction is increasing the demand for cement and aggregate, especially for concrete production. However, the production of cement and concrete increases the emission of carbon dioxide, and the source of natural aggregates to deplete. Hence, alternative materials are needed for concrete applications. Concrete is the mixture of various materials, aggregate (fine and coarse), cement & water. Each of them is mixed in different amounts to realize specific strength. Concrete is the most widely and extensively used material in the world. The concrete industry generates severe environmental problems. Cement manufacture is an energy-intensive and highly polluting process that gives about 5–8% to overall carbon dioxide (CO_2) emissions. This high influence is because each ton of cement manufacture releases one ton of CO_2 to the air from both fuel and cement raw material burning. The waste materials recycling in concrete as a partial substitution of cement is a practical policy for reducing cement use, Therefore, lessening the environmental influences of concrete production.

Literature Review
Agricultural residues
Agricultural residues are waste products obtained after the consumption, processing or use of agricultural products. After the harvesting and consumption of some agricultural products such as corn, groundnut and sugarcane; abundant wastes are leftover such as corn cobs, groundnut shell and sugarcane bagasse. The processing of some agricultural products such as timber, palm oil, and rice; also led to generation of wastes such as sawdust, palm kernel and rice husk. According to Ref. [30], plants have high silicate content, which are absorbed from soilduring growth. This high silicate content makes plants residues pozzolanic in nature and are therefore suitable as supplementary cementitious materials (SCM) in concrete. In this study, agricultural residues that are used as SCM in mortar and concrete were considered. These are residues that possess pozzolanic properties and are used as partial replacement for cement in concrete or mortar. The mixture could be done on site or in the factory during cement manufacturing. Where done in the factory, the residue is used to replace part of the cement clinker thus, blended cement is produced.

The residues discussed under this category are: corn cob ash (CCA), corn stalk ash (CSA); Corn husk ash (CHA), rice husk ash (RHA); sawdust ash (SDA); wood ash (WA); sugarcane bagasse ash (SCBA); palm oil fuel ash (POFA); cocoanut shell ash (CSA) and neem seed husk ash (NSHA).

Wood Ash (WA)

It is prepared from the uncontrolled burning of the saw dust is evaluated for its suitability as partial cement replacement in conventional concrete. The saw dust has been acquired from a wood polishing unit. The physical, chemical and mineralogical characteristics of WA is presented and analyzed. The strength parameters (compressive strength, split tensile strength and flexural strength) of concrete with blended WA cement are evaluated and studied. Two different water-to-binder ratio (0.4 and 0.45) and five different replacement percentages of WA (5%, 10%, 15%, 18% and 20%) including control specimens for both water-to-cement ratio is considered. Results of compressive strength, split tensile strength and flexural strength showed that the strength properties of concrete mixture decreased marginally with increase in wood ash contents, but strength increased with later age. The XRD test results and chemical analysis of WA showed that it contains amorphous silica and thus can be used as cement replacing material. Through the analysis of results obtained in this study, it was concluded that WA could be blended with cement without adversely affecting the strength properties of concrete.

When this is used as the interchange with cement materials it will increase the strength and does not affect the environment with their Co2 emission. Also, the usage of wastes generated from the biomass industries (sawdust, woodchips, wood bark, saw mill scraps and hard chips) as fuel offer a way for their safe and efficient disposal. Y reduces the mass and the volume of the waste thus providing an environmentally safe and economically efficient way to reduce emission. It is commonly observed that the hardwood produce more cash than softwood and the bark and leaves generally produce more ash as compared to the inner part of the trees. The most prevailing method for disposal of the ash is land filling which accounts for 70% of the ash generated, rest being either used as soil supplement (20%) or other miscellaneous jobs (10%).The characteristics of the ash depend upon biomass characteristics (herbaceous material, wood or bark) Extensive research is being conducted on industrial byproducts and other agricultural material ash like wood ash or rice husk ash which can be used as cement replacement in concrete.

Due to current boom in construction industry, cement demand has escalated which is the main constituent in concrete. Also, the cement industry is one of the primary sources which release large amounts of major consumer of natural resources like aggregate and has high power and energy demand for its operation. So, utilization of such by product and agricultural wastes ashes solves a twofold problem of their disposal as well providing a viable alternative for cement substitutes in concrete. Researchers have conducted tests which showed promising results that wood ash can be suitably used to replace cement partially in concrete production. Hence, incorporating the usage of wood ash as replacement for cement in blended cement is beneficial for the environmental point of view as well as Producing low cost construction entity thus leading to a sustainable relationship.

The basic aim of this study was to investigate the effect of wood ash obtained from uncontrolled burning of Sawdust on the strength development of concrete (Compressive strength, Flexural strength and Split Tensile strength) for two different water–cement ratio so we can comfortably use the saw dust as a replacement of cement mixture with environmentally safe condition. The process employed for generation of wood ash can be improvised as this research employed the wood ash obtained from the uncontrolled burning of saw dust. Quantity and quality of wood ash are dependent on several factors namely combustion, temperatures of the wooden biomass, species of wood from which the ash is obtained and the type of incineration method employed. So, as such any future work must focus on the above factors to produce a more reactive ash by working out optimum condition for the production of amorphous silica.

Neem Seed Husk Ash

The production of neem products from neem tree generates large quantity of waste annually. There is need to reduce environmental pollution resulting from neem seed covering. Therefore, the use of Neem Seed Husk Ash (NSHA) as partial substitution for cement in concrete was investigated. Neem seed husk was obtained from Bishop Smith Memorial College, Ilorin, Nigeria; sun – dried for 3 days and then calcined at 650 o C. The calcined neem seed husk was ground and sieved using 200 μm sieve to obtain NSHA. Pozzolanicity test was conducted on NSHA to determine its chemical composition. Concrete was produced with 5, 10, 15, 20 and 25% by weight of NSHA substitution for ordinary Portland cement. Workability tests (slump and compacting factor) were performed on fresh concrete while compressive strength test was conducted on 150 mm cubes at ages 3, 7, 14, 21, 28, 56, 90 and 180 days for the hardened concrete. NSHA mainly comprises Al_2O_3, SiO_2 and Fe_2O_3 with a combined percentage of 75.35%. The slump and compacting factors of NSHA concrete ranged from 5.50 mm to 10.00 mm and 0.91 to 0.95, respectively. The compressive strength at 180 days decreased from 26.9 N/mm^2 to 19.4 N/mm^2 as the NSHA content increased from 5% to 25%. Only 5% NSHA substitution is adequate to enjoy maximum benefit of strength gain [2].

Corn Stalk Ash (CSA)

Corn stalk is obtained from maize after harvesting dried corn hub from the stand (See Fig 1). CSA is obtained by burning corn stalk at calcining temperature of 600 degree C for 7 h. In terms of chemical composition, CSA satisfies the combined chemical composition of silica, alumina and iron oxide above 70% [12], which classifies it as a good pozzolan according to ASTM C 618 [13]. CSA was used to replace part of cement in the production of interlocking paving stones [12]. As observed for CHA, as curing age increases the compressive strength increases and increased amount of CSA results in decreased compressive strength [12]. Optimum percentage recommended by Raheem *et al*. [12] for use in interlocking paving stone with minimum curing of 28 days is 10% CSA.

Fig 1: Dried Corn Stalk and ash [12].

Rice Husk Ash (RHA)

Rice husk is a waste product obtained from rice production. The husk is removed from the rice during harvesting on farm. According to Khan *et al*. [6], up to 78% rice and 22% rice husk could be produced in the process of milling. Rice husk is in abundance in East and South Asia as a result of the favourable environmental condition for rice growth in these regions [5]. Rice husk ash (RHA) is obtained after burning rice husk. The silica content in the RHA turns into amorphous phase (which makes it more reactive) when calcined at a temperature of about 700 degree C. Several researchers had worked on the chemical composition of RHA and Table 1 indicated their findings. It could be observed from the table that SiO2 is the predominant content in RHA with values ranging from 82.14 to 91.15%.
The high silica content and its fineness, which is greater than that of cement makes it one of the widely used SCM confirms that RHA can be classified as a pozzolan having the percentages of SiO2 þ Al2O3 þ Fe2O3 above 70% as specified in ASTM C 618 [13]. As determined by Ganesan *et al*. [8], the mean grain size (MGS), average specific surface area (SSA), bulk density (BD), specific gravity (SG) and loss on ignition (LOI) of RHA are 3.80 µm, 36.47 m2 /g, 0.40 g/cm3, 2.06 and 2.10%, respectively. The MGS, SSA, BD and SG have lesser values than those of ordinary Portland cement (OPC), which are 22.50 µm, 326 m2 /kg, 1.16 g/cm3 and 3.10, respectively. Lower MGS and LOI usually contribute to increase in compressive strength of pozzolan concrete. In term of compressive strength, it was reported by Ganesan *et al*. [8] that the compressive strength of RHA blended cement mortar increases with addition of RHA up to 15% and then decreases. However, the 30%
RHA replacement attained the same compressive strength value as the control. A similar trend was obtained for compressive strength of concrete, which increases with RHA replacement up to 20% and 30% RHA addition having same strength as the control. The increase in compressive strength is partly due to pozzolanic reaction and partly as a result of the low MGS and high reactivity of silica in RHA. Optimum replacement of RHA was put at 30%. In addition, RHA enhanced the performance of the ultra-high performance concrete (UHPC) [10]. Mosaberpanah and Umar [10] reported that with improved pozzolanic reaction of RHA when used as a partial replacement of cement up to 30%, improved compressive strength, splitting tensile and flexural strength was observed at early and longtime ages. A recent investigation [9] showed that the inclusion of lime in the RHA-concrete could increase the compressive strength by 45% when cement is being replaced by 15% RHA.

Table 1: Chemical composition of RHA

References	Common Oxide Composition (%)						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	MgO	K_2O
Raheem and Kareem [18]	82.14	1.34	127	1.21	0.14	1.96	2.09
Ganesan *et al.* [8]	87.32	0.22	028	0.48	1.02	0.28	3.14
Liang *et al.* [18]	93.1	0.30	020	1.50	0.06	0.60	2.30
Khan *et al.* [40]	89.50	0.40	2.86	0.30	-	0.25	-
Mohseni *et al.* [41]	91.15	0.41	021	0.41	0.05	0.45	6.25
Chatveera and Lertwauanaruk [42]	90.61	0.50	1.40	0.82	0.02	0.50	1.92

Khan *et al*. [6] performed x-ray diffraction analysis on RHA using XRD Diffractometer, Siemens D500 with K radiations. The result as indicated in the irregular shapes of RHA particles assisted in its filling effect capacity. The water permeability property of RHA blended cement concrete was studied by Genesan *et al*. [8]. At 28 days, water absorption capacity of RHA concrete increases as RHA content increases up to 35%. Also, increased in water absorption was observed with RHA concrete [1] at 20% RHA replacement of cement and lime RHA concrete [9] at 15% RHA replacement of cement. However, decrease in water absorbed was observed as RHA content increases up to 25% at 90 days. This indicated that prolonged curing of RHA blended cement concrete led to reduction of permeable voids. Chloride permeability was also reduced when OPC was replaced with RHA up to 30%.

Sawdust Ash (SDA)

Sawdust is a waste produced after the timber has been sawn into planks at sawmills. This is in readily available in countries that have thick forests with abundant trees. As production progresses, sawdust is being piled up at the sawmills, thereby constituting environmental Nuisance. Sawdust ash (SDA) is obtained by incinerating sawdust at temperature of 650 degree C in about 8 h. The chemical composition of SDA had been widely studied. Table 2 showed the elemental composition of SDA as obtained by various researchers. It could be observed from Table 2 that SiO2 is the main elemental oxide in SDA with composition ranging from 65.30% to 78.92%. The combined SiO2 þ Al2O3 þ Fe2O3 of more than 70% as stipulated by ASTM C 618 was satisfied by all the authors. Thus, SDA is a good pozzolanic material. The physical properties of SDA as obtained by Refs. [3] are specific gravity - 2.16, mean size – 170 µm and bulk density – 720 kg/m3.

Table 2: Summary of chemical composition of SDA.

References	Elemental Oxide Composition (%)							
	SiO_2	Al_2O_3	Fe_2O_3	Ca0	Mg0	K_2O	Na_2O	LOI
Raheem and Ige [12]	69.29	522	2.03	10.07	5.48	0.86	9.68	3.64
Raheem *et al.* [13]	65.75	523	2.09	9.62	4.09	2.43	0.06	4.30
Chowdhury *et al.* [43]	65.30	425	2.24	9.98	5.32	1.90	2.60	4.67
Elinwa *et al.* [44]	67.20	4.10	2.30	10.00	5.80	0.10	0.10	-
Udoeyo and Dashibil [45]	78.92	0.89	0.85	0.58	0.96	-	0.43	8.40
Elinwa and Mahmood [46]	67.20	4.09	2.26	9.98	5.80	-	0.08	4.67

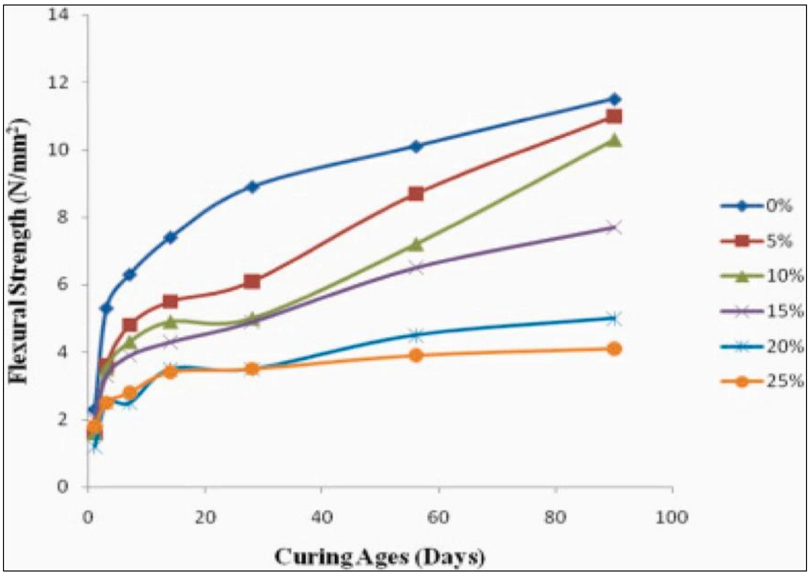

Fig 2: Flexural Strength

According to Ref. [5], concrete becomes stiffer as the SDA content increases. Therefore, increased water content is needed for workable concrete. The compressive strength of SDA concrete was investigated by Elinwa and Mahmood [18]. The results indicated that the compressive strength decreases as the percentage of SDA in the mix is increased. This result was corroborated by Raheem *et al.* [5] who extended the curing period beyond the 28 days studied by Elinwa and Mahmood [18] and discovered that prolonged curing is more beneficial to SDA concrete. The study found that higher percentage increase in strength were recorded beyond 28 days. The significant increase in strength was due to pozzolanic reaction of SDA and the continuous hydration of cement. Raheem and Ige [17] studied the flexural strength of SDA mortar. The results as shown in Fig 2 indicated that flexural strength of mortar increases with age and decreases with increase in SDA content. The optimum percentage replacement was 15%. Chowdhury *et al.* [16] studied the splitting tensile strength of SDA blended concrete and X-ray diffraction analysis of SDA sample. It was observed that higher SDA substitution resulted in reduction of splitting tensile strength. The reduction effect of increased SDA content was lower in relation to that of compressive strength result. The reduction could be because of the filler activity of SDA particles in the concrete [18].

Conclusion

There are many ways to reduce greenhouse gas emissions from the industrial sector, including energy efficiency, fuel switching combined heat and power, use of renewable energy, and the more efficiency use and recycling of materials. Reducing your carbon footprint is important because it mitigates the effects of global climate change, improves public health, boosts the global economy, and maintains biodiversity. When we cut carbon emission we help ensure cleaner air, water, and food for our generation and for generations yet to come. The use of waste heat as an alternative source of energy, CO2 capture and storage technologies, reduction of clinker to cement ratio, the use of alternative and biomass fuels, the use of alternative raw materials of energy. Increasing sustainability awareness has put the concrete industry in the spotlight to reduce its carbon dioxide emissions. Most of the carbon dioxide emission from the concrete industry is from the production of Portland cement which is the main binder in concrete, and the transportation of materials. Also, the production of other components in concrete such as aggregates, admixtures, and construction processes contribute to the industry's emission.

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