Research Paper

Investigative Study of Wood Ash (WA) Application as Oilfield Cement Additives

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Abstract
The development of oilfield additives from locally sourced biomass has always been at the front burner of research at the local content level, as many of these wastes constitute environmental pollution. Hence, recycling them into useful oilfield cement additives becomes expedient. Wood wastes are among the wastes on top of the list of biomass raising environmental concerns over decades. Its conversion to wood ash by incineration has not abated the challenge posed by it because wood ash (WA) accumulation is hard to manage, hence the need for this work.In this work, the focus was on the comparative investigation of wood (WA) and polymer-lignosulphonate (LS) as oil field additives. The rheological properties of cement slurries were formulated with WA and LS at 0.1 and 0.2% at temperatures - 80℉, 120℉, and 150℉. The results showed that the local and imported polymer acted as a dispersant at 0.1% concentration in the cement slurries as the temperature increased because, at the above concentration, the plastic viscosity of WA-based slurry decreased from 49 – 7.90 while that of LS-based slurry decreased from 121.5 – 2.WA-based cement slurry showed a reversal of dispersing property between 0.15 – 0.2% of WA. WA polymer also reduced the volume of free fluid and increased the pH of the cement slurry from 7.0 to 8.0 (alkaline). The above results showed clearly that WA polymer performed excellently with LS as an oil field additive and could serve as a substitute.
Keywords: *lignosulphonate, wood ash, rheology, polymer, dispersant, additive, biomass*

I.   Introduction

Wood ash (WA) is the end product of the combustion of wood. Burning biomass wastes such as sawdust from paper mills is one of the conventional methods of waste disposal. In the process of burning agro-wastes, a considerable amount of ash is generated, [22]. Wood Ash (W A) is a waste and its generation is fast growing, resulting in a serious environmental concern. It was gathered that the estimated amount of wood ash in Hungary was 30 thousand tons and its volume was 50 thousand m^3, [37]. In Nigeria, a large volume of wood waste is churned out annually. Sawmills in Nigeria produce more than one million meter cubes ($100000m^3$) of waste wood and the plywood industry produced five thousand meters of a cube of waste in 2010, [25]. It was equally gathered that they generate over 1.8 million tons of sawdust and 5.2 million tons of wood waste yearly, [25]. Population growth and urbanization have also continued to increase the growth of wood ash at an alarming rate through electric power generation by wood-burning industries utilizing woodchips, wood barks, sawmill scraps, hardships, and wood sawdust as a fuel source, [5] and by so doing produce a large of quantity of wood ash, which can pose the risk of health threat to the biotic environment are accumulated, [8], if not properly managed. The only known and effective wood ash disposal method is landfill which takes care of about 70% of wood ash disposal, [10, 16] and it has been in use over the decades. In the landfill disposal method, there is an inherent respiratory-related issue for the people living around the dumpsite due to the highly fine particles which WA has that get easily airborne, [5]. It also causes pollution of the underground water through the leaching of its heavy metal components, [38]. Hence, the landfill method of WA disposal has not sufficiently addressed the problem of pollution and economics. Finding the industrial use of wood ash in the oil and gas industry would go a long way to solve the problem of pollution and hence take advantage of the useful components for monetization of WA, thereby adopting the most economic approach to wood ash disposal. WA is rich in SiO_2, P_2O_5, SO_3, K_2O, CaO, TiO_2, V_2O_5, MnO, Cr2O3, Fe_2O_3, ZnO, CuO, Y_2O_3, Ag2O, BaO, Eu2O3, Re2O7, HgO,

and CeO while Al_2O_3 was found in both X-ray fluorescence (XRF) and Scanning Electron Microscopy (SEM) tests carried out, [5].

Wood ash has various uses which have been explored by some researchers, though not exhaustive. WA is used in agriculture, horticulture, and forestry as a source of manure for soil amelioration, [12,32,41] as a result of its micro-element and macro-element components. The aforementioned use of wood ash has not been able to address the environmental concerns posed by the enormous quantity produced annually.

It also has high lignin and cellulose contents, making it a veritable locally sourced material for oil field additives. For instance, wood ash is used in the bioremediation of soil polluted with oil spills[15]. WA has been used in the improvement of the fertility of the soil for high productivity but can release heavy metals like sodium and the like. Sodium (Na) poses unfavorable conditions for cultivated crops by excessively raising the salinity of the soil to as high as 60mg/kg, [22]. Wood ash was experimentally examined to ascertain its ability to treat oil-contaminated soil in comparison with the chemically synthesized surfactant, Tween 80. WA achieved 94.54% success while Tween 80 had 90.28% success, [1]. This is a clear indication that WA is a good surfactant. However, the application of WA has not been harnessed in the area of cement and mud additives, specifically, oil field cement and mud dispersant. The surfactant ability of wood ash in oil spill clean-up shows that it could do well serving as an oil field additive. Hence, this work focused mainly on experimentally studying AW as oil field cement and mud additives. This is to help abet the problem of environmental pollution, and health hazard to man and optimize cement and mud slurry designs.

Wood Ash Effects on the Environments

Wood ash has been proven to have some useful applications in the agricultural sector to improve the fertility of the soil, reduce the acidity of the soil, [22], pollution control i.e bioremediation procedure, [1]. As of 2012, forest biomass, of which wood waste contributed a very high portion was expected to hit 231 million tons in the United State of America and grow more to 286 million tons in 2017, [11]. It was gathered from some research works that WA has different components as observed in the SEM and XRF tests conducted. These constituents include: SiO_2, P_2O_5, SO_3, K_2O, CaO, TiO_2, V_2O_5, MnO, Cr_2O_3, Fe_2O_3, ZnO, CuO, Y_2O_3, Ag_2O, BaO, Eu_2O_3, Re_2O_7, HgO, and CeO but lacks Al_2O_3, [18, 5]. The components mentioned above contribute to the characteristic functions of wood ash for different purposes. Wood ash is in abundance globally and it could pose health challenges to the biotic environment and edaphic factors through the release of heavy metals. It has the potential to chemically alter the composition and pH of the soil, especially the top layer, [28, 29]. However, it was also gathered that the wood ash reduces the mobility of the heavy metals when it is released into the soil, [39, 10], making it less toxic but still limiting its use coupled with the fact that urbanization and population have added so much the increased production wood ash globally, [5], making a potential threat to environments and lives. It was however argued that the chemistry of the wood ash is dependent on the species of wood burnt, the nature of the combustion process, and conditions at the application site. In the UK, it was discovered that recycling wood ash is posing a big challenge in management and requires carefully tailor-made biomass project design, [14].

Also, wood ash has been studied by many researchers to evaluate its capacity to be used for engineering projects like construction, [3] concrete mixtures, [34], and soil stabilization, [35, 27] but other applications of wood ash have not been delved into, which could be economical and equally solve the problem of pollution which remains unsolved as the production of wood ash is on the increase due the human activities such as industrialization and urbanization. Recycling wood ash for use in the oil and gas industry is gradually gathering global interest but unharnessed. For instance, geotechnical projects always need a large amount of biomass, using recycled wood ash would be a good move, [18]. Wood ash and sugar cane ash have been used as a pozzolanic material in the concrete mixture, [38].This pozzolanic characteristic of wood ash makes it a very good material for the conditioning of oilfield additives. WA can increase the strength of materials from various studies by researchers. Another work revealed that WA has a comparably high specific surface area suitable for a good adsorption process, [20]. Wood ash is generally in a powdered form and has fine particles. Its particle size is responsible for the attribute. Dry sieve analysis done by some researchers showed that it has two-grain sizes; the fine grain which is below 100μm and the coarse grain size which is above 100μm, [13].

Table1 Chemical Composition of Wood Ash (WA) [4, 1, 36]

CONSTITUENTS	WOOD ASH (WA)
SiO_2	31.8
Fe_2O_3	2.34
Al_2O_3	28
CaO	10.53

Na$_2$O	6.5
SO$_3$	-
K$_2$O	10.38
MgO	9.32

Wood ash has been used as a surfactant and its performance was compared with that of Tween 80. WA achieved 94.54% success while Tween 80 had 90.28% success, [1]. This result showed succinctly that WA is a good surfactant. However, it has not been explored in the area of oilfield additives, creating a gap for further studies.

Factors Affecting the Quantity and Quality of Wood Ash

The quantity and quality of wood ash depend largely on some factors such as temperature, wood type, and others. The temperature at which the ash is obtained affects the quality and quantity of ash after combustion. High temperatures yield low quality and quantity of wood ash. It reported that a combustion temperature of 1000.4°F to 1999.4°F would reduce ash production to 45% and the temperature above 1832°F would lead to the decomposition of carbonates and bicarbonates but at the combustion temperature of 932°F results in a high concentration of bicarbonates and carbonates, especially calcite (CaCO$_3$) in ass, [9]. Some elemental components such as potassium, zinc, and sodium decrease in quantity as the temperature increases to 1999.4°F leaving more oxides like quicklime (CaO) in the ash, [10, 16]. The use of ash is dependent on its quality and components (chemical characteristics). Wood ash contains carbonate which could be carbonate of sodium or calcium. According to work done by Campbell, [10], wood ash contains other elemental components at different percentages such as carbon (5 – 30%), calcium (7- 33%), potassium (3 – 4%), magnesium (1 – 2%), manganese (0.3 – 1.3%), phosphorus (0.3 – 1.4%), and sodium (0.2 – 0.5%). In comparison with lignosulphonate, wood ash shares the carbonate component property with lignosulphonate which is responsible for the dispersing characteristic of both polymers.

Lignin Structure and Components

Lignin is a veritable raw material for the production of paper in the pulp and paper industry and it is the most abundant biopolymer known globally, [23]. Rini, *et al.*, [30], categorically stated that unreacted lignin has three basic functional group components which include: phenolic O-H functional group, aliphatic and aromatic -CH- stretching functional groups, and C=C aromatic groups as shown in fig. 1.1. The extraction loop which is done using NaOH is not stopped until the lignin meets the standard required before the process is halted, else, the loop continues until the desired result is obtained.As soon as the sulfonation process which yields lignosulfonate is successfully carried out, there will be alteration in the functional group components as shown in fig.2.2. The new functional groups resulting from the displacement reaction will be alkene functional group (-C=C- aromatic), stretching sulfonate functional group (S=O), carboxyl functional group (C=O) and ester functional group (S-OR) as revealed in the recent work by Rini, *et al.*, [30].Lignosulfonates are highly branched macromolecules and are formed from phenylpropane units connected in a non-regular manner by ether or C–C bonds, the latter between the aromatic ring*s'*(Flatt and Schober, 2012), as shown in **Figure 1.**Lignin with high purity α-cellulose is a veritable raw material for the production of the cellulose ester for making plastics as investigated by Varma AJ [40].
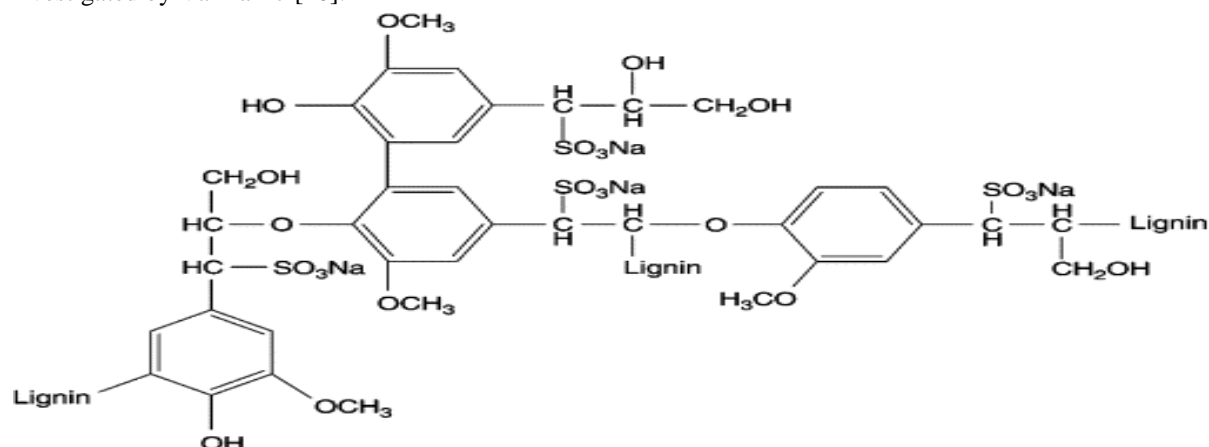

Figure 1 Schematic of Lignosulfonate

Also, Guterman, *et al.*, [31], found out that unmodified lignosulfonate could produce undesirable substances because it cannot maximize interfacial contact and complexation with cellulose and protein.

Carbonate component of Wood Ash and Modified Lignosulphonate

The chemical compositions and structures of modified lignosulphonate (see figure 2.6) and wood ash, [10], show that both of the polymers have carbonates which are responsible for their dispersing characteristics. Calcium carbonate in calcium-modified lignosulphonate is responsible for the anionic surfactant property of lignosulphonate containing hydrophilic end (sulphoric, phenolic, and hydroxyl groups) and hydrophobic end (carbon chain). This makes it have some level of surface activity, [19]. Wood ash obtained at a regulated temperature of about 932°F, [9], also contains carbonate which could be carbonate of sodium or calcium according to work done by Campbell, [10].

Cement Additives

The properties of cement slurry could be unfavorably altered during cementing operation due to variations in temperature and pressure of a zone in consideration, pumping rates, pressure, etc. In a review work done by Joel, *et al.*, [26], it was gathered that these changes could cause problems that can jeopardize the cementing operation integrity. As a result of these potential problems associated with the alteration of the oil well cement slurry properties, additives are added to cement slurries to mitigate them. There are several Oil well cement additives, which include: accelerator, fluid loss, lost circulation materials, retarder, weighting agent, dispersant, deformer and extenders, [26], and they are used for the conditioning cement slurries because of high temperatures and pressures at different zones which could alter the original properties of the cement slurries.

Extenders also known as thinners, are materials used to reduce the density (weight) of oil well cement slurries. So, to prevent fracture of the formation during cementing operation, an extender is added to it. The cement slurry density reduction could be achieved in three ways, depending on the type of extender used. Extenders are of various types. These are physical extenders (organics and clay), pozzolanic extenders, chemical extenders, and gases. Pozzolanic extenders, being an inert organic material, less dense than cement, decrease the density of cement slurries through partial replacement of the cement in the slurries. Retarders are used to increase the thickening time of cement slurries to allow for adequate setting, [21]. Also, they do not decrease the compressive strength of cement slurry, rather, reduce the rate of strength development of cement slurries, [24, 7].Some local materials have been used to develop retarders. Saw dust was used in the formulation of cement additive – retarder and it was found to be good for the retardation of cement slurry setting time, [7].Dispersants are used to lower the very high viscosity of cement slurry for easy pumping and reduction of frictional loss due to high initial viscosity. Dispersants can affect the thickening time of the cement slurry as they increase the hydration capacity of the cement slurry. It equally allows for a high solid-water ratio, preventing fluid loss even at densities, [17]. Dispersants could be organic or inorganic. The organic dispersants are lignosulfonate derivatives like Polynapthalene Sulphonate (PNS), cellulose derivatives, polycarboxylates, and guar gum, which are commonly used these days while the inorganic types are sodium tripolyphosphate, sodium hexametaphosphate, and sodium pyrophosphate. These inorganic dispersants are classified under silicate and alkali metal phosphate, [33]. Displacement of cement at turbulent flow has always proven to be an ideal procedure for near-perfect cementing operation. The incidence of loss circulation associated with it is reduced to the barest minimum using dispersants, [6].

II.   Materials and Methods

Materials and apparatus used for the study include the following; weighing balance, Atmospheric consistometer, Hamilton beach mixer, Fann viscometer, mud cup, measuring cylinder, measuring cup, oven, syringe, wood ash sample, lignosulphonate, water, defoamer, and class-G cement.

Cement Slurry Formulation

Wood ash was obtained from hardwood wastes in a sawmill located in Port Harcourt, Nigeria. Wood ash has been reported to have all the components of wood except carbon, nitrogen, and hydrogen which evaporate during the combustion of firewood (Vance, 1996). The wood ash was simply obtained by burning sawdust from the sawmill. The class G cement and defoamer were obtained from a service company based in Port Harcourt. The cement slurry was formulated using API standard procedure. (API-RP10B-2, 2009) using the same concentration for the imported polymer and local polymer.

The following masses of dried wood ash obtained from hardwood were taken using a weighing balance: of 0.88g and 1.57g, according to the experimental design. The 175.04ml of water was measured and the constant weight (392.12) of the Class-G cement sample was measured with a weighing balance. The percentage concentrations considered for this work were 0.1% and 0.2% and the total slurry density was 15.8ppg according to the design. The samples were carefully prepared using the standard as approved by API. A design was

equally done for lignosulphonate. The following amounts of dried lignosulphonate were measured using a weighing balance: 0.395g and 0.79g at concentrations of 0.1% and 0.2% respectively. Antifoam was 0.445g and 394.75g of class G cement was measured out using a weighing balance and the amount of water used was 173.44ml according**g** to the**e**xperimental design. The total slurry density was 15.8pp

Rheological Property Determination

The rheological properties of the two samples were determined using a Fann viscometer at surface temperature (120℃) and the torque responses for each rotational speed provided by the equipment at 300rpm, 200rpm, 100rpm, 6rpm, and 3rpm were recorded. At each rotation speed, the dial reading was taken when the speed stabilized. The temperature of the samples of lignosulphonate and wood ash treated samples was raised to 120℃ using an atmospheric consistometer. The results were recorded. Free water from both samples was determined at 80℃ and 120℃ by allowing the slurry to stand for 30min. The yield point (YP) and plastic viscosity (PV) were obtained by calculation. The rheological values obtained from the viscometer and various calculations obtained from test results are shown below. The reference for measuring and calculating viscosity was done based on the specifications of API (API RP-13B-1/ISO10414-1, 2016). The features and specifications of the Model-35 Fann direct-indicating viscometer used are equipped with the standard R1 rotor sleeve, B1 bob, F1 torsion spring, and stainless-steel sample cup. The constant values used for the calculation are based on the stipulated standard for R1-B1-F1.

The readings obtained from the viscometer were converted to the oilfield units to get the values for shear stress and shear rate by employing **equation 3** and **equation 4.**

Free Fluid Determination

The free water from both samples was determined by allowing the slurry to stand for 30min. After the samples stood for 30min, the free water on the surface of the cement slurry was decanted into a cylinder and the measurement of the volume of free water was taken using a graduated syringe. The readings were taken for temperatures - 80°F (ambient), 120°F, and 150°F. The readings were taken for wood ash-based cement slurries and lignosulphonate-based samples. The results are shown in the table

Determination of the Plastic Viscosity (PV) and Yield Point (YP)

The plastic viscosity (PV) and yield point (P) of both oil field cement and drilling mud slurries were calculated using **equation 4** and **equation 5**

$$PV\ (cP) = (\boldsymbol{\theta}300 - \boldsymbol{\theta}100) \times 1.5 \qquad 1$$
$$YP\ (lb/100ft^2) = (\boldsymbol{\theta}300 - PV) \qquad 2$$

Where;

$\boldsymbol{\theta}$ = dial reading

The gel strength at 10 seconds and gel strength at 10 minutes were obtained from the Fann Viscometer immediately after the required duration, at the first deflection. This was according to the America Petroleum Institute Specification and procedures (API RP 13B-1/1SO 10414-1, 2016).

Calculation of Shear Stress and Shear Rate

According to the R_1-B_1-F_1 specification

$$Shear\ stress\ (lb/100ft2) = 1.065 \times 1\theta Fann \qquad 3$$
$$Shear\ rate\ (sec\text{-}1) = 1.7023 \times rpm, N \qquad 4$$

N = Rate of revolution of the outer cylinder, rpm

θ = Fann viscometer reading

Viscosity was obtained by the equations (5a, 5b, 5c)and the conversion factors as listed in **Table 4**.

$$\mu = k_1k_2/k_3\ (100)\theta/N \qquad 5a$$
$$\mu = kf^\theta/N \qquad 5b$$
$$\mu = \tau/^\gamma\ (100) \qquad 5c$$

Where;

μ = viscosity in centipoise (cP)

N = Rate of revolution of the outer cylinder (rpm)

θ = Fann Viscometer reading

τ = shear stress, dynes/cm^2 which is calculated as $k_1k_2\theta$

$^\gamma$ = shear rate, sec-1, which is calculated as k_3N

Note: 1Poise = 100cP

III. Results and Discussion

Tabulated readings of Fann Viscometer at Varied Temperatures

Table 1 to**Table 4**show the viscometer reading is obtained at different temperatures for both the LS-based cement slurry and WA-cement slurry.

Table 1 Results of Rheological Properties of Wood Ash-Based Cement Slurry at 0.1%

RPM (θ)	80°F	120°F	150°F
θ_{300}	47	97	135
θ_{200}	39	85	120
θ_{100}	30	72	104
θ_6	13	31	45
Θ_3	10	16	21
PV (Cp)	49	25.5	7.90
YP (lb/100ft^2)	81	21.5	10.20
%FF	1.02	1.4	1.70

Table 2 Results of Rheological Properties of Wood Ash-Based Cement Slurry at 0.2%

RPM (θ)	80°F	120°F	150°F
θ_{300}	42	137	208
θ_{200}	35	128	193
θ_{100}	26	115	156
θ_6	13	24	32
θ_3	10	18	24
PV (cP)	24	33	39.8
YP (lb/100ft2)	18	104	168.5
%FF	2.56	0.6	0.1

Table 3 Results of Rheological Properties of Lignosulphonate-Based Cement Slurry at 0.1%

RPM (θ)	80°F	120°F	150°F
θ_{300}	170	61	31
θ_{200}	120	61	19
θ_{100}	89	55	30
θ_6	33	19	9
θ_3	25	12	2
PV (cP)	121.5	9	2
YP (lb/100ft2)	48.5	52	54.6
%FF	2.68	3.24	3.70

Table 4 Results of Rheological Properties of Lignosulphonate-Based Cement Slurry at 0.2%

RPM (θ)	80°F	120°F	150°F
θ_{300}	48	130	192
θ_{200}	39	112	167
θ_{100}	26	97	150
θ_6	13	22	29
θ_3	9	14	18
PV (cP)	33	49	61
YP (lb/100ft2)	15	81	131
%FF	4.3	2.2	0.73

Effect of Temperature on Shear Stress and Shear Rate Relationship on Imported Polymer (Lignosulphonate) and Local Polymer (Wood Ash) Based Cement
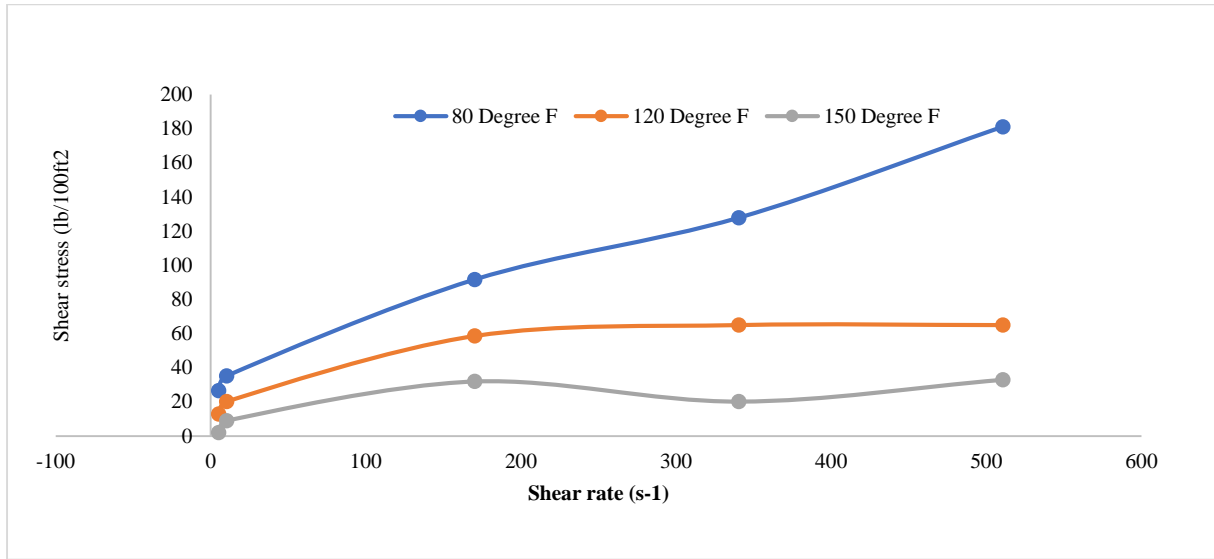

Figure 2 Variation of Shear Stress versus Shear Rate of 0.1% of Lignosulphonate of cement slurry of 15.8 ppg
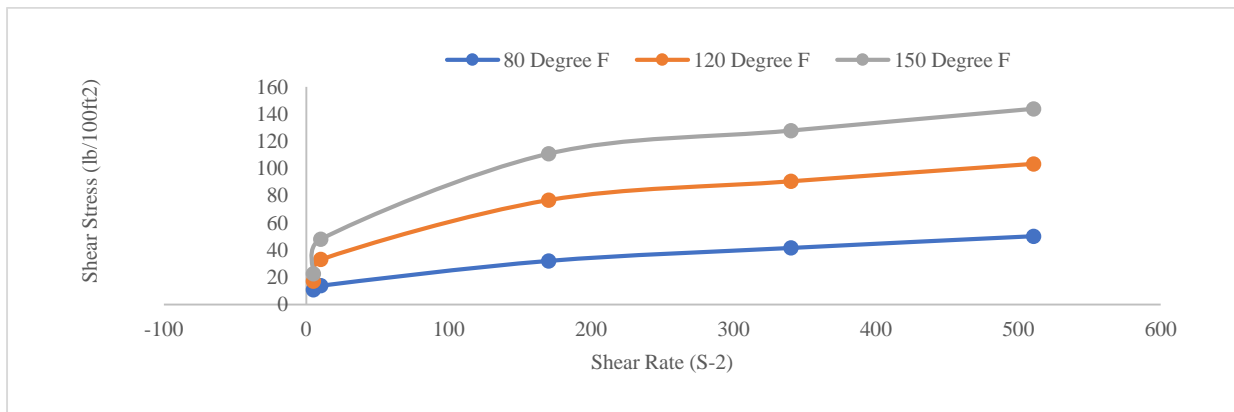

Figure. 3 Variation of Shear Stress versus Shear Rate at 0.1% of Wood Ash of cement slurry of 8.5ppg at Different Temperatures
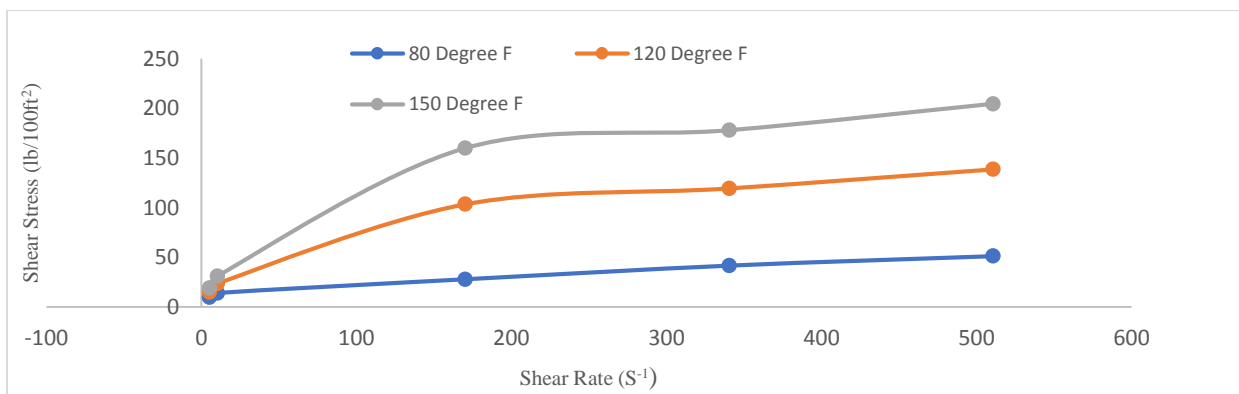

Figure 4 Variation of Shear Stress versus Shear Rate of 0.2% of Lignosulphonate of cement slurry of 15.8pp
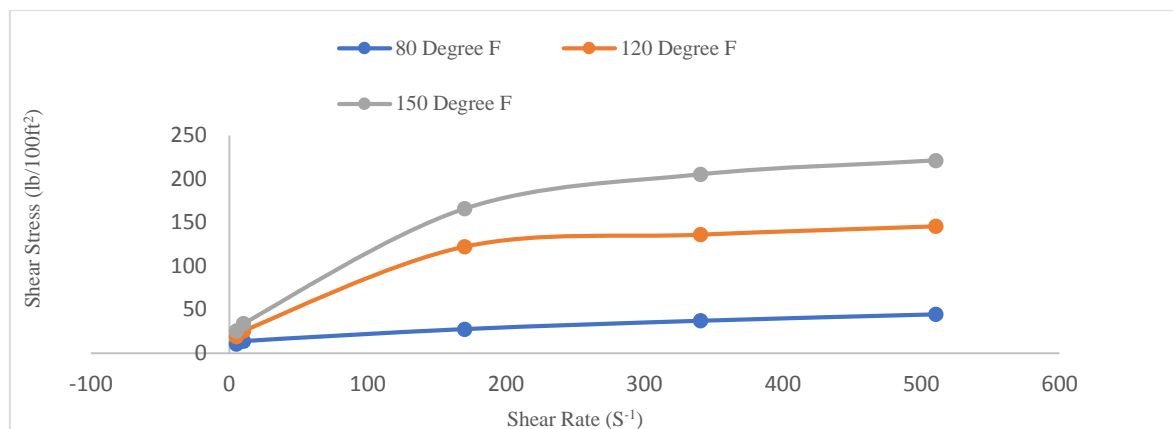
Figure 5 Variation of Shear Stress versus Shear Rate of 0.2% of wood ash of cement slurry of 15.8pp

Temperature and concentration have effects on the shear stress and shear rate relationship. These effects are shown in **Figure2** to **Figure 5**. The WA-based slurries showed a maximum shear rate (510.7 sec^{-1}) with a maximum shear stress (50.06 lb/100ft^2) at 150°F at concentrations 0.1% and 0.2% of WA and a minimum shear rate with a minimum shear stress at 0.1% and 0.1% WA at 80°F as shown in**Figure 3** and **Figure 5**. The LS-based cement slurries showed that a maximum shear rate (510.7 sec^{-1}) with maximum shear stress (51.1lb/100ft^2) stress was obtained at 80°F at 0.1% of LS and minimum shear rate with shear stress at 150°F at 0.1%.Maximum shear stress and the maximum shear rate at 150°F were obtained at a concentration of 0.2% for cement slurry (**Figure 4**).

The results show explicitly the increasing trend of shear stress versus shear rate at different temperatures of the various samples for both cement slurries. The graphs (**Figure2 – Figure 5**) imply a linear relationship between shear stress and shear rates, meaning that cement slurry will not flow until the yield point (critical value) is exceeded. From the graphical presentation of shear stress against shear rate, it is therefore established that the fluid flow is in line with the Bingham plastic model.

Effect of Temperature on Plastic Viscosity of Imported and Local Polymers-Based Cement Slurries
The effects of temperature on the shear stress-shear rate relationship of the imported polymer (LS) and local polymer at different concentrations of the polymers are shown in **Figure 6** to **Figure 7**
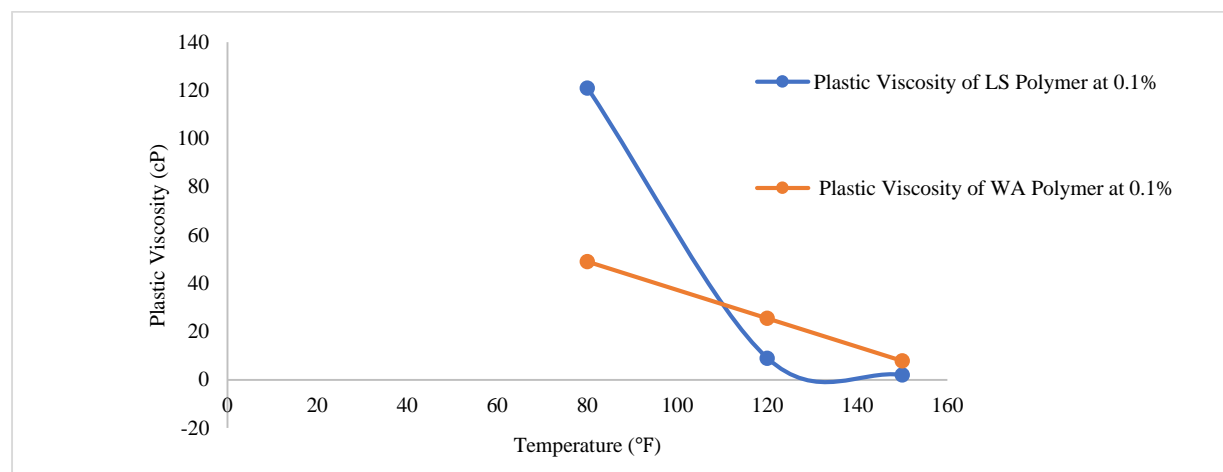

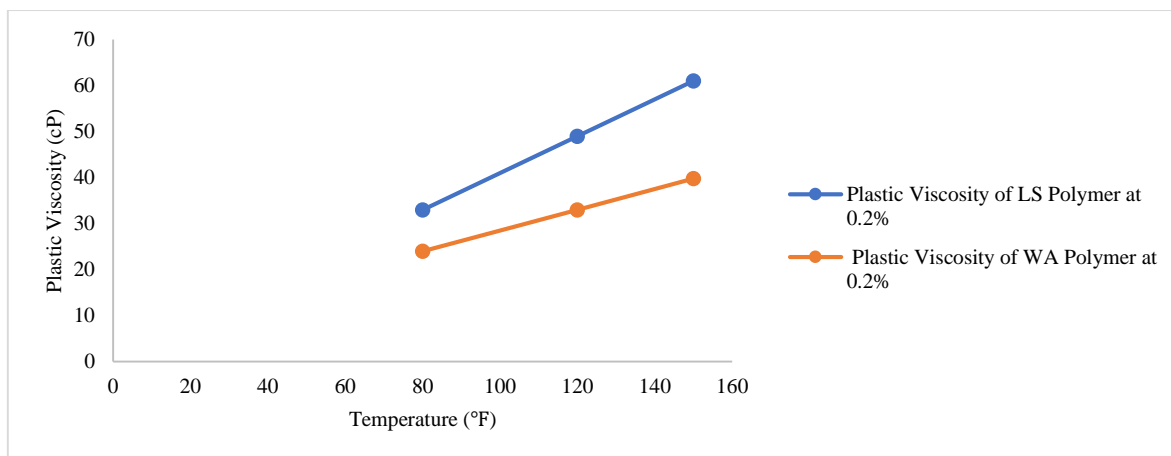**Figure 6**Variation of Plastic Viscosity at Different Temperature Values for 0.1% of LS

Figure 7 Variation of Plastic Viscosity at Different Temperature Values for 0.2% of LS Polymer and WA Polymer in 15.9ppg of Cement Slurry

The rheological properties of wood ash (WA) based cementand lignosulphonate (LS) based cement was obtained using a Fann viscometer. The results showed that the viscosities of the imported and local polymers of density (15.8ppg) were affected by temperature, rotational speed, and concentrations of the polymers. As the temperature of cement slurries formulated with 0.1% of local polymer and imported polymer increases from 80°F to 150°F, the viscosities decrease geometrically as shown in **Figure 6**. With a concentration of 0.2% for both LS-based and WA-based cement slurries, their viscosities increase with an increase in temperature, showing a reversal behavior (**Figure 7**).

The Variation of Yield Point with Imported Polymer (LS) and Local Polymer (WA) at Different Concentrations in Cement Slurries
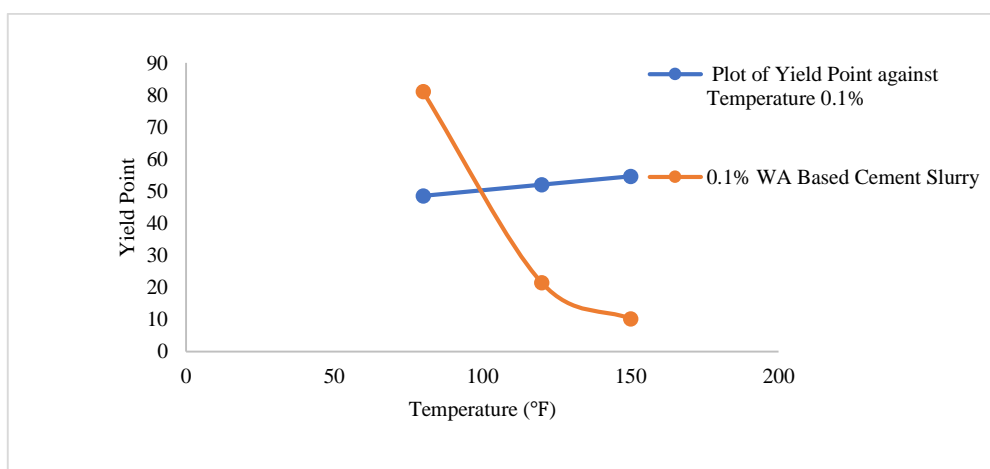

Figure 8 The variation of Yield Point with Imported Polymer (LS) and LocalPolymer (WA) at 0.1% in Cement Slurries
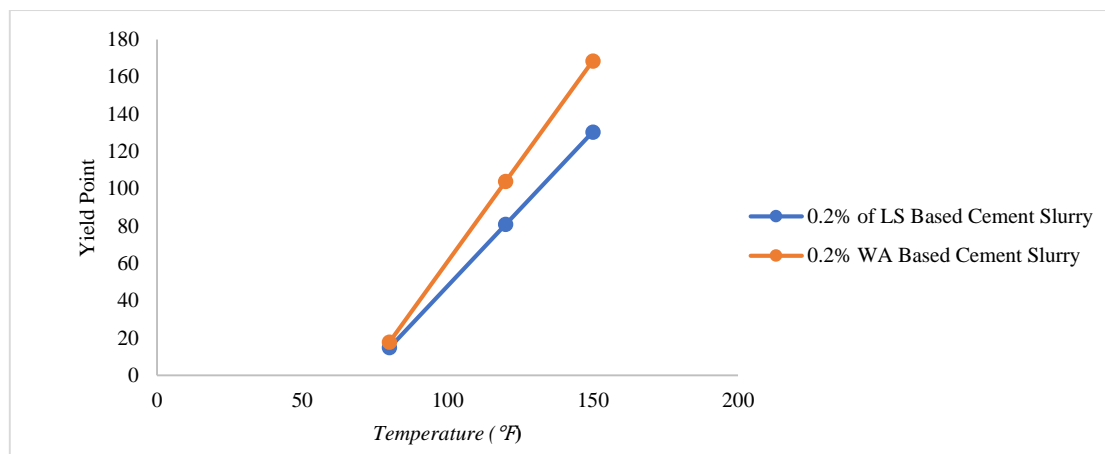
Figure 9 The variation of Yield Point with Imported Polymer (LS) and Local Polymer (WA) at 0.2% in Cement Slurries

Figure 8 and **Figure 9** showed the variation of yield point (YP) of LS-based and WA-based cement slurries at different concentrations (0.1% and 0.2%) at different temperatures. The yield point of WA-based cement slurry decreased as the temperature increased from 80°F - 150°F at 0.1% of the WA polymer concentration. The peak yield point occurred at 80°F. The cement slurry treated with lignosulphonate had its yield point increasing with an increase in temperature (**Figure 8**). The local polymer-based and imported polymer-based cement slurries had their yield points increasing with an increase in temperature with a polymer concentration of 0.2% (**Figure 9**). The result shows that WA-based polymer did not do well at the concentration of 0.1% but performed favorably with LS at 0.2%. However, it is important to know that a further increase in the concentration may cause a problem with the flow pattern of cement slurry and it is, therefore, necessary to take precautions about the concentration of WA polymer used in cement slurry formulation.

Impact of Imported and Local Polymers on Free Fluid (% FF) at Different Temperatures and Concentrations
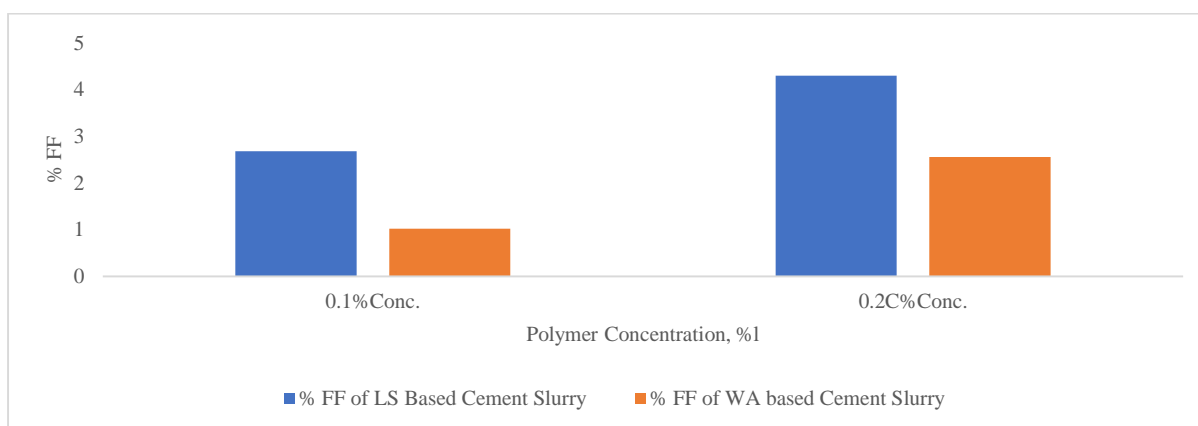

Figure 10 Effect of Imported Polymer (LS) and Local Polymer (WA) on Free Fluid (FF) at 80°F at Different Concentrations
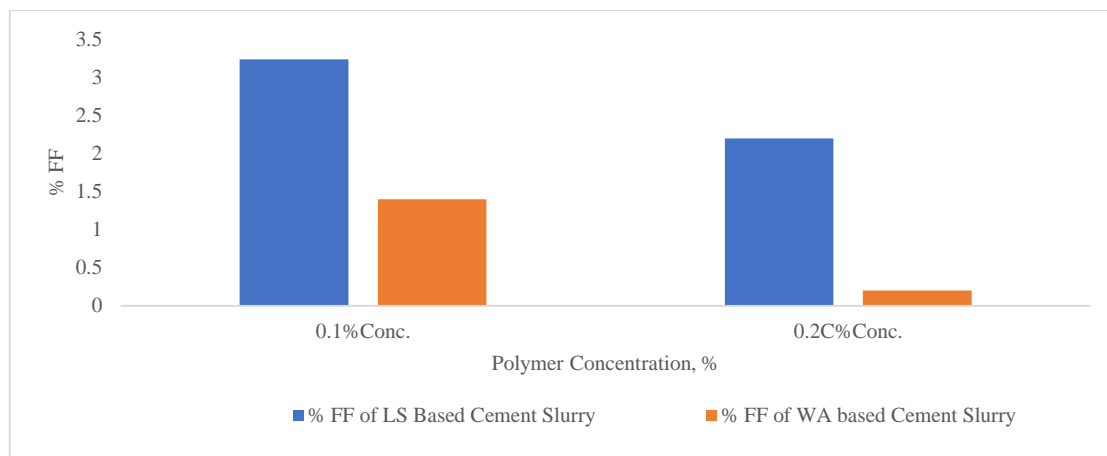
Figure 11 Effect of Imported Polymer (LS) and Local Polymer (WA) on Free Fluid (FF) at 120°F at Different Concentrations
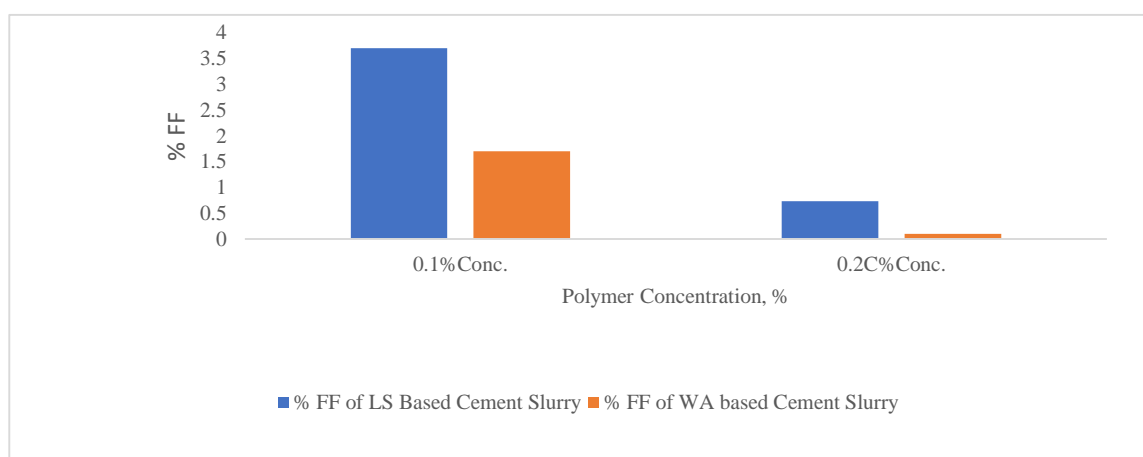

Figure 12 Effect of Imported Polymer (LS) and Local Polymer (WA) on Free Fluid (FF) at 150°F at Different Concentrations

Figure 11 – **Figure 12** showed the effects of local and imported polymers on free fluid (FF) at different temperatures and concentrations. At 80°F, LS-treated cement slurry at 0.1% had free fluid of 2.68% and WA-based cement had free fluid of 1.02% and at 0.2% concentration, free fluid increased to 4.3% in LS-based cement slurry and free fluid in WS-based cement slurry increased to 2.56% (**Figure 10**). At 120°F, the free fluid in 0.1%-WA-based cement slurry had 1.4% and 0.1%-LS-based cement slurry was 3.24%. 0.2%-WA-based cement slurry had a free fluid of 0.6% and 0.2%-LS-based cement slurry had 2.2% of free fluid (**Figure 11**). At 150°F, 0.1%-WA-based cement slurry had 1.7% of free fluid, and 0.1%-LS- based cement slurry had 3.7% of free fluid. 0.2%-WA-based had 0.1% of free fluid and 0.2%-LS-based had 0.73% of free fluid (**Figure 12**). It can be deduced that as the temperature increases, the percentage of free fluid decreases for both imported polymer (LS) and local polymer (WA). Therefore, WA polymer performed excellently with LS (imported sample).

IV. Conclusions

Wood ash (WA) used in the cement slurries showed excellent rheological properties in comparison with the imported polymer (LS) at 80°F - 150°F. Local polymer (WA)'s ability to thin or disperse cement or mud slurry depends on its concentration just as the imported sample (LS) does. Wood ash increased the pH of cement slurries and Lignosulphonate made the slurries neutral and that is an advantage over the imported sample (LS). Also, the local and imported polymers reduced free fluids at increased temperatures. The dispersing property of WA polymer could be reversed at the concentration range of 1.1% - 0.2%. The graph of shear stress against shear rate for wood ash-based cement and mud slurries is in tandem with the Bingham Plastic model. The study reveals that wood ash could serve as a substitute for lignosulphonate.

Acknowledgment

References

[1]. Akan O. D., Etok C. A and Adegoke A. A., (2013). Bioremediation of Crude Oil Contaminated Soil using Wood Ash; Journal of Pure and Applied Microbiology; 7(3), 1749 – 1756*.*

[2]. Abdullahi, M. (2006). Characteristics of Wood Ash/OPC Concrete. Leonardo Electron. J. Pract. Technol., 8, 9–16.

[3]. Athanasopoulou, A. (2013). Addition of lime and fly ash to improve highway subgrade soils. J. Mater. Civil Eng., 26, 773–775.

[4]. American Coal Ash Association (1995). Fly Ash Facts for Highway Engineers; American Coal Ash Association: Aurora, CO, USA.

[5]. Annune J. Eric, Nwafor Christiana, Shawon M. Caesar, Ahmed Yakubu Ahmed (2020). Production and Characterization of Wood Ash Pozzolan of Melina and Cashew Tropical Woods. International Journal of Scientific & Engineering Research, Volume 11, Issue 10, October2020 735 ISSN 2229-5518

[6]. Boughton, L.D.; Pavlich, J.P.; Wahl, W.W. (1962). Society of Petroleum Engineers Fall Meeting of the Society of Petroleum Engineers of AIME - Los Angeles, California Fall Meeting of the Society of Petroleum Engineers of AIME - The Use of Dispersants in Cement Slurries to Improve Placement Techniques.

[7]. Bett EK (2010). Geothermal Well Cementing Materials and Placement techniques Geothermal Training Programme-Report 10: 99-130.

[8]. Barathan, S. and Gominath, B. (2013). Evaluation of Wood Ash as a partial replacement to Cement; International Journal of Science, Engineering and Technology Research (IJSETR); Volume 2, Issue 10.

[9]. Cheah Chee Ban, Ramli Mahyuddin (2011). The implementation of Wood Waste Ash as a Partial Replacement Material in theProduction of Structural Grade Concrete and Mortar: An Overview. Resour Conserv Recycl.;55:669–85.

[10]. Campbell, A. G. (1990). Recycling and Disposing of Wood Ash. TAPPI Journal, TAPPI Press, Norcross, Ga. 73(9), 141-143.

[11]. Clarke, S. and Preto, F. (2015). Biomass Burn Characteristics. Available online: http://www.omafra.gov.on.ca/ English/engineer/facts/11-033.pd

[12]. Demeyer, A., Voundi Nkana, J. C., Verloo, M. G. (2001). Characteristics of wood ash and Its Influence on Soil Properties and Nutrient Uptake: An Overview. Bioresource Technology 77: 287–295.

[13]. Danuta, Samolk-Danielowska and Mariola Jablonska (2021). Chemical and Mineral Composition of Ashes from Wood Biomass Combustion in Domestic Wood-Fired Furnace; International Journal of Environmental Science and Technology 19:5359–5372

[14]. Étienne Joseph Marcel Bastien (2020). Towards Circular Economy: Wood ash management for biomass CHP plants in the UK; Master of Science Thesis in Energy Technology TRITA-ITM-EX 2020:559

[15]. Essien, J. R., Ubom, R. M., Udosen, A., (1995). Bioremediation of Petroleum Contaminated Soil: Effect on the Population Dynamics and Capacities of Hydrocarbondastic Bacteria. Journal Biology and Applied Chemistry 43: 23 – 27.

[16]. Etiegni, L. and Campbell, A.G. (1991). Physical and Chemical Characteristics of Wood Fly Ash. Bioresource Technology, Elsevier Science Publisher Ltd., England, UK. (37)2, 173- 178.

[17]. Eric B, Joel F, Grace O (2016). Oil Well Cement Additives: A Review of the Common Types. Oil Gas Res 2: 112. doi: 10.4172/2472- 0518.1000112

[18]. Francisco Grau, Hyunwook Choo, Jong Wan Hu, and Jongwon Jung (2015). Engineering Behavior and Characteristics of Wood Ash and Sugarcane Bagasse Ash.

[19]. Fredheim, G. E, Christensen C., and Bjom E., (2003); Polyelectrolyte Complexes; Interaction between Lignosulphonate and Chitosan. Biomacromolecules. Vol. 4. Pp. 232 – 239

[20]. Genty, T.; Bussière, B.; Benzaazoua, M.; Zagury, G.J. (2012). Capacity of Wood Ash Filters to Remove Iron from acid Mine Drainage: Assessment of Retention mechanism. Mine Water Environ. 31, 273–286.

[21]. Huwel, J. P. E., Faustino, V. and Roberts, R. (2014). "Cement Compressive Strength Development Drastically Affected by Testing Procedure", Proceedings of American Association of Drilling Engineers Fluid Conference and Exhibition, Houston, Texas, 1 – 5

[22]. István FÜZESI, Bálint HEIL and Gábor KOVÁC (2015). Effects of Wood Ash on the Chemical Properties of Soil and Crop Vitality in Small Plot Experiments; Acta Silv. Lign. Hung., Vol. 11, Nr. 55–64.

[23]. Joseph Zakzeski, Pieter C. A. Bruijnincx, Anna L. Jongerius and Bert M. Weckhuysen (2010). The Catalytic Valorization of Lignin for the Production of Renewable Chemical; Chem. Rev., 110; 6, 3552 – 3599.

[24]. Joel. O. F. (2009). The secondary effects of lignosulfonate cement retarder on cement slurry properties, ARPN Journal of Engineering and Applied Sciences, 4(9).

[25]. Jacob Mayowa Owoyemi1, Habeeb Olawale Zakariya1, Isa Olalekan Elegbede (2016). Sustainable wood waste management in Nigeria; Environ. Socio-Econ. Stud., 4(3): 1-9.

[26]. John Vitus Anaele, Ogbonna Friday Joel, Franklin Odua Chukwuma, Ipeghan Jonathan Otaraku (2019). Alternative Utilization of Sawdust for Oilfield Chemical Additive (Cement Retarder).

[27]. Kumar, A.; Walia, B.S.; Bajaj, A. (2007). Influence of Fly Ash, Lime, and Polyester Fibers on Compaction and Strength Properties of Expansive Soil. J. Mater. Civil Eng. 19, 242–248.

[28]. Mandre, M., Pärn, H., Ots, K. (2006). Short-term effects of Wood Ash on the Soil and the Lignin Concentration and Growth of Pinus Sylvestris L. Forest Ecology and Management 223: 349–357

[29]. Ozolincius, R., Buozyte, R., Varnagiryte, Kabasinskiene, I. (2007). Wood Ash and Nitrogen Influence on Ground Vegetation Cover and Chemical Composition. Biomass and Bioenergy 31: 710–716

[30]. Rini Setiati, Septoratno Siregar and Deana Wahyuningrum (2020); Laboratory Optimization Study of Sulfonation Reaction toward Lignin Isolated from Bagasse.

[31]. Ryan Guterman Valerio Molinari, and Elinor Josef (2019). Ionic Liquid Lignosulfonate: Dispersant and Binder for Preparation of Biocomposite Materials; Angew. Chem., 131, 13178 –13184

[32]. Steenari, B.-M. – Lindqvist, O. (1997): Stabilisation of Biofuel Ashes for Recycling to Forest Soil. Biomass und Bioenergy 13: 39–50.

[33]. Shuying Wang, Jinyang Fu, Cong Zhang, Junsheng Yan (2021). Muck Conditioning for EPB Shield Tunnelling and Muck Recycling. Shield Tunnel Engineering, Elsevier, Pages 433-490

[34]. Sumer, M. (2012). Compressive strength and sulfate resistance properties of concretes containing Class F

[35]. and Class C fly ashes. Constr. Build. Mater, 34, 531−536.

[36]. Tastan, E.O.; Edil, T.B.; Benson, C.H.; Aydilek, A.H. (2011). Stabilization of Organic Soils with Fly Ash. J. Geotech. Geoenviron. Eng., 137, 819–833.

[37]. Teixeira, S.R.; de Souza, A.E.; de Almeida Santos, G.T.; Vilche Peña, A.F.; Miguel, A.G. (2008). Sugarcane Bagasse Ash as a Potential Quartz Replacement in Red Ceramic. J. Am. Ceram. Soc., 91, 1883–1887.

[38]. Tóth, P., Bulla, M., Nagy, G. (2011). Energetika (Energetics) Pannon Egyetem, Veszprém. 204 p. (in Hungarian).

[39]. Udoeyo, F.F.; Inyang, H.; Young, D.T.; Oparadu, E.E. (2006). Potential of Wood Waste Ash as an Additive in Concrete. J. Mater. Civil Eng. 18, 605–611.

[40]. VANCE, E. D. (1996). Land application of wood-fired and combination boiler ashes: An overview. Journal of Environmental Quality 25(5): 937–944.

[41]. Varma AJ (2013). Process for Fractionating Sugarcane Bagasse into High Celloluse Pulp, Xylan and Lignin, Patent No. 8529731 B2, New Delhi.

[42]. Zimmerman, S., Hässig, J., Landolt, W. (2010). Literature Review Holzasche – Wald. Bundesamt für Umwelt BAFU, Birmensdorf. 80 p.