OBAFEMI AWOLOWO UNIVERSITY

# Investigation of Air Emissions from Optimally Mixed Wood Chips and Palm Kernel Shell Energy Carriers in Portland Cement Manufacturing Plant.

**BY**

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## ABSTRACT

This study determined the best mixing ratio of wood chips and palm kernel shell combination for air emissions. It also characterized the air emission from open burning of wood chips and palm kernel shell and determined the emission factors of air pollutants from the fuel mixed.

About 95 g of palm kernel shell was mixed with 5 g of wood chips and it was subjected to open burning. During burning, the generated air emission was analyzed for air pollutants including carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$), hydrocarbons ($C_xH_y$), hydrogen sulphide ($H_2S$) and air particulate matter while the analysis of the gaseous pollutants was carried out using the E- instrument E8500 combustion analyzer. The particulate concentration was determined with the aid of the gravimetric method. Emission factor (mg/kg) of each of the identified air pollutants were calculated from the combination of the measured pollutants concentrations, quantity of mixture of palm kernel shell and wood chips burned and the time required for complete burning of predetermined weight. During each of the experimental runs, weather tracker was used to determine the micro climatic parameter. The experiment was repeated for other wood chips and palm kernel shell mixing ratios with the weight of the wood chips increased in a step of 5 g while that of palm kernel shell was decreased with the step. The air emission from burning of 100 % wood chips and 100 % palm kernel shell was also investigated.

Results showed that CO had its highest emission factor of 1166.06 mg/kg at sample D and its least emission factor of 34.85 mg/kg at sample J. At sample D and J, the emission factor of $NO_2$ were 22.97 mg/kg and 0.36 mg/kg respectively, while hydrocarbons had 2552.24 mg/kg has

highest emission factor at sample D and its lowest emission factor of 31.06 mg/kg at sample J. It was observed that $SO_2$ had its highest emission factor of 8.03 mg/kg at sample D with its least emission factor of 0 mg/kg. Nitrogen dioxide (NO) had its highest emission factor of 22.97 mg/kg at sample D while 0.36 mg/kg has the least emission factor at sample J. It was observed that $H_2S$ had its highest emission factor of 5.19 mg/kg at sample D while the lowest emission factor of 0.08 mg/kg was recorded at sample J. The total suspended particle recorded was 31 mg/kg for the highest emission factor at sample F while 1 mg/kg was recorded at sample A and N for lowest emission factor.

This study established the best mixing ratio of wood chips and palm kernel shell to be sample J, based on air emission as an alternative source of energy in the cement manufacturing industry.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background to the Study

Cement is a commodity being produced in over 150 countries of the world (Engin *et al*., 2005). It is an essential input into the production of concrete needed for building purposes and other construction related activities. According to Madlool *et al*. (2011), world demand for cement was predicted to increase from 2283 million tones in 2005 to about 2836 million tones in the year 2010. The growth witnessed in recent days is largely driven by rising production in emerging economies and developing countries, especially in Asia. However, its production is greatly energy consumed. In Nigeria, cement industry accounting for 63.6 % of the West African region's cement output in 2011. Daily production is in excess of sales having recorded a zero importation from January 2012 to date and is in the process of formalizing the exportation of cement to Economic Community of West African States (ECOWAS) and other neighboring countries. With the new Ibeshe cement factory by Dangote Group the country's production capacity is expected to hit 39.4 million metric tones per annum thereby recognizing Nigeria as a cement producing country.

The cement sub-sector is one of the most energy consuming industries and it consumes approximately 12 % - 15 % of total industrial energy use (Madlool *et al.*, 2011 and Avami *et al.*, 2007). Since the industrial sector plays a significant role in global energy consumption, its demand can be said to be majorly determined by population and socio-economic activities of a country. In Nigeria, approximately 40 to 50 per cent of cement manufacturing cost is energy related where each tonne of cement requires 60 - 130 kg of fuel oil or its equivalent and about 105 kWh of electricity, depending on the cement variety and process type employed (Worrell *et al.*, 2001). Ohunakin *et al*. (2013), stated that the unit cost of fuel component for cement production is as low as $ 6 per tonne in China as opposed to $ 30 per tone in Nigeria, this has contributed largely to the high and persistent rise in unit cost of cement production. Since the associated energy used in the item production is extensively based on fossil fuels, environmental issues are further heightened and are of great importance (Schneider *et al.*, 2011 and Rasul *et al*., 2005). There is thus the need for the adoption of biomass energy in cement production in Nigeria.

The strong environmental concerns associated with emissions in cement industry have attracted much attention worldwide. Developing countries are confronted with the great challenge of controlling the atmospheric pollution, especially in the rapidly growing urban regions. Air pollution is an important problem in industrial areas which may have adverse effects on the health of the population. Air pollution is due to the discharge of toxic fumes, gases, smoke and dusts into the atmosphere (Park *et al*., 2005).

Air pollution in urban regions is receiving increasing importance worldwide, especially pollution gaseous and particulate trace metals (Begum *et al*., 2004 and Krivacsy *et al.*, 2006). Several epidemiological studies have indicated a strong association between elevated concentrations of inhalable particles and increased mortality and morbidity. (Namdeo and Bell, 2005). Particulate matter pollution in the atmosphere primarily consists of micron and sub-micron particles from anthropogenic and natural sources. The characterization of fine particles and emission factors has become an important priority of regulators, and researchers due to their potential impact on health, climate, global warming, and long- range transport (Dockery *et al*., 1993). Different industrial activities are degrading various environmental components like water, air, soil and vegetation (Bishnoi *et al.*, 2004 and Sharma *et al*., 2009). Cement industry is one of the 17 most polluting industries listed by the central pollution control board. It is the major source of particulate matter, SOx, NOx, HC and $CO_2$ emissions. Cement dust contains heavy metals like chromium, nickel, cobalt, lead and mercury. These pollutants are hazardous to the biotic environment with impact on vegetation, human health, animal health and ecosystem (Baby *et al*., 2008).

It has been estimated that $CO_2$ emissions from the cement manufacturing contribute 5 % of global $CO_2$ emissions and hence it is a major impact on the environmental threat and global warming (Benhelal *et al*., 2013). Now, the cement industry is close to the limit of what can be achieved through technical improvements. In order to keep its competitiveness, the cement industry tries to use alternative fuels. Although coal, petroleum coke, and other fossil fuels have been traditionally burned in cement kilns, because of the high energy usage and high environmental impact of the process, many cement companies have turned to energy-rich alternative fuels.

Furthermore, due to their high burning temperatures, cement kilns are well-suited for accepting and efficiently utilizing a wide range of wastes that can present a disposal challenge. This integrated activity offers additional revenues to the cement industry as the disposal of wastes normally receives a financial incentive (Andrade *et al*, 2007). Today, many plants meet between 20-70 % of their energy requirements with alternative fuels such as palm kernel shell, wood chips, animal meal, waste tyres, waste oils, solvents, plastics, paper, wood, rubber, sewage, refused derived fuels, etc (Kookos *et al*., 2011). This type of energy recovery conserves not only the valuable fossil fuels for future generations while safely destroying wastes that would otherwise be deposited in landfills but also reduces the fuel expenses and emission generation.

Alternative fuels have been used in cement industry in order to replace fossil fuels and reduces emissions of Criteria Air Contaminants (CAC), which contributes to long-term cost savings for cement plants during cement production. The fuel and the energy crises of the late

1970's and early 1980 as well as accompanying concerns about the depletion of the world's non-renewable resources provided the incentive to seek alternatives to conventional, petroleum based fuels (Peterson and Saxon, 1996).