INVESTIGATION OF PARTICULATE EMISSIONS FROM A CEMENT MANUFACTURING PLANT INTO ITS HOST COMMUNITY AIR SHED

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LETTER OF CERTIFICATION

We certified that this project was carried out by Yekini Usman (TP12/13/H/1178) of the Department of Chemical Engineering in partial fulfillment of the requirements for the Award of M.Sc. Degree in Chemical Engineering of the Obafemi Awolowo University, Ile-ife.

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DEDICATION

This study is dedicated to Allah and His messenger, Muhammadu Rasululahi (S.A.W).

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In the name of Allah, the Beneficent, the merciful. Glory be to Allah the Lord of the Worlds. May the peace and blessing of Allah be upon the noblest of mankind, Muhammadu the messenger of Allah (S.A.W). My profound gratitude goes to Allah, for, out of his infinite mercy, making it possible for me to begin this programme and complete it successfully despite of all odds.

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ABSTRACT

This study measured particulate deposition rates in Ewekoro cement manufacturing host community and determined the elemental composition of the measured particulates. It also determined the contribution of the cement plants to the measured particulates and recommended appropriate technology for the control of the particulates around the cement manufacturing plants.

The particulate deposition rates were measured by placing two deposition gauges of 10.5 cm diameter by 10 cm height at elevations ranging between 5 m to 10 m above ground level. These gauges were positioned at specified locations in the 10 towns/villages of radius 5 km around the plant for a sampling period of 30 days. After the first sampling period, the gauges were harvested and the process repeated for another 30 days. The particulate content of the harvested gauges were accurately weighed and the average weight of the measured particulates in each town/village was calculated. The deposition rates (flux) in g/m^2 month for the respective towns/villages were also calculated. The measured particulates from the towns/villages were subjected to elemental analysis using X-Ray Fluorescence spectroscopy (X-RF). With the use of elemental ratio, the cement plants' contributions to the measured particulates were determined and the results obtained were compared with existing data in the literature while the appropriate technology for the control of particulates around the cement plants was determined. Data obtained in the study were analysed using appropriate inferential and descriptive statistics.

In the upwind direction, the least value of dust loading of 9.828 – 13.454, 11.641 and 1.812 g/m^2 month as the range, mean and standard deviation of the particulate deposition rates, respectively, was recorded in Agbesi, 4 km away from the plant; and the highest value of dust loading of 10.8785 – 30.223, 19.3786 and 8.069356 g/m^2 month as the range, mean and standard deviation, respectively was recorded at Papalanto, 3.5 km away from the plant. Ewekoro which is

at zero distance away from the cement manufacturing plant had 83.907 – 139.427, 107.583 and 23.3762 g/m^2 month as the range, mean and standard deviation of the deposition rates, respectively. Downwind, Jaguna, 2.5 km away from the plants recorded the least dust loading of 5.5664 – 6.1554, 5.8609 and 0.29450 g/m^2 month as the range, mean and standard deviation of particulate deposition rates, respectively; while Itori 1 km away from the plants recorded the highest value of 13.316 – 22.197, 17.7570 and 3.026343 g/m^2 month as the range, mean and standard deviation of particulate deposition rates, respectively. Akinbo, Papalanto, and Agbesi recorded Ca/Fe ratio of 3.642, 1.323 and 0.399 respectively; and 14.7, 7.4 and 2.2 as the corresponding percentage contribution of cement to the dust loading respectively. Also, Ewekoro, Olapeleke, Itori, Jaguna, Agbon and Eruku had Ca/Fe ratio of 17.94, 3.179, 2.317, 2.011, 0.92, and 1.64, respectively; and 100, 17.7, 12.9, 11.2, 5.1 and 9.1 as corresponding percentage contribution of cement to the dust loading respectively.

Both the high values of dust loading (higher than USEPA standard of 3.9 g/m^2 month) and Ca/Fe ratio recorded in the towns/villages in the host community of the cement manufacturing plant, which decrease with increasing distance away from the plant in both upwind and downwind direction, support the claim that cement dust is the major source of atmospheric pollution in that community. It is therefore recommended that all the possible malfunctioning dust control equipment like baghouses, multiple cyclones and electrostatic precipitator should be replaced with new ones while routine cleaning of baghouses should strictly be adhered to. Finally, Environmental Audit should be carried out on the plant in order to ensure adherence to the international standard for particulate emission from cement plant into its residential neighborhood.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Cement production is a major source of particulates which have been associated with air quality impairment due to the nature of its processes. The cement industry is one of the large scale industries established by various governments and some individuals in Nigeria since independence in 1960 in order to diversify economic main stay of the nation from agricultural sector, discourage importation of finished goods and create local employment. (Oyebanji, 1983; Ofori-Cudjoe, 2009; Boakye, 2010; Endashaw, 2010).

Technological advancement has resulted in cement industries being able to produce higher volumes compared to the past (Zinwara *et al*., 2012). However, these benefits are accompanied by high negative consequences (Aribigbola *et al*., 2012). Establishment of cement industries in the metropolitan areas has constituted serious environmental problem resulting into damage to human health, animal health, material and ecosystem. Akeredolu *et al*. (1994) indicated that cement industries are the worst pollutant in Nigeria today.

Air pollution is a chemical or particulate or biological agent that changes the natural characteristics of the atmosphere (Anita, 2013). The aerial discharge of cement factory (plume consist of particulate matter, CO_2, SO_2 and NO_x producing continuous visible cloud which ultimately settles on the vegetation and soil thereby affecting the whole biotic life around. As a result, the whole ecosystem in the vicinity of the plant is subjected to extra ordinary stress and abuse (Seyed *et al*., 2012).

Particulate matters or particulate air pollutants are complex mixture of small and large particles (i.e. tiny subdivisions of solid or liquid matters) of similar or varying origin and chemical composition. Suspended Particulate Matter (PM) can be categorized as to Total Suspended Particulate Matter (TSP); the finer fraction PM_{10} (median aerodynamic diameter of equal or less than 10 µm which can reach the alveoli, and the most hazardous, $PM_{2.5}$ (median aerodynamic diameter of equal or less than 2.5 µm). Types of suspended PM include mineral dust such as coal, asbestos, limestone and cement, metal dusts, coal fly ash, wood smoke, diesel exhaust particles; fumes; acid mists. These serve as nuclei upon which vapours condense. Akimoto *et al*. (1979) reported that dust and other particulate in the air provide nuclei around which condensation takes place forming droplets and thereby playing a role in snow fall and rainfall patterns. Some particles react chemically with atmospheric gases or vapour to form different compounds. When two particles collide in the air they tend to adhere to each other because of attractive surface forces, thereby forming progressively larger and larger particles by agglomeration. The larger the particle becomes the greater its weight and the greater its likelihood of falling to the ground rather than remaining airborne. The process by which particles fall out of the air to the ground is called sedimentation. Washout of particles by snowflakes, rain, hail, sleet, mist or fog is a common form of agglomeration and sedimentation. Still other particles leave the air by impaction onto and retention by the solid surfaces of vegetation, soil, and building (Boubel *et al*., 1992).

The small particulate in air over city tends to reduce the solar energy and thus prevent the sun from heating the surface air by reflecting and scattering the rays back to the space (Boubel *et al*., 1992).

Several epidemiological studies have indicated a strong association between elevated concentration of inhalable particles (PM_{10} and $PM_{2.5}$) and increased mortality and morbidity (Perez and Peyes, 2002; Lin and Lec, 2004; Namded and Bell, 2005). Cement dust consists of toxic heavy metals such as Chromium, Nickel, Cobalt, Lead, Mercury, Antimony, Cadmium, Zinc, Arsenic and Manganese (Gbadebo and Bankole, 2007). It also consists of some minerals like silica, polychlorinated dioxin and Furans. Majority of these substances are potentially harmful to biotic environment with impact on vegetation, human health, animal health and ecosystem (Baby *et al*., 2008; NPI, 1991). According to the World Health Organization, 2.4 million people die each year from causes directly attributed to air pollution of which cement dust is a major contributor (WHO, 2007)

Cement is a fine grey or white powder. It is a binding agent that holds sand and other aggregates together in a hard stone like mass. Thus, it is a key ingredient in concrete products and therefore widely used in building and construction work globally (Gbadebo and Bankole, 2007). Dust or particulate emission is originated mainly from the raw mill stock pills, quarrying and transportation of raw material, the kiln system, the clinker cooler and cement mill. The process step of dust generation in the hot exhaust air passes through pulverized material resulting into an intimately dispersed mixture of gas and particulates. The mixture of the particulates is linked to the source of the material itself (Karsten, 2007).

Despite efforts being made by most cement manufacturing industries in controlling the emission using most efficient control system such as bag filters, bag houses system of cyclones and Electrostatic Precipitators, though some of the plants were able to meet environmental regulations for stack emission, fugitive emission from various sources in cement plants still remain an area of concern (Sabah, 2006).

For this reason, the study was designed to investigate the effect of particulate emission from a cement industry on the air shed of its host community.