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Environmental and Health Implications of Cement Production Plant Emissions in Nigeria: Ewekoro Cement Plant as a Case Study

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Abstract

Climate change remained one of the most pressing environmental challenges confronting humanity across the globe. Emissive gases coming out of cement production plants invariably contribute to the problem of global warming and climate change. These industrial plants for cement production involves a high energy intensity process marked with high-level consumption of fuel for clinker making which in turn results in releasing emissions into human environment. Apart from the issue of fuel consumption, the process of calcinations equally aggravates emission generation challenges of NO_2, SO_2, CO_2, particulate matters among others. Cement is made up of different forms of chemicals such as lime, silica, and so on. These set of chemicals could induce health related problems especially respiratory illnesses. Topmost in the hierarchy of significant environmental hazards that could be adduced to cement production industries revolves around allergenic complications to respiratory system challenges. To this end, this paper reviewed the intricacy between cement industries and its associated health and environmental implications with a focus on Ewekoro Cement Plant, Ogun State, Nigeria. It adumbrates the processes involved in cement production and sources of emission plus a succinct view of emissions generated as well as health and environmental impacts arising from this subject-view. The research explicitly centered on emissions produced in the course of clinker making while emissions produced via consequent operation in the course of cement production such as transportation, electricity and so on were not accounted for in this study. This was achieved through comprehensive reappraisal of existing literature on the subject-view. To be precise, relevant information with respect to health and environmental impacts associated with cement firms were sourced from published and unpublished articles including journals, reports, theses, magazines, and so on.

Keywords

Cement Production, Emission Generation, Health and Environmental Impact, Sustainability

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1. Introduction

Suffice to say that life without the use of cement in our contemporary world is impossible. This is mirrored from the perspective that cement is an indispensable fabric in the construction sector widely employed for the development of housing and other critical infrastructural facilities which has been argued by scholars to be fundamental towards achieving socioeconomic growth. The demand for cement is intricately interlinked with economic growth and development and as

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such, many developing economies are working towards fast tracking infrastructure development which has actuated a stimulus for epic growth in cement industries and production activities across different climes [1]. The fact remained that the cement industry sector across the globe raises the standard of living through the provision of employment opportunities as well as chain of economic gains accrued by these industries. In spite of these benefits, cement production activities is laced with myriads of challenges with respect to environmental sustainability [2].

Cement production plants are highly energy consuming and substantially contribute to issue of climate change challenges. Chief among health and environmental safety concerns with respect to cement manufacturing activities are emissions into the atmosphere as well as intensive use of heat energy. The fact remained that process of cement production demand the use of vast measure of non-renewable raw materials and fossil fuel consumption. It could be argued that cement production activities accounted for about 5-6% of all anthropogenic activities responsible for releasing carbon dioxide into the atmosphere which majorly contribute to issues of greenhouse gases [2]. The processing of these raw materials invariably leads to emission generation in the form of gases and dust which are released into the air. These exhaust fumes from cement furnace include carbon monoxide (CO), nitrogen oxides (NO_2), small dust particles, oxygen (O_2), sulfur dioxide (SO_2), chlorides, water (H_2O), and minute quantities of organic as well as other heavy metallic compounds [3]. Similarly, in the course of burning industrial wastes in cement furnace, toxic metallic compound and other harmful organic substances are discharged into proximate environment. Likewise, grinders, clinker cooler, crushers and other handling equipment's in the course of cement production are notable dust emission sources. In fact, it takes little analysis to know that emissions dot not only affect air quality but also impairs human health. The impact of emissions on the built and natural environment across transnational boundaries are made manifest in the areas of crop failure, loss of biodiversity, acid precipitation, depletion of the ozone layer as well as global warming challenges [4]. Reliable data acquired through scientific analysis showed that the burning of fossil fuel in the course of cement production give rise to air pollution with its attendant health implication. These include itchy eyes, suffocation, respiratory diseases such as asthma, chest discomfort, chronic bronchitis, tuberculosis, cardio-vascular maladies and even untimely death [6, 7].

The drive towards industrialization has led to the establishment of many heavy and light industries that generate high volume of air pollution in the country. Ogun State is one of the Nigerian states accommodating over 50 manufacturing industries. One of these industries is the LAFARGE Cement factory located in Ewekoro local government area. It is the second largest cement manufacturing industry in Nigeria. It enjoys a wide coverage with its plant located across different geo-political zones in Nigeria such as Ashaka in the North Eastern region, Mfamosing in the South-Southern landscape and Ewekoro and Sagamu in the south Western region. The installed capacity of the firm with respect to cement production currently stands at 10.5 MTPA with plans in the pipeline to increase productivity in the future.

Figure 1. Impact of Smoke, Dust and Mining around Ewekoro community.

Observable outcomes by many researchers of the production activities of LAFARGE Cement in Ewekoro community include cement dust, noise from machine operation, and vibration. Also, roof tops of houses, vegetation, land, road, and items sold in nearby shops are covered with cement dusts. In addition, the area as shown in figure 1 has a low visibility view as a result of air pollution from cement dusts. Cement dust contains lots of hazardous chemicals and heavy metallic elements such as mercury, chromium, cobalt, lead and nickel which constitute grave impairments on human health [8]. In addition, it has been adduced to be the principal sources of atmospheric pollutants which include NOx, CO_2, Sox gases among others [9]. It therefore becomes dangerous for humans to be exposed to these air pollutants. This review thus become a matter of necessity looking at series of complaints coming from inhabitants of Lafarge Cement's host communities which in turn constitute a major threat to their corporate relationship built from time immemorial [10].

2. Processes Involved in Cement Production

The principal factor with regards to cement production plant is the clinker with limestone and clay as its major raw materials [11]. With respect to limestone, it is a vital component providing $CaCO_3$ for producing cement. Other raw materials are Silica, alumina, and iron. Limestone constitute between 75-90% of $CaCO_3$ used for cement production while $MgCO_3$ and other impurities complete the manufacturing chain [12]. These raw materials are gotten through mining and quarrying process, after which they are drilled, blasted, excavated, handled, loaded, hauled, crushed, screened, stockpiled and stored [13]. These raw materials are crushed and powdered into fine particles to enhance the quality of cement. They are commingled in blending silos and made to be heated in the pre-heating plant. This method breaks down carbonate compound into carbon dioxide and calcium oxide [12]. This could be done in three ways and they include the dry, the wet, plus the semi wet method [13]. With respect to dry cement production method, dry raw mixture accounted for less than 20% of its moisture content by weight. As for the wet method, the raw mixed is immixed with water to make slurry and then moved to the furnace/kiln [12]. These raw materials which have been blended are transferred into the upper part of the pre-heater plant and made to go through the rotary furnace. The kiln circumvolves and these raw materials at the base of the kiln move down to the direction of the heat. With increase in temperature, strings of physical and chemical changes typified with calcium oxides reactions with other elements begin. At about 1500°C, the end product of these reactions is the formation of aluminates and calcium silicates. It is noteworthy to posit that the flame could be set up by using fuel materials like coal, natural gas, petroleum coke among others. At this point, varieties of chemical reactions occurred with the resultant effect leading to the melting and fusing together of these raw materials a clinker as its end product. At around 1500°C, the clinker is then released from the kiln as red-hot and made to go through coolers from where superfluous heat are retrieved. There are varieties of these cooling system and they include planetary cooler, grate cooler and tube (rotary) cooler among others. These set of cooling system could regain up to 30% of the heat generated in the kiln system and recoup it back to the pre-heater points [14, 13, 12, 15]. Finally, the clinker produced is grounded and mixed with additives in a cement plant with a view to controlling cement quality. These additives include fly ash, anhydrite, blast furnace gypsum, slag, pozzolana, and so on. Series of milling methods comprising ball and roller mills are employed to grind clinker mixed with additives in cement plant. Capping off this discourse, the processed cement are channelled through bucket elevators via a conveyor belt and stored in silos. The schematic analysis of cement production techniques is shown in figure 2.

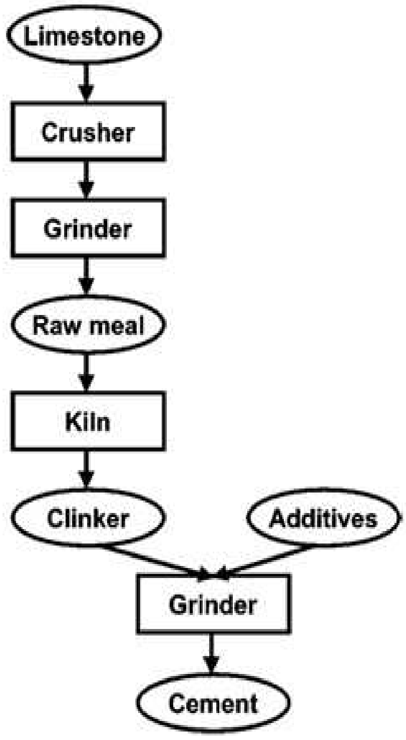

Figure 2. Schematic diagram highlighting cement production processes.

3. Cement Production Plant Emissions

Topmost among health and environmental safety challenges with respect to cement production plant is the emission of atmospheric pollutants into the environment [18]. It will not be out of place to argue that human activities arising from cement production significantly contribute to environmental pollution problems. Studies have even revealed that 8% of human-induced CO_2 discharges into the environment could be linked to cement manufacturing activities [16]. Notable among the gases emitted into the air in the course of cement manufacturing activities include H_2S, NOx, furans, SOx, CO_2, VOCs, CO, particulate matters, dioxins, just to mention a few [17-19]. These environmental impairment substances coming from cement plant could be succinctly categorized into two. They are particulate and gaseous substances. Fuel combustion during production processes remained the principal source of gas emission and some of the gases as earlier reiterated include carbon oxides, hydrogen sulphide, nitrogen oxides, sulphur oxides among others. Conversely, carbon and dust particles are sources of particulate matter springing from quarrying activities, process of drilling and blasting, trucking as well as cement milling while others include fuelling, packaging, activities of road cleaning and storage [17-19, 26]

4. Environmental Health Implications of Emissions

Air pollution arising from cement production activities is fast becoming a global environmental concern. Scholars are of the parallel opinion that there is a link between pollution from cement plants and the challenge of health impairment on residents of their proximate environment. These emissions are deleterious to man and his environment with wide reaching implications on health and issue of environmental sustainability [16]. Some of these emissions released into human environment in the course of cement production are succinctly discussed in this section.

4.1. Sulphur Oxide (SOx)

With respect to oxides of sulphur, they are produced via fuel combustions as well as the process of oxidation especially of sulphur with raw content [21]. As shown in Table 1, sulphur is an inherent raw material for cement production. A comparative analysis of sulphur oxides emission intensity produced from fuel combustion and the process of oxidation of raw sulphur materials showed that the latter is lesser than the former [19]. At 370°C and 420°C respectively, Sulphur II oxide and Sulphur III are produced from raw materials in the rotary kiln through the process of oxidation [18]. Calcium sulphate is decomposed in the clinker to produce sulphur dioxide (SO_2). SO_3 is in anhydrous form and can be deoxidized into SO_2 as well as O_2. However, the high state of alkaline substance present in the kiln is inhibitory to sulphur oxides formation as it could lead to 90% of these SO_2. All the same, scholars are of the consensus that the effect of sulphur oxides emission on man and his environment could be put under control by employing the use of low sulphur fuel.

Table 1. Sulphur oxides emission process.

Process	[22, 23]	
Raw mill	SO_2 Formation	Sulphides + $O_2 \rightarrow$ Oxides +SO_2 Organic S + $O_2 \rightarrow SO_2$
	SO_2 Absorption	$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$
Preheating zone	SO_2 Formation	Sulphides + $O_2 \rightarrow$ Oxides +SO_2 Organic S + $O_2 \rightarrow SO_2$
	SO_2 Absorption	$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$
Calcining zone	SO_2 Formation	Fuel S + $O_2 \rightarrow SO_2$ $CaSO_4 + C \rightarrow CaO + SO_2 + CO$
	SO_2 Absorption	$CaO + SO_2 \rightarrow CaSO_3 + ½ O_2 \rightarrow CaSO_4$
Burning zone	SO_2 Formation	Fuel S + $O_2 \rightarrow SO_2$ Sulphates $\rightarrow$ Oxides + SO_2 + ½ O_2
	SO_2 Absorption	$NaO + SO_2 + ½ O_2 \rightarrow NaSO_4$ $K_2O + SO_2 + ½ O_2 \rightarrow K_2SO_4$ $CaO + SO_2 + ½ O_2 \rightarrow CaSO_4$

Sulphuric acid is a product of reactions influenced by sunlight energy between sulphur oxides and water vapour as well as other chemical elements. It dissolves in the cloud and is released to the soil in the course of precipitation. This sulphuric acid is harmful to human health and if not addressed could endanger human life on the long run. The effect of increased level of sulphur dioxide on human health is conspicuous in the area of respiratory disease challenges which include bronchitis among others [24]. Increase in atmospheric density with respect to this acid significantly affect agricultural yield as it is pernicious to plant life.

4.2. Nitrogen Oxide (NOx)

Nitrogen oxides are produced through the process of combustion in the rotary furnace and when released into the environment exhibit series of chemical reactions in the air. Primarily, nitrogen oxides are made via thermal oxidation at high temperature of about 1,200 to 1,600°C. As a result of the rotary kiln's extreme temperature, substantial measure of NO are produced. Burning of nitrogen-content fuel which include coals among others results in NO_2 as well as in NO formation.

$$N_2 + O \rightarrow NO + N$$

$$N + O_2 \rightarrow NO + O$$ [19].

An increase in temperature will invariably lead to increase in the formation of nitrogen oxide. Nearly 90% of nitrogen oxides generated take the form of nitric oxide [NO] while the remaining percentage exists as nitrogen dioxide [NO_2] [24]. The product of NO are changed to NO_2 at the outlet of the stack appearing in amber colour at atmospheric state.

$$NO + 1/2O_2 \rightarrow NO_2$$ [19].

Research has shown that nitrogen oxides and its numerous derivatives such as nitrogen dioxide, nitrous oxide, nitric oxide, nitric acid, nitrates among others constitute severe negative impact on human health and his environment. Like sulphur dioxide, nitrogen oxide react with H_2O as well as different forms of compound to produce varieties of acidic materials. Whenever these acidic materials from nitrogen oxide are released into the surface of the earth, it affects water quality by polluting water bodies as well as causing streams and lake's acidification. This challenge of watercourse acidification coupled with other chemical changes has a debilitating effect on aquatic organisms such as fish with the resultant effect cutting across survival, growth and reproduction problems. Similarly, the impact of acid rain on forest ecosystem is catastrophic as it damages plant tissues and a host of other floral problems [25]. Nitrogen oxide derivatives like nitrous acid is a greenhouse gas {GHG} which piled up in the air together with other GHG leading to a gradual increase in earth's surface temperature. The resultant effect of these GHG emissions is obvious in global warming challenges and ultimately climate change problem. Reactions between nitrogen oxide and explosive chemical compound influenced by sunlight in the atmosphere lead to ozone formation which in turn induces smog production in the environment. The ozone lead to respiratory ailments as well as other health related challenges [25]. Nitrogen oxide derivatives such as nitrogen dioxide seriously impair human physiological functions in the areas of breathing difficulties, severe lung sicknesses which include chronic rubor and inveterate structural alterations in the lungs and if not checked, would on the long run stimulate untimely senescence of the lung and other respiratory diseases. Research has shown that positive relationship exists between NO_2 concentrations and cases of heart ailments as well as vulnerability to cancer problems [24].

4.3. Carbon Dioxide (CO_2) & CO

The cement industry sector is one of the principal sources of CO_2 released into the environment. CO_2 is discharged into the air in the course of heating limestone at high temperature as well as in the process of burning fuel in the furnace. It is estimated that 50% of these carbon dioxide is produced in the course of fuel combustion while the remaining percent are generated from limestone's decarbonisation. Other sources of CO_2 and pollution arising from cement processing could be traced to electricity consumption especially when it is produced via fossil fuel combustion [14].

$$CaCO_3 \rightarrow CaO + CO_2$$ [9]

$$MgCO_3 \rightarrow MgO + CO_2$$ [16]

It should be noted that the limestone's component weight ratio formula is a veritable tool for estimating the quantity of CO_2 emitted during the process of calcinations [27]. Discharges from varieties of fuel combustion could be measured using the Inter Government Panel on Climate Change (IPCC) emission factor standards [14]. The quantity of CO_2 generated during this course of action has an outright correlation with the kind of fuel utilized such as coal, pet coke, natural gas, fuel oil among others. Generally, going by the expensive nature of fossil fuels, coal is often employed in fueling the kiln in the course of making cement. All the same, carbon content waste substances which include tires and so on are usually employed to power the kiln for cement production [26]. Scholars have attributed 5% of human induced CO_2 emission across the globe to activities of the cement industry sector [28]. It is even becoming a cliché to note that CO_2 contribute to climate change challenges. Unabatedly increase in CO_2 discharges have been adduced to be the major factor influencing temperature increase which has been predicted to rise between +1.4° to +5.8°C by year 2100 across the globe. Constant temperature increase could equally aggravate the challenge of drought in some regions of the world, trigger extreme weather condition, loss of biodiversity as well as constitute health hazards to mankind [30]. Results from previous studies have established a nexus between temperature increase and CO_2 emission leading to air pollution with the resultant effect causing thousands of deaths across as well as issues of respiratory sicknesses such as asthma across the globe. Equally, fossil fuel of CO_2 content influence surface ozone, carcinogenic substances as well as atmospheric pollutants leading to cancer, asthma, hospitalization and even death [29]. Carbon monoxide on the other hand is harmful to human health as it reduces oxygen supply to the body system thus stimulating central nervous system challenges as well as cardiovascular problems. Carbon monoxide also influences the production of smog in the atmosphere which could in turn induce respiratory sicknesses. CO_2 emission from cement industry sector could be addressed by embracing energy efficient processes, employing more effective techniques, shifting from high to low carbon fuel materials which include biomass among others, clinker to cement ratio reduction as well as removal of CO_2 fuel gas content [26].

4.4. Particulate Matters (PM10, PM2.5)

As depicted in Table 2, these atmospheric pollutants are released during quarrying processes, hauling and crushing as well as grinding of clinker and raw materials substances. Others include fueling and cement packing activities. They consist of suspended fine particles in the atmosphere in the form of liquid droplets, soot as well as dust [19]. Research has even shown that decreased visibility and poor atmospheric air quality are the major environmental challenges arising from dust emission. When these dust particles are rain-washed, they pollute water sources [20]. Emissions from these particulate matters consist of potentially noxious elements which are injurious to human health and they include nickel, lead, barium, chromium among others. These emitted materials carry toxic substances such as immunotoxins mutagens, neurological toxins, carcinogenic elements, respiratory toxins and so on. The intensity of these particulate matters with respect to their effect on human health is influenced by their physical composition [31]. It has equally been established in research that coarse particulate matter (>PM10) constitute more of local nuisance than health related challenges. Conversely, fine particles such as (<PM10- PM2.5) induces serious health implications influenced by their nature of reparability. The major entry point of dust particles to human system is through the alimentary canal by inhalation or deglution [32]. Whenever particulate matter whose diameter less than 10 pm is breathed in, it goes deep into the systema respiratorium while that of PM less than 2.5 pm penetrate into the lungs which in turn diffuses into the bloodstream. Thus, vulnerability to this particulate matter increases the risk of developing respiratory and cardiovascular illnesses. It also induces irritation of the throat and the eye, lung ailment, bronchitis, heart diseases and high rate of mortality [5, 19, 24, 27, 28]. Previous studies with respect to this subject-view equally revealed that dust from cement could also induce respiratory as well as non-respiratory illnesses [23]. It also adversely affects the agriculture sector especially people with farms in cement factory contiguous environment by reducing crop productivity. This assertion is premised on the ground that dust emission from cement affect the process of photosynthesis as it stifles the formation of chlorophyll materials in plant leaves.

Table 2. Dust typologies and their process of generation at cement factory (34).

Type	Generation mechanism
Raw material dust	Quarrying process, crushing as well as raw material handling
Feed material	dust Feeding, activities of milling, piling or stacking, the process of blending, reclaiming operation, conveying and transporting of feed substances
Cement kiln dust	Feeding plus materials processing via diffusion of hot gases in crosscurrent manner
Clinker dust	Cooling using air circulation as well as open-storage of clinker
Cement dust	Feeding process, milling activities, conveying, bagging and loading of cement substances

4.5. Volatile Organic Compounds, Dioxins, Heavy Metals and Other Pollutants

Volatile organic compounds (VOCs), dioxins, furans, methane, and heavy metallic elements equally accounted for trace quantum of emissions associated with cement production activities. The primary source of VOC discharge emanating from cement kiln is organic materials inherent in its raw substances. It is also a truism that incomplete combustion influences the emission of VOCs. It has also been established in literature that heavy metal is shaped by these trace's elements content naturally occurring in low concentration in fuel as well as raw materials. Dioxins are also produced in cement making plants in the course of combustion brought about by the presence of chlorine and other organic compounds. The use of fuel and raw materials composed of low organic content as well as heavy metals of low content volatility and semi volatility could keep down emission level of these substances coming from cement plant. Research has also shown that VOCs are substances from which ozone is formed which in turn induce soil and groundwater contamination. It equally aggravates the problem of plant growth retardation, iron deficiency in broad plant leaves as well as issue of necrosis [33]. VOCs are also detrimental to human health as emission of these substances could lead to chronic sicknesses which include central nervous system related ailment, Kidney diseases, liver disorder and other minor ailments such as nausea, eye irritation, headache, respiratory diseases among others [35]. It is also carcinogenic to the body system. Emissions from dioxins and heavy metals have been proven scientifically to cause soil and water contamination with adverse effect cutting across plant growth and cell structure development. The process of bioaccumulation leading to biomagnifications triggered by emission from heavy metals could result into poisoning of terrestrial and aquatic organism. Studies have also shown that dioxins and furans could impair human health with the resultant effect cutting across weight loss, skin rashes, liver damage and immunological disorder [34].

The public health concern and the concern of health educators by the occurrence of these risk-factors, especially in their severe forms, cannot be compared to the economic benefits if the masses and government would face the environmental risk-factors squarely to control the causative-agent which is emission from cement plants [36]

5. Summary & Conclusion

It has been established across different line of thought that environmental pollution poses serious health hazards to humanity. As urbanization intensifies, globalization and industrialization set in, thus necessitating large-scale investment in infrastructure development. Looking at the fact that cement is an integral element when it comes to building and maintaining infrastructural facilities, its use becomes inevitable thereby paving way for all=round development in the cement industry sector across the globe. In spite of the gains associated with the use of cement, it has been pointed out in this study that emission emanating from its manufacturing plant is deleterious to human health. This is conspicuous in the areas of environmental pollution (particularly air pollution) marked by poor air quality. Previous studies have also revealed that the cement industry sector significantly contributes to the issues of global warming predicament and climate change challenges across the globe. A meticulous review of literature in this study has unearthed the dire consequences of emissions coming from cement plants on man and his environment. It could thus be inferred from this academic adventure that cement industry constitutes serious health and environmental challenges to mankind and thus mitigating measures need to be put in place forthwith. Chief among health and environmental challenges discovered in the course of this study are emission from gas and dust elements. Emissions from gas grossly impair human health and also deteriorate his environment. Similarly, communities and those working in cement contiguous environment are prone to dust emissions with wide reaching effect on their health.

6. Recommendation

Cement factory dust is responsible for substantial amount of dust in the atmosphere resulting in damage not only to air quality but also to the human environment. The study thus recommends the use of state of the art technology to control emission emanating from cement plants, efficient use of energy and employing the use of environmentally friendly technology to drastically reduce smoke and dust emissions which will in turn engender environmental sustainability. The study also advocated the development of a thick green belt around the periphery of cement plants to buffer contiguous environments from dust and smoke emission.

References

[1] World Business Council for Sustainable Development (WBCSD) - Cement Sustainability Initiative – About the cement industry. Online available at: http://www.wbcsdcement.org/index.php/about-cement) [accessed 07 May 2014].

[2] Potgieter Johannes H. (2012). An Overview of Cement production: How "green" and sustainable is the industry? Environmental Management and Sustainable Development, 1 (2): 14 – 37.

[3] Marlowe Ian and Mansfield David (2002). Towards a Sustainable Cement Industry Sub study 10: Environment, Health & Safety Performance Improvement, an Independent Study Commissioned by WBCSD.

[4] Pariyar Suman K, Das Tapash, Ferdous Tanima (2013). Environment and Health Impact for Brick Kilns in Kathmandu Valley, Nepal.

[5] Marchwinska-Wyrwal E., Dziubanek G., Hajo I., Rusin M., Oleksiuk K. and Kubasiak M. (2011). Impact of Air Pollution on Public Health.

[6] Pollution Prevention and Abatement Handbook 1998 toward Cleaner Production, World Bank Group, International Finance Corporation, Washington D.C., 1999.

[7] Mehraj. S, Bhat G. A., Balkhi. H. M (2013). Cement Factories and Human Health.

[8] Zerrouqi Z.; Sbaa M.; Oujidi M.; Elkharmouz M.; Bengamra S.; Zerrouqi A. (2008.) Assessment of Cement Dust Impact on the Soil using Principal Component Analysis and GIS', *International Journey Environmental Science Technology*, Vol. 5 (1), 125-134.

[9] Sustainable Cement Production, Co-Processing of Alternative Fuels and Raw Materials in The European Cement Industry Chembureau, 2009.

[10] The Nation, July 23, 2014. Online available htpp://thenationolineng.net

[11] Stanley, H. O., Odu, N. N. & Immanuel, O. M. (2014), 'Impact of Cement Dust Pollution on Physicochemical and Microbiological Properties of Soil around Lafarge Cement Wapco, Ewekoro, South-western Nigeria', *International Journal of Advanced Biological Research,* 4 (4) 400-404.

[12] Worrell Ernst, Price Lynn, Martin Nathan, Hendriks Chris, and Ozawa Meida Leticia (2001). Carbon Dioxide Emissions from The Global Cement Industry.

[13] Sharma Kuldeep (2912). Treatment of Waste Generated from Cement Industry and Their Treatment.

[14] Madlool N. A., Saidur R, Hossain M. S, Rahim N. A, A (2011). critical review on energy use and savings in the cement industries.

[15] Huntzinger Deborah N., D. Eatmon Thomas (2008). A life-cycle assessment of Portland cement manufacturing: comparing the traditional process with alternative technologies.

[16] Rai Priyanka, Mishra RM and Parihar Sarita (2013). Quantifying the Cement Air Pollution related Human Health diseases in Maihar city, MP, India.

[17] Bashar M. Al Smadi, Kamel K. Al-Zboon and Khaldoun M. Shatnawi (2009). Assessment of Air Pollutants Emissions from a Cement Plant: A Case Study in Jordan.

[18] Babatunde Saheed Bada, Kofoworola Amudat Olatunde and Adeola Oluwajana (2013). Air Quality Assessment in The Vicinity of Cement Company.

[19] Hesham G. Ibrahim, Aly Y. Okasha, Mokhtar S. Elatrash and Mohamed A. Al-Meshragi (2012). Emissions of SO_2, NOx and PMs from Cement Plant in Vicinity of Khoms City in North-western Libya.

[20] Aribigbola Afolabi, Fatusin Afolabi Francis and Fagbohunka Adejompo (2012). Assessment of Health and Environmental Challenges of Cement Factory on Ewekoro Community Residents, Ogun State, Nigeria.

[21] Pollution Prevention and Abatement Handbook 1998, 1999.

[22] Process Compatible SO_2 Control in Cement Kilns, 2011, Online available at: http://gcisolutions.com/gcitn0711.html [accessed 13 May 2014].

[23] Sayed Horkoss (2008). Reducing the SO_2 emission from a Cement Furnace.

[24] Yousef S. H. Najjar (2011). Gaseous Pollutants Formation and Their Harmful Effects on Health and Environment.

[25] Human Health and environmental effects of emissions from power generation, Environment protection Agency report, Online available at: http://www.epa.gov/captrade/documents/power.pdf, [accessed 14 May 2014].

[26] Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from The Portland Cement Industry, EPA, 2010.

[27] Hendrik G. van Oss and Amy C. Padovani. (2003) Cement Manufacture and the Environment Part II: Environmental Challenges and Opportunities.

[28] Health Effects of Regulated Air Pollutants from Toxic Waste Burning Cement Kilns, online available at: http://www.groundwork.org.za/Cement, [accessed 15 May 2014].

[29] Mark Z. Jacobson (2008). On the causal link between carbon dioxide and air pollution mortality.

[30] Cristian Dincă, Călin-Cristian Cormoş, Horia Necula (2013). Environmental Impact Assessment of GHG Emissions Generated by Coal Life Cycle and Solutions for Reducing CO_2.

[31] Cement Manufacturing Enforcement Initiative, Environment protection Agency report, online available at: http://www2.epa.gov/enforcement/cementmanufacturing-enforcement-initiative, [accessed 15 May 2014].

[32] Manjula R., R. Praveena, Rashmi R. Clevin, C. H. Ghattargi, A. S. Dorle, D. H. Lalitha. (2014). Effects of occupational dust exposure on the health status of portland cement factory workers.

[33] M. A. Darweesh, M. K. El-Sayed (2014). The Effect of Cement Dust Pollution on the Zygophyllum Coccinum Plant.

[34] Environmental Assessment of the Amran Cement Plant, US Agency for International Development, 2005.

[35] Syed Sana Mehraj, Bhat, G. A., Henah Mehraj Balkhi (2013). Research Article Comparative Study of Ambient Air Quality and Health Symptoms Associated with the Population Living in the Neighborhood of the Cement Industries.

[36] Ogunsina Olabode Isaiah and Akintan George Blessing (2020). Environmental and Biochemical Implication of Solid Waste Dumpsites in Ondo State, Nigeria. *American Journal of Environment and Sustainable Development,* 5 (4), 64-71.