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IMPACTS OF CEMENT INDUSTRY ON ENVIRONMENT – AN OVERVIEW

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ABSTRACT

Climate change is considered as the major environmental challenge for the world. Technological advancement has resulted in Cement making companies being able to produce higher volumes compared to the past. However, the higher production levels have also been largely labelled as the leading cause of pollution (Zimwara et al., 2012). Building industry is one of the leaders in deterioration of environment by depleting resources and consuming energy or creation of waste (Stajanca and Estokova., 2012). Emissions from Cement manufacturing are one of the major contributors in global warming and climate change. Cement belongs to the most often used building materials and its production is increasing over the world. But the cement industry is an energy enormous intensive and products many emissions, odors and noise. It is a major source of emissions such as CO_2, NO_X, SO_X, VOCs, Particulate matter etc. The present paper is a review taken from literature, peer reviewed journals, industry sector reports etc.

Key Words: *Cement Production, Environmental and Health Impacts*

INTRODUCITON:

It is impossible to envisage a modern life without cement. Cement is an extremely important construction material used for housing and infrastructure development and a key to economic growth. Cement demand is directly associated to economic growth and many growing economies are striving for rapid infrastructure development which underlines the tremendous growth in cement production (Shraddha and Siddiqui., 2014). The cement industry plays a major role in improving living standard all over the world by creating direct employment and providing multiple cascading economic benefits to associated industries. Despite its popularity and profitability, the cement industry faces many challenges due to environmental concerns and sustainability issues (Shraddha and Siddiqui., 2014).

Concrete is the most common construction material used in building industry. Cement is a basic component of concrete used for building and civil engineering construction. On average approximately 1 ton of concrete is produced each year for every human being in the world. Therefore, concrete (i.e. cement) is one of the World's most significant manufactured materials. Because of its abundance in the world market, understanding the environmental implications of concrete and cement manufacturing are becoming increasingly important (Huntzinger and Eatmon
and Eatmon., 2009).

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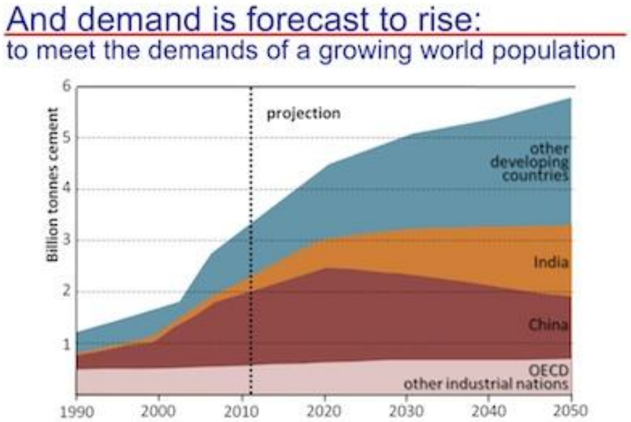

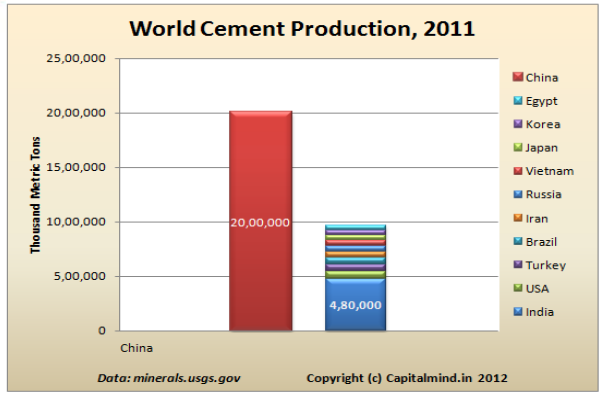

The cement industry has made significant progress in reducing CO2 emissions through improvements in process and efficiency, but further improvements are limited because CO2 production is inherent to the basic process of calcinating limestone.

The cement industry contributes significantly to the imbalances of the environment; in particular air quality. The key environmental emissions are nitrogen oxides (NOx), sulphur dioxide (SO2) and grey dust (Albeanu et al., 2004). Industrial plant smokestacks from cement and construction companies are some of the biggest contributors to poor air quality, especially in urban developments. The Portland cement manufacturing industry is under close scrutiny these days because of the large volumes of CO2 emitted. Actually this industrial sector is thought to represent 5–7% of the total CO2 anthropogenic emissions (Hendricks et al., 1998; Humphreys and Mahasenan, 2002). Therefore, numerous studies have been done to evaluate CO2 emissions and energy consumption (Capros et al., 2001; CIF, 2003; Gartner, 2004). Technological advancement has resulted in cement making companies being able to produce higher volumes compared to the past. However, the higher production levels have also been largely labelled as the leading cause of pollution. The main sources of air pollution in the industry include excavation activities, dumps, tips, conveyer belts, crushing mills and kiln emissions. As of 2007, the cement industry alone was reported to produced 5% of total greenhouse gases in the atmosphere (Air Quality Resources,2011).

Cement Production:

Cement is produced from raw materials such as limestone, chalk, shale, clay, and sand. These raw materials are quarried, crushed, finely ground, and blended to the correct chemical composition (US EPA, 2010).

After the mining, grinding and homogenization of raw materials, the process of calcination is followed by burning the resulting calcium oxide together with silica, alumina and ferrous oxide at high temperatures to form clinker; the clinker is then ground or milled together with other constituents (as gypsum, slag etc.) to produce cement. (Karstensen., 2006 & 2007).

The main stages in Cement Production:

A. Quarrying (Raw material acquisition):

Most of the raw materials used are extracted from the earth through mining and quarrying and can be divided into the following groups: lime, silica, alumina, and iron (Albeanu et al., 2004). Limestone (calcium carbonate – CaCO3) is the predominant raw material therefore most plants are situated near a limestone quarry or receive this material from a source via inexpensive transportation. The plant must minimize the transportation cost since one third of the limestone is converted to carbon dioxide (CO2) during the pyro-processing and is subsequently lost. Quarry operations consist of drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing.

B. Raw Materials Preparation (Raw Milling And Fuels Preparation):

Raw milling involves mixing the extracted raw materials to obtain the correct chemical configuration, and grinding them to achieve the proper particle-size to ensure optimal fuel efficiency in the cement kiln and strength in the final concrete product (Karstensen., 2006 & 2007).

TYPES OF PROCESSESS:

The three important types of processes are

- **i) Dry Process**
- **ii) Wet Process**
- **iii) Semidry Process**

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i) **Dry Process:**
In the dry process, the raw materials are dried using impact dryers, drum dryers, paddle-equipped rapid dryers, or air separators, before grinding, or in the grinding process itself.

ii) **Wet Process**
In the wet process, water is added during grinding.

iii) **Semidry Process**
In the semidry process the materials are formed into pellets with the addition of water in a pelletizing device.

C. Clinker Burning – Pyro Processing:

The raw mix is heated to produce cement clinkers. Clinkers are hard, grey, spherical nodules with diameters ranging from 0.32 - 5.0cm created from the chemical reactions (sintering) between the raw materials.

The raw mix is supplied to the system as a slurry (wet process), a powder (dry process), or as moist pellets (semidry process).

Steps in Pyro Processing:

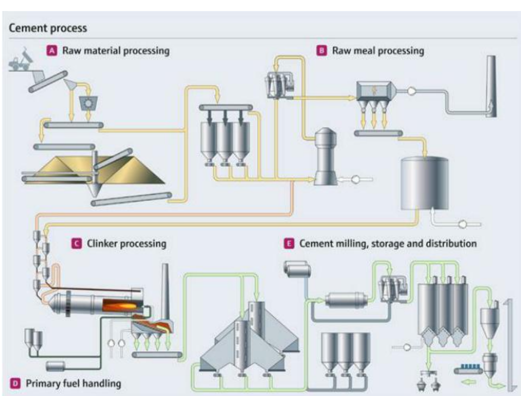
The pyro-processing system involves three steps: drying or preheating, calcining (a heating process in which calcium oxide is formed), and burning (sintering). The pyro-processing takes place in the burning/kiln department. The raw mix is supplied to the system as a slurry (wet process), a powder (dry process), or as moist pellets (semidry process). All systems use a rotary kiln and contain the burning stage and all or part of the calcining stage. All pyro-processing operations take place in the rotary kiln, while drying and preheating and some of the calcination is performed outside the kiln on moving grates supplied with hot kiln gases.

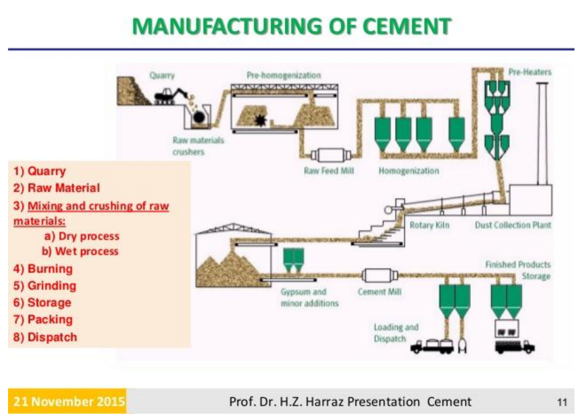
D. Cement Grinding:

This stage is also known as finish milling. Here the clinker is ground with other materials (which impart special characteristics to the finished product) into a fine powder. Gypsum and/or natural anhydrite are added to regulate the setting time of the cement.

D. Cement Packaging and Dispatch:

The finished product is transferred using bucket elevators and conveyors to storage silos. Most of the cement is transported to customers in bulk by railway, trucks, and in bags (normally 50kg bags). Cement is mostly used in mortar and concrete in the construction industry.





Emissions from Cement Industry:

Cement manufacturing is a "high volume process" and correspondingly requires adequate quantities of resources, that is, raw materials, thermal fuels and electrical power. The main environmental (air quality) impacts of the manufacture of cement in general are related to the categories as:

i) **Gases & VOCs:**
Gaseous atmospheric emissions of CO_2, NO_x, SO_2, Volatile Organic Compounds (VOCs) and others Carbon dioxide is released during the production of clinker, a component of cement, in which calcium carbonate ($CaCO_3$) is heated in a rotary kiln to induce a series of complex chemical reactions (Conneely et al., 2001). Specifically, CO_2 is released as a by-product during calcination, which occurs in the upper, cooler end of the kiln, or a pre calciner, at temperatures of 600-900°C, and results in the conversion of carbonates to oxides.

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Sulphur oxides and nitrogen oxides generated from the kiln and drying processes. Sulphur dioxide is generated from the sulphur compounds in the ores and the combusted fuel and varies in amount produced from plant to plant. The efficiency of particulate control devices is inconclusive as the result of variables such as feed sulphur content, temperature, moisture, and feed chemical composition, in addition to alkali and sulphur content of the raw materials and fuel. The combustion of fuel in rotary cement kilns generates nitrogen oxides from the nitrogen in the fuel and incoming combustion air (Zimwara et al., 2012).

The amount emitted depends on several factors including fuel type, nitrogen content, and combustion temperature. Both sulphur dioxide and some of the nitrogen oxide react with the alkaline cement and are removed from the gas stream.

Volatile organic carbon compounds (VOCs) are a class of chemicals that are emitted directly to the air as a result of evaporation or another type of volatilization. Sources include stored gasoline, stored solvents and other industrial chemicals, and certain industrial processes. Incomplete combustion of fuels of many types is also an important source of VOC discharge to the ambient air (Zimwara et al., 2012).

ii) **Dust:**

Dust emissions originate mainly from the raw mills, the kiln system, the clinker cooler, and the cement mills. A general feature of these process steps is that hot exhaust gas or exhaust air is passing through pulverised material resulting in an intimately dispersed mixture of gas and particulates. The nature of the particulates generated is linked to the source material itself, that is, raw materials (partly calcined), clinker or cement (Karstensen., 2006 & 2007).

iii) **Noise:**

Noise emissions occur throughout the whole cement manufacturing process from preparing and processing raw materials, from the clinker burning and cement production process, from material storage as well as from the dispatch and shipping of the final products (Stajanca and Estokova., 2012).

The heavy machinery and large fans used in various parts of the cement manufacturing process can give rise to noise and/or vibration emissions, particularly from: chutes and hoppers, any operations involving fracture, crushing, milling and screening of raw material, fuels, clinker and cement; exhaust fans; blowers; duct vibration.

iv) Bad Odour:

Foul smell is sometimes a direct result of the gases emitted during cement manufacturing. Moreover, since cement manufacture has life threatening impacts to plants and animals, the manufacturing process then directly and indirectly gives rise to offensive smells as the dead plants and animals decay (Zimwara et al., 2012).

ENVIRONMENTAL & HEALTH IMPACTS:

Climate change effects can occur on atmospheric temperatures, precipitation levels and patterns, water resources, terrestrial and aquatic habitats, threatened and endangered species, agricultural productivity, and many other natural and man-made resources.

The cement industry is an energy intensive and significant contributor to climate change. The major environment health and safety issues associated with cement production are emissions to air and energy use. Cement manufacturing requires huge amount of non renewable resources like raw material and fossil fuels. It is estimated that 5-6% of all carbon dioxide greenhouse gases generated by human activities originates from cement production (Potgieter Johannes., 2012). Raw material and Energy consumption result in emissions to air which include dust and gases. The exhaust gases from a cement kiln contains are nitrogen oxides (NOx), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulfur dioxide, carbon monoxide , and still smaller quantities of organic compounds and heavy metals (Ian and David., 2002). Toxic metals and organic compounds are released when industrial waste is burnt in cement kiln. Other sources of dust emissions include the clinker cooler, crushers, grinders, and materials-handling equipment (Mishra and Siddiqui., 2014).

These emissions are not only deteriorating air quality but also degrading human health. Emissions have local and global environment impact resulting in global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity etc (Pariyar., 2013). Scientific evidence indicates that air pollution from the combustion of fossil fuels causes a spectrum of health effects from allergy to death . The results of several studies showed that these emissions are adversely affecting human health in a variety of ways, like itchy eyes, respiratory diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, cardio-vascular diseases and even premature death (Pollution Prevention Handbook, 1998; Mehraj et al., 2013).

NOx causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide. Similar to sulphur dioxide, NOx react with water and other compounds to form various acidic compounds. When these acidic compounds that are deposited to the earth's surface, they can impair the water quality of different water bodies and acidify lakes and streams. Acidification (low pH) and the chemical changes result in making it difficult for some fish and other aquatic species to survive, grow, and reproduce. Acid rain can also harm forest ecosystems by directly damaging plant tissues (EPA Report, 2014). Nitrous oxide is a greenhouse gas and it accumulates in the atmosphere with other greenhouse gasses causing a gradual rise in the earth's temperature. This will lead to global

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warming and climate change. NOx and volatile organic compounds react in the atmosphere in the presence of sunlight to form ground-level ozone, which causes smog in cities and rural areas. This ground level ozone when breathed, it causes respiratory disease and other health problems (EPA Report, 2014). Nitrogen dioxide affects body functions such as difficulty in breathing, chronic lung diseases, such as chronic inflammation and irreversible structural changes in the lungs, which with repeated exposure, can lead to premature aging of the lungs and other respiratory illness.

The principal harmful effects of VOCs are toxicity, possible contribution to smog via photochemical reactions in the atmosphere, and possible contribution to the “greenhouse effect” and consequent global warming (Woodard). Dust emissions have been linked to respiratory problems such as Tuberculosis.

SUMMARY & CONCLUSION:

It is well known act that air pollution is hazardous to environment and human health. Due to infrastructure, developmental activities Cement industry is flourishing & resulting in environmental degradation and in the degradation of human health worldwide. The gaseous & particulate emissions from Cement plants are degrading air quality & thus creating considerable environmental pollution especially air pollution.

A current trend in the field of cement production is the focus on low-energy cements, utilization of waste in cement production and the associated reduction of CO2 emissions. Evaluation of cement impact to environment is a very important process.

Impacts related to global warming are due nearly exclusively to CO2, those for acidification are mainly due to SOx (34%), NH3 (30%), N20 (17%), SO2 (13%) and NOx (6%) and impacts for marine eco toxicity are essentially related to the emission of Fluorine and its inorganic compounds (54%), barite and Barium (34%) and many heavy metals such as Vanadium (3%).

Von Bahr and co-authors have studied the variability of three types of emissions (Dust, NOx, and SO2) from 1993 to 1999 in 6 different cement plants (von Bahr et al., 2003). They show an improvement of processes with time as well as a large variability between cement plants.

This review examines various impacts of Cement manufacturing companies on Environmental and Health aspects, by adoption of appropriate technology and computer modelling, industry will not only reduce production waste but also comply with legislation to do with environmental protection, control used for air and looks at how computer modelling can be adopted for the classification, quantification and control of particulate matter; and how efficient energy use can contribute to better air quality.

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