CEMENT FACTORIES, AIR POLLUTION AND CONSEQUENCES

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CONTENTS

PREFACE

The fact that air pollution is hazardous to human health is well known. WHO estimates that, worldwide, at least two million people every year die prematurely due to health effects caused by a lack of clean air? Air is the basic necessity of human life but the quality of air is deteriorating continuously and it is being constantly polluted from different sources. One of the major sources of air pollution are automobiles and industries, as per estimates vehicular pollution is the primary cause of air pollution in urban areas (60%), followed by industries (20-30%). Cement industry is one of the most important industries involved in air pollution. The aerial discharge of cement factories consist of Particulate matter, Sulphur dioxide and Nitrogen oxides producing continuous visible clouds which ultimately settle on the vegetation, soil and effects whole biotic life around, as a result the whole ecosystem around the cement factory is subjected to extraordinary stress and abuse. This book provides an insite into the process of cement manufacturing, various types of pollutants which are released from these factories and their immediate and long term impacts. As whole process of cement manufacturing, involves release of enormous pollutants need is to strictly and sustainably regulate its manufacturing, distribution and use especially in residential and biodiversity rich areas, so that human lives may not be lost at the name of so called development.

Syed Sana Mehraj

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CHAPTER I

INTRODUCTION

The modernization and industrialization of developing countries has led to the increased use of fossil fuels and their derivatives. As such, developing countries are confronted with the great challenge of controlling the atmospheric pollution, especially in the rapidly growing urban centres. Air pollution is an important problem in industrial areas which may have an adverse effect on the health of the population. Air pollution is due to the discharge of toxic fumes, gases, smoke and dusts into the atmosphere (Park and Park, 1985).

Concern about air pollution in urban regions is receiving increasingly importance worldwide, especially pollution by gaseous and particulate trace metals (Azad and Kitada, 1998; Salam *et al*., 2003; Begum *et al*., 2004; and Cachier *et al.,* 2005). A great deal of attention has focused on particulate matter (PM) pollution, due to their severe health effects, especially fine particles. Several epidemiological studies have indicated a strong association between elevated concentrations of inhalable particles (PM_{10} and $PM_{2.5}$) and increased mortality and morbidity (Perez and Reyes, 2002; Lin and Lee, 2004; 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 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; IPCC, 2001).

Numerous studies and the lack of effective policies reveal that air pollution continues to threaten public health (Cropper et al., 1860; Medina *et al.,* 2009). Studies of long- term exposure to air pollution (especially particles) suggest an increased risk of chronic respiratory illness (Schwartz, 1994; Pope *et al*., 1995; Dockery and Pope, 1994) and of developing various types of cancers (Hemminki and Pershagen, 1994; Knox and Gilman, 1997; Nyberg et al. 2000). In an apparently worst case scenario carried out on the WHO data sets, (Kunzll *et al*., 2000) found that 6% of the deaths in Austria, France, and Switzerland might be associated with exposure of the population to particulate air pollution. Major air pollution problems are occurring at urban and industrial centers, increasing pollution levels however can also be observed at remote sites as a consequence of agricultural practices and mineral mining and processing. Motor vehicle traffic is the main contributor of deterioration of air quality in the urban centers. The high average of fleet, poor fuel quality, insufficient car maintenance and high concentration of vehicles in the areas with inadequate infrastructure all contribute to the high pollutant load. Other important pollutant sources are industrial activities including cement industry.

As we know India is one of the leading developing countries that have undergone rapid industrialization in the few decades of near past. India today is among first ten industrialized countries of the world (Sharma, 2004). Besides steel and power the cement production of India is recognized as one of the most important industries. The consumption pattern of cement often

denotes economic development of any nation. The rapid and unsafe growth of various industries during the last 50 years has, however, resulted in remarkable deterioration of the environment.

Environment is a major issue which confronts industry and business in today's world on daily basis. Different industrial activities are degrading various environmental components like water, air, soil and vegetation (Dolgner *et al*., 1983; Sai *et al.,* 1987; Mishra, 1991; Murugesan *et al.,* 2004; Kumar *et al*., 2008). 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 and CO_2 emissions. Cement dust contains heavy metals like chromium, nickel, cobalt, lead and mercury pollutants hazardous to the biotic environment with impact for vegetation, human health, animal health and ecosystem (Baby *et al*. 2008). The cement industry is involved in the development of structures in this advanced and modern world because it is the basic ingredient of concrete used in constructing modern edifices and structures. In fact, life without cement in this 21st century is inconceivable. Cement, however, generates dust during its production (Meo, 2004). Cement is a fine, gray or white powder which is largely made up of Cement Kiln Dust (CKD), a by-product of the final cement product, usually stored as wastes in open-pits and landfills. Exposure to cement dust for a short period may not cause serious problem, however prolonged exposure can cause serious irreversible damage to plants and animals (Heather, 2003).Cement dust of sufficient quantities have been reported to dissolve leaf tissues (TRF, 2008). Other reported effects of cement dust on plants include reduced growth, reduced chlorophyll, clogged stomata in leaves, cell metabolism disruption, interrupt absorption of light and diffusion of

gases, lowering starch formation, reducing fruit setting (Lerman, 1972), inducing premature leaf fall and leading to stunted growth (Darley, 1966) thus causing suppression in plants and in animals it leads to various respiratory and hematological disease, cancers, eye defects and genetic problems (Iqbal and Shafug, 2001; Meo, 2004; Mohammed and Sambo, 2008; Ogunbileje and Akinosun, 2011).Besides gaseous and particulate pollutants there are also enhanced levels of toxic heavy metals in the environment of cement factory likely cobalt, lead, chromium, nickel, mercury (Baby *et al.,* 2008) posing very potential hazard for all living organisms (Lewis and Mcintosh, 1989). Increased concentrations of the above pollutants cause progressive reduction in the photosynthetic ability of leaves, mainly a reduction in growth and productivity of plants (Larcher, 1995).

Metal toxicity in plants has been reported by various authors (Bollard and Butler, 1966; Brown and Jones, 1975; Foy *et al.,* 1978; Chidambaram et al., 2009). Heavy metal pollutants are stable in the environment but highly toxic to biological organisms (Zou *et al.,* 2006; Levent *et al.,* 2009). Among the heavy metals, Mercury, lead, nickel, chromium are most dangerous heavy metals released by cement factories (Kumar et al., 2008) and is responsible for causing various biochemical changes which also includes cytotoxic and mutagenic effects (Ritambhara *et al.,* 2010 and Yahaya *et al.,* 2012) such as chromosomal aberrations, stickiness, c-mitosis, chromosomal bridge, chromosome fragmentation, vagrant chromosomes, DNA fragmentation etc in various plants as well as in humans.

Blooming of cement factories has resulted in the environmental deterioration and in turn degrades the human health

status in whole world. Studies have shown adverse respiratory health effects in the people exposed to cement dust, exemplified in increased frequency of respiratory problems (Al-Neaimi *et al.,* 2001).It has also been revealed that people of cement dust zone are badly affected by respiratory problems, gastro intestinal diseases etc. (Adak *et al.,* 2007). Several studies have also demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population. Cement dust irritates the skin (Ikli *et al.,* 2003). Its deposition in the respiratory tract causes a basic reaction leading to increased pH values that irritates the exposed mucous membranes (Zeleke *et al.,* 2010). Numerous studies and the lack of effective policies reveal that air pollution continues to threaten public health. Studies of long – term exposure to air pollution (especially particles) suggest an increased risk of chronic respiratory illness (Schwartz, 1994; Sivicommar *et al.,* 2001). Besides health, cement factories are deteriorating environment as shown by studies. The exhaust gases and particulate matters of the dust exhausted from cement plants are released to air and degrading air quality and thus creates considerable environmental pollution (Adak *et al.,* 2007). Since early 1980s, it has become clear that air pollution affects the health of human beings and animals (Parada *et al.,* 1987), damages vegetation, soils and deteriorates materials and generally affects not only the large metropolitan areas but also the medium sized urban areas. Air pollution has a great impact on human health, climate change, agriculture and natural ecosystem (Molina *et al.,* 2004)

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CHAPTER II

CEMENT FACTORIES AND CEMENT MANUFACTURING

Cement industry is one of the most basic industries involved in the development of a country. Cement is the most widely used building material throughout the world. With the increase in demand for cement in India too the numbers of factories are increasing each year and both consumption and production of cement has increased greatly in recent years. The cement industry has been recognized to be playing a vital role in the imbalances of the environment and producing air pollution hazards. The industry releases huge amounts of cement dust into the atmosphere which settle on the surrounding areas forming a hard crust and causes various adverse impacts.

India is the second largest producer of cement after China. The production process for cement consists of drying, grinding and mixing limestone and additives like bauxite and iron ore into a powder known as “raw meal”. The raw meal is then heated and burned in a pre-heater and kiln and then cooled in an air cooling system to form a semi-finished product, known as a clinker. Clinker (95%) is cooled by air and subsequently ground with gypsum (5%) to form Ordinary Portland Cement (OPC). Other forms of cement require increased blending with other raw materials. Blending of clinker with other materials helps to impart key characteristics to cement, which eventually govern its end use. There are two general processes for producing clinker i.e. a dry process and a wet process. The basic differences between these processes are the form in which the raw meal is fed into the kiln, and the amount of energy consumed in each of the processes. In the dry process, the

raw meal is fed into the kiln in the form of a dry powder resulting in energy saving, whereas in the wet process the raw meal is fed into the kiln in the form of slurry. There is a semi-dry processing, which consumes more energy than the dry process but lesser than the wet process. Majority of Cement plants are dry process plants. Limestone is crushed to a uniform and usable size, blended with certain additives (such as iron ore and bauxite) and discharged on a vertical roller mill, where the raw materials are ground to fine powder. An electrostatic precipitator de-dusts the raw mill gases and collects the raw meal for a series of further stages of blending. The homogenized raw meal thus extracted is pumped to the top of a pre-heater by air lift pumps. In the pre-heaters the material is heated to 750°C. Subsequently, the raw meal undergoes a process of calcination in a pre-calcinator (in which the carbonates present are reduced to oxides) and is then fed to the kiln. The remaining calcination and clinkerization reactions are completed in the kiln where the temperature is raised to between 1,450°C and 1,500°C. The clinker formed is cooled and conveyed to the clinker silo from where it is extracted and transported to the cement mills for producing cement. For producing OPC, clinker and gypsum are used and for producing Portland Pozzolana Cement (PPC), clinker, gypsum and fly ash are used. In the production of Portland Blast Furnace Stag Cement (PSC), granulated blast furnace slag from steel plants is added to clinker. The main raw material used over here for cement industry includes limestone ($CaCO_3$), clay, sandstone (SiO_2), bauxite (N_2O_3) and gypsum ($Ca_2SO_4.2H_2O$) and involves the release of various particulates, dust, gases and heavy metals. The whole process can be summarized in the following flowchart (Figure 1):

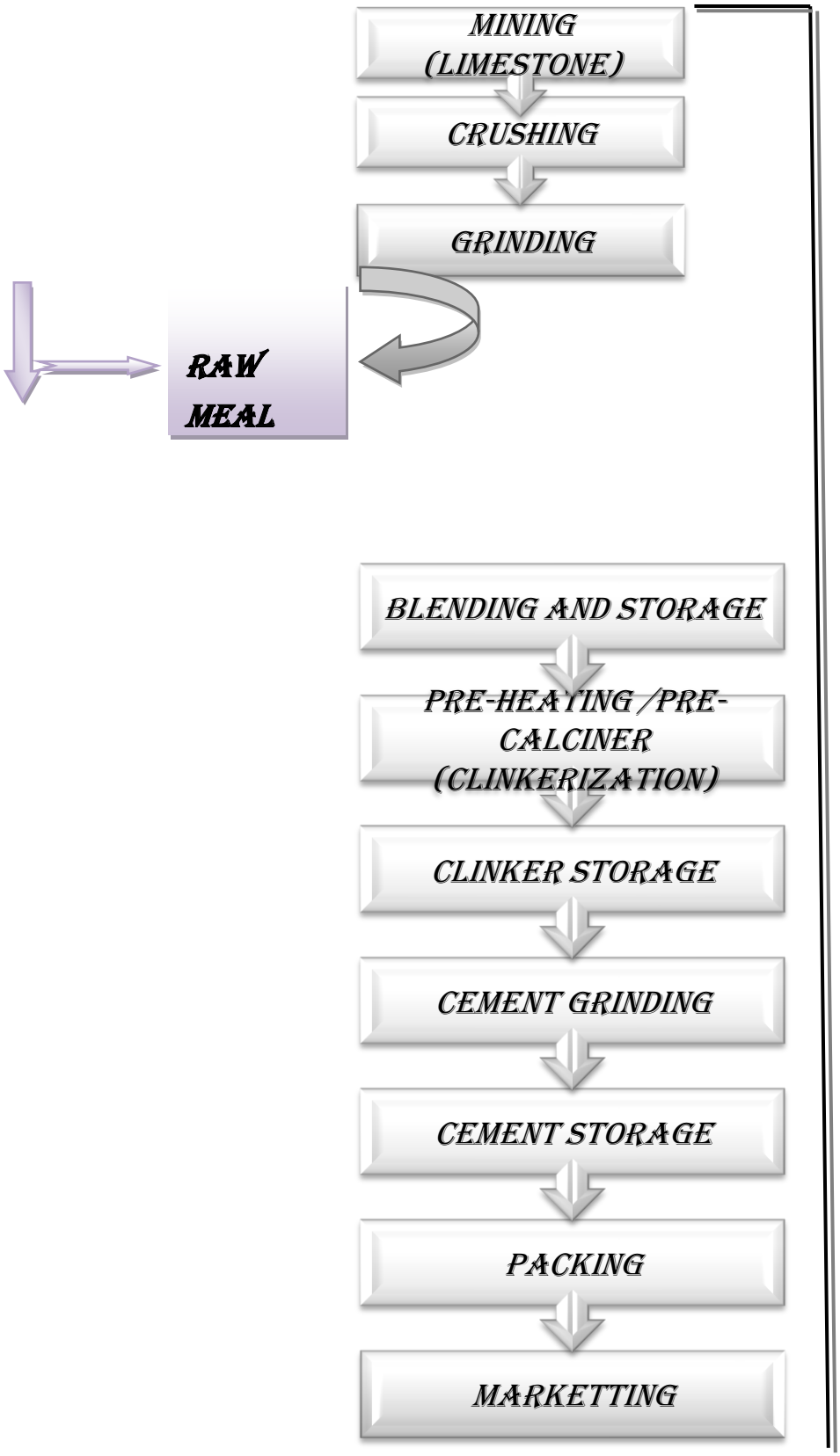

Figure 1: Source: JK Cements LTD

Cement manufacture has caused environmental impacts at all stages of the process in the area. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries, and damage to countryside from quarrying. Equipment to reduce dust emissions during quarrying and manufacture of cement should have been widely used, and equipment to trap and separate exhaust gases should have come into increased use.

Unplanned discharges of atmospheric pollutants influenced by intense industrialization, population explosion and urbanization result in injury and damage. The intensity and nature of the damage is a function of the concentration of the pollutant and the duration of exposure (dose). This has immediate (acute) and long (chronic) effects on the quantity and quality of agricultural products (Shaibu -Imodagbe, 1991). Based on the properties of these pollutants, the resulting effects on the receptor may cause biochemical and physiological modifications/alterations at the cellular level as well as whole plant, animal and ecosystem. These may cause significant changes in agricultural output. The first argument advanced by the cement industry was that the industry did not emit any pollutants at all and that what is added by the cement plants to the environment is only dust and nothing beyond that. The truth shockingly is otherwise. Almost all the manufacturing units of a cement factory e.g., raw mill, kiln, coal mill, cement mill are point sources of pollution emission. In addition some other activities associated with post-manufacturing stages like open air handling,

loading and unloading etc. result in leakage of dust into the environment, which are called fugitive sources of emissions. Emissions of Carbon dioxide take place during cement manufacturing due to decarbonisation of Calcium carbonate and Magnesium carbonate and burning of fossil fuels. Oxidation of Sulphur in fuel generates SO_x (Sulphur dioxides) and combination of Oxygen and Nitrogen at high temperature in the burning zone generates Nitrogen oxides. The cement manufacturing processes thus result in release/ emission of following pollutants:

Criteria Air Contaminants (CAC):

Particulate matter (Suspended and Respirable), Nitrogen oxides, Sulphur oxides, Carbon monoxide, Volatile organic compounds (VOC) and Green House Gases (GHG). Other substances include: Acidic compounds, Heavy metals – Cadmium, Lead, Mercury and Nickel. It is due to emission of such and other lethal pollutants that the cement industry finds place in the red category club i.e. the most polluting industry (Ministry of Environment and Forest, Government of India and Central Pollution Control Board).

Blooming of cement factories has resulted in the environmental deterioration and in turn degrades the human health status in whole world. Studies have shown adverse respiratory health effects in the people exposed to cement dust, exemplified in increased frequency of respiratory problems (Al-Neaimi *et al.,* 2001). It has also been revealed that people of cement dust zone are badly affected by respiratory problems, gastro intestinal diseases etc. (Adak *et al*., 2007). Several studies have also demonstrated

linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population. Cement dust irritates the skin (Ikli *et al*., 2003). Its deposition in the respiratory tract causes a basic reaction leading to increased pH values that irritates the exposed mucous membranes (Zeleke *et al.,* 2010). Numerous studies and the lack of effective policies reveal that air pollution continues to threaten public health. Studies of long – term exposure to air pollution (especially particles) suggest an increased risk of chronic respiratory illness (Schwartz, 1994; Sivicommar *et al.,* 2001). Besides health, cement factories are deteriorating environment as shown by studies. The exhaust gases and particulate matters of the dust exhausted from cement plants are released to air and degrading air quality and thus creates considerable environmental pollution (Adak *et al*., 2007). Since early 1980s, it has become clear that air pollution affects the health of human beings and animals (Parada *et al*., 1987), damages vegetation, soils and deteriorates materials and generally affects not only the large metropolitan areas but also the medium sized urban areas. Air pollution has a great impact on human health, climate change, agriculture and natural ecosystem (Molina *et al*., 2004).

The impacts of cement industry are countless and it even did not spare humans from its deteriorating impacts and have adversely impacted human health in the area. Exposure to cement pollution has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function, continuing to restricted activity/reduced performance, emergency room visits and hospital admissions and to mortality (Schuhmacher *et al*., 2004; Aydin *et al.*, 2010; Zeleke *et al.*, 2010; Vestbo *et al*., 1900). There is also increasing evidence for

adverse effects of cement pollution not only on the respiratory system, but also on the cardiovascular system (Dockery, 1993). The most severe effects in terms of the overall health burden include a significant reduction in life expectancy of the average population by a month or more (Samet *et al*., 2000), which is linked to the long-term exposure to high levels of air pollution with PM from these cement industries(Sheppard, 1990; Pope and Dockey., 2006; Grau, 2009)). Besides human health air pollutants have shown more adverse impacts on livestock (Schwabe, 1984) effecting gross domestic product (GDP) of the precious wealth of livestock in form of cattle-buffalo, sheep, goats, poultry etc. The cattle and poultry amongst all the livestock are considered the most important tool for the development of the rural economy. The various diseases such as respiratory infections and various other pollution related problems are arising among livestock at an alarming rate in the areas.

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CHAPTER III

POLLUTANTS FROM CEMENT FACTORIES

Three criteria air pollutants are released to the air during cement manufacturing which includes particulate matter (PM), nitrogen oxides (NOX) and sulfur dioxide (SO2) which can be categorised into two headings:

1) Particulates

2) Gaseous pollutants

Particulates

Particulate air pollution is a complex mixture of small and large particles of varying origin and chemical composition. Larger particles, ranging from about 2.5 microns to 100 microns in diameter, usually comprise smoke and dust from industrial processes, agriculture, construction, and road traffic, as well as plant pollen and other natural sources. Smaller particles those less than 2.5 microns in diameter generally come from combustion of fossil fuels. These particles include soot from vehicle exhaust, which is often coated with various chemical contaminants or metals, and fine sulfate and nitrate aerosols that form when SO_2 and nitrogen oxides condense in the atmosphere. The largest source of fine particles is industries, but auto and diesel exhaust are also prime contributors, especially along busy transportation corridors.

The health effects of particulates are strongly linked to particle size. Small particles, such as those from fossil fuel combustion, are likely to be most dangerous, because they can be inhaled deeply into the lungs, settling in areas where the body's natural clearance mechanisms can't remove them. The constituents in small particulates also tend to be more chemically active and may

be acidic as well and therefore more damaging. Numerous studies associate particulate pollution with acute changes in lung function and respiratory illness (Douglas et.al 1996., USEPA, 1996), resulting in increased hospital admissions for respiratory disease and heart disease, school and job absences from respiratory infections, or aggravation of chronic conditions such as asthma and bronchitis (Deborah,1996).

Numerous studies suggest that health effects can occur at particulate levels that are at or below the levels permitted under national and international air quality standards. In fact, according to the WHO and other organizations, no evidence so far shows there is a threshold below which particle pollution does not induce any adverse health effects, especially for the more susceptible populations.

Table 1: Particulate size varies with the type of particulate from different sources:

S. No	Particulate type	Diameter	References
1	Cement Dust	80-90% greater than 30 um	Darley (1966)
2	Motor Vehicles	0.01-5000um	Nimaniya *et.al* (1971)
3	Urban road dust	3-100um	Thompson *et.al* (1984)
4	Fly Ash	1-2000um	Kragickova and Mejstrick (1984)
5	Coal Dust	3-100um	Rao (1971)

Gaseous pollutants

Gaseous pollutants have major negative impacts on health. They also play an important role in environmental changes in atmospheric chemistry. SO_2 and NO_2 form acids through different chemical reactions in the atmosphere, and these acids are subsequently deposited on land and ocean surfaces as acid rain. It is anticipated that the increasing load of atmosphere sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon dioxide (CO_2), carbon monoxide (CO), and ozone (O_3) will contribute to global climate change, consequently, it is necessary to quantify the emission in the very near future. The combustion of fuels at high temperatures in cement kilns results in the release of NO_X emissions, which causes various health adverse health effects. In SO_2 emissions from cement plants result from the combustion of sulfur-bearing compounds in coal, oil, and petroleum coke, and from the processing of pyrite and sulfur in raw materials. Cement manufacturing releases carbon dioxide (green house gas) in the atmosphere both directly when calcium carbonate is heated, producing lime and carbon dioxide, and also indirectly through the use of energy if its production involves the emission of carbon dioxide. The cement industry is the second largest CO_2 emitting industry behind power generation. The cement industry produces about 5% of global man made CO_2 emissions, of which 50% is from the chemical process, and 40% from burning fuel. The amount of CO_2 emitted by the cement industry is nearly 900kg of CO_2 for every1000 kg of cement produced. The high proposition of CO_2 produced in the chemical

reactions leads to large decrease in mass in the conservation from lime stone to cement. So, to reduce the transport of heavier raw materials and to minimize the associated costs, it is more economical for cement plants to be closer to the lime stone quarries rather than to the consumer centres. Besides particulates and gaseous pollutants many other pollutants are also released from cement factories which include toxic heavy metals

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CHAPTER IV

CONSEQUENCES OF CEMENT POLLUTION

The aerodynamic diameter of cement particles makes it a potential health hazard, as these are respirable in size and reaches in internal organs particularly lungs leading to occupational lung diseases. This size distribution would make the trachea-bronchial respiratory zone, the primary target of cement deposition. The main route of entry of cement dust particles in the body is the respiratory tract and/ or the gastrointestinal tract by inhalation or swallowing respectively (Green, 1970). Both routes, especially the respiratory tract are exposed to numerous potentially harmful substances in the cement mill environment. Besides cement dust various gaseous pollutants are also contributed by cement factories which cause pollution and ultimately affect human health.

The various organ systems which get affected because of cement factories include:

Respiratory system: In respiratory system, these causes lungs cough and phlegm production, chest tightness, impairment of lung function, obstructive and restrictive lung diseases, Pleural thickening, fibrosis, emphysema, lung nodulation, pneumoconiosis and carcinoma of lung

Gastro intestinal system: Oral cavity, mechanical trauma, mucosal inflammation, loss of tooth surface, periodontal diseases, dental caries, dental abrasion, liver diffuse, swelling and proliferation of sinusoidal (hepatic) lining cells, sarcoid type granulomas, perisinusoidal and portal fibrosis and hepatic lesions is caused in the gastro intestinal system.

Stomach: In stomach it causes stomach ache and cancer.

Central nervous system (brain): Usually causes headache and fatigue.

Lymphatic system: Spleen diminished lymphatic tissue and splenic lesions.

Other affects includes affect in eyes, skin and bones. Irritation in eyes, running eyes and conjunctivitis, skin irritation, itching, skin boil and burn, osteonecrosis, lesion of humerus, thinning of the cortex and reduction of epiphyseal cartilage.

Allergic reactions that interfere with breathing: Allergic reactions which create many breathing problems, from simple runny noses to life-threatening respiratory arrest. The immune system's abnormal response to harmless allergens unleashes histamines and other substances that work to restore equilibrium .The side effects of this process result in respiratory and other allergy symptoms. Complications can occur in people with extreme sensitivities to the allergenic proteins in some pollen, foods, household pollutants, animal secretions and other substances. Pre-existing respiratory conditions also contribute to the severity of allergic effects on the respiratory system.

Chronic bronchitis: Bronchitis is an infection of the bronchial tree. The bronchial tree is made up of the tubes that carry air into the lungs. When these tubes get infected, they swell and mucus forms. This makes it hard for a person to breathe. The person may cough up mucus and many wheeze.

Asthma: Asthma (AZ-ma) is a condition in which the airflow in and out of the lungs may be partially blocked by swelling, muscle squeezing, and mucus in the lower airways. These episodes of

partial blockage, called asthma "fares" or "attacks," can be triggered by dust, pollutants, smoke, allergies, cold air, or infections.

Emphysema: In emphysema the alveolar tissue is partially destroyed and the remaining alveoli are weakened and enlarge. The bronchioles collapse on exhalation, trapping air in the alveoli. Over time this process impairs the ability to exchange particulate matter oxygen and carbon dioxide with the circulatory system, leading to breathing difficulties; Emphysema is a noncontiguous disease that results from multiple factors, including a genetic predisposition to the condition, smog, cigarette smoke, and infection.

Lung cancer: Studies of the American Cancer Society cohort directly link the particulate exposure to with lung cancer. For example, if the concentration of particles in the air increases by only 1%, the risk of developing a lung cancer increases by 14% (Pope et al, 2002 and Kweskhi et al, 2004). Further, it has been established that particle size matters, as ultrafine particles penetrate further into the lungs (Valavinidis, 2008).

Pneumonia: Pneumonia is an inflammation and infection of the lungs. Although pneumonia is special concern for older people and those with chronic illnesses, it can also strike young, healthy people as well. In infectious pneumonia, bacteria, viruses, fungi or other organisms attack the lungs, leading to inflammation that makes it hard to breathe. Pneumonia can affect one or both lungs. Infection of both lungs is referred to as double pneumonia.

Tuberculosis: Tuberculosis is caused by a bacterium that attacks the lungs and sometimes other body tissues as well. If infections in the lungs are left un-treated, the disease destroys lung tissue. In the past, antibiotics have con-trolled tuberculosis, but recently, new antibiotic-resistant strains of the tuberculosis bacterium have

evolved. These new strains now pose a significant public health problem.

Cough: A cough is a sudden and often repetitively occurring reflex which helps to clear the large breathing passages from secretions, irritants, foreign particles and microbes. The cough reflex consists of three phases: an inhalation, a forced exhalation against a closed glottis, and a violent release of air from the lungs following opening of the glottis, usually accompanied by a distinctive sounds (Chung and Pavord, 2008).Coughing can happen voluntarily as well as involuntarily. Coughing may be caused by air pollution including tobacco smoke, particulate matter, irritant gases, and dampness in the home (Goldsobel and Chipps, 2010). The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system.

Wheezing: Wheezing is a high-pitched whistling sound during breathing. It occurs when air flows through narrowed breathing tubes. There may be various causes of wheezing such as asthma, bronchitis, breathing of any foreign substance or dust etc (David et.al, 2010).

Besides humans, cement affects directly the quality of soil, as it adds number of harmful substances to it. Although, the basic constituents of cement dust are calcium ($CaCO_3$), silicon (SiO_2), aluminum (Al_2O_3), ferric and manganese oxides (Akpan *et al.,* 2011) its production produces known toxic, carcinogenic and mutagenic substances, such as particulate matters, sulfur dioxide, nitrogen dioxide, volatile compounds, long lived dioxins and heavy metals (Davidovits, 1994). The calcinations and burning processes of cement production produce poisonous gases that cause injuries to plants and animals (Abimbola *et al.,* 2007; Gbadebo and Bankole,

2007). Cement dust causes numerous hazards to the biotic environment, which have adverse effects and toxicological risks for vegetation, animal health and ecosystems (Shukla *et al.*, 1990; Armolaitis *et al.,* 1996; Sivicommar *et al.,* 2001; Schwartz, 1994; Adak *et al*., 2007) Plant growth parameters, yield and yield components of crops can be considerably influenced by excessive metal accumulation in soil (Lerman, 1972). The particles of cement deposits are quite alkaline making soils of neighborhood alkaline and changing its other properties which in turn affects vegetation growth, decreases chlorophyll content thus decreasing photosynthesis rate as chlorophyll pigments are essential component for photosynthesis, decreasing respiration rate, reducing transpiration and thus growth rate (Borka *et al.,* 1978; Sai *et al.,* 1987; Shukla *et al*., 1990; Asubiojo *et al*., 1991; Iqbal and Shafiq, 2001; Ade-Ademilua and Umebese, 2007; Nanos *et al*., 2007). Jan and Bhat, 2006; Rafiq *et al.,* 2008; Jan, 2009 studied the impacts of cement pollution on morphology of Saffron plant and its productivity. One of the important aspects is decrease in chlorophyll content. A decrease in chlorophyll has been used as an indicator of an air pollution injury (Gibbert, 1968).Decrease in chlorophyll ‘a’ chlorophyll ‘b’ and Total chlorophyll content in fresh tissues of affected leaves might be due to chloroplast damage by incorporation of cement dust into foliar tissue. Similar observation have also been made by Pandey *et al*. (1998, 1999) with stone crusher dust and by Lerman (1972); Singh and Rao (1968); Pandey and Singh (1990) and by Pandey *et al*. (1998) with cement dust. Agarwal and Tiwari (1997) are of the opinion that the alkaline conditions caused by solubilisation of dust in cell cap may be responsible for chlorophyll degradation vis–a-vis photosynthetic efficiency. However, Mengel

and Kirby (1983); Hewitt (1983) indicated that decrease in chlorophyll is due to induced Iron deficiency caused in excess of Calcium supply. A number of workers have reported the similar results (Borka,1980; Lerman, 1972) has suggested that continuous application of cement clogs the stomata, and thus interfering with gaseous exchange. This may lead to increased leaf temperatures which may retard the chlorophyll synthesis (Mark, 1963; Singh and Rao, 1981). Chlorophyll may be destroyed in cells under cement cover (Bredemann, 1992; Panjenkemp, 1961; Samdor, 1973; Klinesek, 1970; Borka, 1978). Reduction in chlorophyll content in the cement affected plants and in the leaves can be attributed to the effect of Nitrogen oxides and Sulphur dioxide released from the factory as the pollutants. The appreciable reduction in chlorophyll contents in Sulphur dioxide treated plants were also noticed by some other workers like (Chand and Kumar, 1987; Kumar and Pandey, 1985).

Besides morphological and physiological changes in plants there also occur biochemical changes because of cement dust such as decrease in protein contents , change in proline level, total free amino acids, reducing sugars, abnormality during mitosis, chromosomal breakages etc (Kaushik, 1996). Besides gaseous and particulate pollutants there are also enhanced levels of other elements (metals and non- metals) in cement dust which cause numerous effects on plant which includes decrease in yield, seed germination, leaf area and water content of the leaves (Hasan *et al.,* 2011). Among the elements most toxic are heavy metals, as cement dust contains a number of heavy metals such as Mercury, lead, nickel, chromium etc. These cause cytogenic as well as mutagenic effects such as decrease in plant growth, low pollen fertility,

decrease in seed yield, decrease in total protein levels, chromosomal stickness in meiosis phase, c-mitosis, chromosomal bridge, chromosome fragmentation, vagrant chromosomes, bi-nucleus chromosomes and multi-polar anaphase and DNA fragmentation (Abdul, 2010; Ritambhara *et al.,* 2010; Yahaya *et al.*, 2012).Among heavy metals Mercury plays an essential role. Mercury is a typical toxic metal pollutant. Bioaccumulation of mercury in plants and its entry into the food chain resulting in long term health hazards is of major concern. Since the beginning of the industrial era, anthropogenic adulteration of the atmosphere, increased mining, high rate containing mercury in the industries are some of the sources of mercury, creating a vitiated environment. The uptake and accumulation of chemicals by plants may prove to be the most important aspect of chemical pollution dynamics (Mohapatra, 1989). It is interesting to note that the elements like mercury are easily absorbed by the plants than the other elements (Pendias and Pendias, 1989).The higher concentration of mercury is due to the mercury released from the factory kiln and preheating/ precalcining operations which gets accumulated in the nearest area of the factory. Mercury is introduced into the kiln with raw materials (90% of the material input) and to a minor extent with fuels, such as coal and oil which are used to provide energy for calcinations. It is also reported that the hypogeal parts accumulated comparatively lesser amounts of mercury than the epigeal parts in plant (Jan and Bhat, 2008). Mobility of heavy metal mercury has been demonstrated by a members of workers, Furgusson (1984) correlated the transportation system through the xylem and phloem and transpiration intensity which significantly influence its accumulation. Mercury mobility to Peterson, (1984) appeared to be

greater when it entered the plant through the stem or leaf .The metal entry into plants through the leaves is more significant for pollution elements because of aerosol deposits (Furgusson, 1984). A number of reports revealed that the accumulated levels in plants are influenced by their distance from the source of the metal (Steinnes, 1987) and also seasonal effect (Chaney *et al.,* 1984).

Cement dust causes numerous hazards to the biotic environment, which have adverse effects and toxicological risks for vegetation, animal health and ecosystems (Shukla *et al.*, 1990; Armolaitis *et al.,* 1996; Sivicommar *et al.,* 2001; Schwartz, 1994; Adak *et al*., 2007) Plant growth parameters, yield and yield components of crops can be considerably influenced by excessive metal accumulation in soil (Lerman, 1972).

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PHOTO GALLERY

Some photo Glimpses

Of pollution from cement factories

Panoramic View of Saifco Cement Factory in Khonmoh, Jammu and Kashmir, India

Dust and Gas Emission from JK Cements, Khonmoh, Jammu and Kashmir, India

Huge Gaseous Clouds Emanating from Khrew Cement Factory, Jammu and Kashmir, India

Dust and Gas Emissions from Khrew, Jammu and Kashmir, India (JK Cements)

Cement Dust on Wild Fruit Shrub (Rubus viveus)

Cement Dust on Forest Tree (Celtis australis) and the Ground Herbage on which Cattle Graze

Dust and Gas coming out from the Chimney of the Factory

Cement Dust Settled on the Vehicles

Cement factory of Khrew, Jammu and Kashmir, India

Cement Dust settled on creepers

Cement Dust settled on herbage

SUMMARY

Cement is currently the most widely used material throughout the world. Its production is being recognized to be playing a hazardous role in the imbalances of the environment and producing air pollutants. The cement kilns emit enormous amounts of cement dust into the atmosphere which settle on the soil and vegetation of landscape. Cement dust is a potential phytotoxic pollutant in the vicinities of cement producing factories creating serious pollution problems. Quality of air is vitally important simply because we can't avoid breathing in the air around us. The average adult breathes in about 20 cubic meters, or 20,000 liters of air a day. Those who live in urban and sub urban areas should be especially concerned, since they are exposed to a greater amount of pollutants coming from automobile traffic, commercial, industrial and manufacturing facilities, as well as other sources. Air pollutants can cause a variety of health problems - including breathing problems; asthma; reduced lung function; lung damage; bronchitis; cancer; and brain and nervous system damage. Air pollution can also irritate the eyes, nose and throat, and reduce resistance to colds and other illnesses. Air pollution can be especially harmful to the very young, the very old, and those with certain -existing medical conditions. Air pollution also causes haze and smog, reduces visibility, dirties and damages buildings and other landmarks, and harms trees, lakes and animals. It is also responsible for thinning the protective ozone layer in the upper atmosphere that protects us from harmful ultraviolet radiation from the sun, and is also contributing to the phenomenon known as global warming- the steady increase in

average temperature of the global climate(Environmental assessment and policy).

The fact that air pollution is hazardous to human health is well known. WHO estimates that, worldwide, at least two million people every year die prematurely due to health effects caused by a lack of clean air? Air is the basic necessity of human life but the quality of air is deteriorating continuously and it is being constantly polluted from different sources. One of the major sources of air pollution are automobiles and industries, as per estimates vehicular pollution is the primary cause of air pollution in urban areas (60%), followed by industries (20-30%) in India (Sivasamy and Srinivasan,1997). Number of industries in India is increasing with time so is increase in air pollution. Cement industry is one of the most important industry in India, as India is the second largest cement producer in the world, cement consumption in the country has been growing @ 10% per annum in the last few years and this growth pattern is expected to be maintained, still country has per capita consumption about 150 as compared to world average of about 400 which is a huge gap, so cement production of country is expected to increase at an alarming rate.

The discharge of cement factories generally consist of Particulate matter, Sulphur dioxide and Nitrogen oxides producing continuous visible clouds which ultimately settle on the surroundings as a result the whole ecosystem around the cement factory is subjected to extraordinary stress and abuse. Huge clouds of cement dust have been in generation in the area right from the establishment of these factories.

Almost all the manufacturing units of a cement factory e.g., raw mill, kiln, coal mill, cement mill are point sources of pollution emission. In addition some other activities associated with post-manufacturing stages like open air handling, loading and unloading etc. result in leakage of dust into the environment, which are called fugitive sources of emissions. Emissions of Carbon dioxide take place during cement manufacturing due to decarbonisation of Calcium carbonate and Magnesium carbonate and burning of fossil fuels. Oxidation of Sulphur in fuel generates SO_x (Sulphur dioxides) and combination of Oxygen and Nitrogen at high temperature in the burning zone generates Nitrogen oxides. The cement manufacturing processes thus result in release/ emission of following pollutants:

Particulate matter (Respirable and non respirable), Nitrogen oxides, Sulphur oxides, Carbon monoxide, Volatile organic compounds (VOC) and Green House Gases (GHG).Other substances include: Acidic compounds, Heavy metals – Cadmium, Lead, Mercury and Nickel. It is due to emission of such and other lethal pollutants that the cement industry finds place in the red category industry i.e. the most polluting industry (Ministry of Environment and Forest, Government of India and Central Pollution Control Board).

Besides all these there are some hidden impacts on the surrounding community such as the visual blight and resulting drop in property values, lowering living standard and quality of life, noise and diesel truck emissions, socio economic degradation, increase in stress level and many more.Cement industry is a major pollution problem contributor in terms of dust and particulate matter emitted at various steps of cement manufacture. Besides particulate matter,

SO2, NOx, discharge from cement factories generally consists of heavy metals and dust producing continuous visible clouds which ultimately settle on the surroundings as a result the whole ecosystem around the cement factory is subjected to extraordinary stress and abuse.

Keeping in view the hazards of cement dust it is recommendable that the cement industry management, their workers and health officials should work together to adopt scientific and technical preventive measures, such as well ventilated work areas and workers should wear appropriate apparel, mask, safety goggles etc. It is also suggested that cement mill workers must undergo pre-employment and periodic medical surveillance tests. These measures would help to identify susceptible workers in due time and improve the technical preventive measures that will decrease the risk of occupational hazards in the cement industrial workers. Tree belts must be established around the newly come up cement factories. The stack height must be appropriate and air pollution control devices should be installed and regularly checked.

About the Author

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