



Health Hazards and Environmental Impact of Cement Industries

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Abstract: This study delves into the health implications for workers employed in India's cement industry. Despite the cement industry's pivotal role in global economic development, its manufacturing processes generate significant environmental burdens, including air pollution from dust, gases, noise, and vibrations. Cement plants are notorious for exposing workers to quartz, cement dust, and other harmful substances, which have been linked to respiratory ailments such as chronic bronchitis, silicosis, and interstitial lung diseases. This research is based on a comprehensive review of existing literature, including academic articles, online resources, and expert opinions. The findings indicate a strong correlation between cement industry exposure and a range of health issues, extending beyond respiratory problems to encompass skin, eye, and heart conditions. Prolonged exposure can lead to reduced life expectancy and a general decline in workers' health. The study concludes by proposing strategies to safeguard the well-being of cement industry workers.

Keywords: Environment, Health, Chronic Respiratory Diseases, Impaired Pulmonary Functions, Carbon Monoxide, Nitrogen Oxides

Introduction

Air pollution has emerged as a global health crisis, claiming millions of lives annually, according to the World Health Organization. The correlation between exposure to environmental contaminants and respiratory illnesses is increasingly evident.

Climate change poses a significant worldwide challenge, and the cement industry has become a major contributor. Despite technological advancements boosting

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production, the sector is a primary source of pollution, resource depletion, and energy consumption. As the construction industry thrives, the demand for cement surges, exacerbating environmental problems. Cement production is energy-intensive and generates substantial emissions, noise, and odor.

Elevated levels of fine particulate matter (PM 2.5) have been linked to increased rates of respiratory illnesses such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. Cement plants are significant contributors to this air pollution problem. Cement, a key component in construction, is produced by grinding clinker, a material formed by heating a mixture of clay and limestone. Most cement plants primarily engage in clinker grinding and cement bagging.

Research indicates that dust and noise are the primary occupational hazards in the cement industry. Dust levels in quarries and cement plants have been recorded between 26 and 114 mg/m³. While noise levels generally fall within acceptable limits, dust exposure poses a significant health risk.

Pulmonary diseases are the most prevalent occupational health issues in the cement sector, primarily caused by inhaling airborne dust. Chronic bronchitis is a common ailment among workers. Moreover, cement dust dispersion can impact the health of nearby residents.

This study aims to evaluate the environmental and health consequences of cement production, focusing on dust pollution. Key objectives include reducing occupational hazards, promoting workplace safety, and contributing to the well-being of local communities.

Role of Cement and Cement Industries

Cement is an indispensable component of modern infrastructure development and economic progress. The construction boom experienced by many nations has fueled significant growth in the cement industry. This sector is a cornerstone of economic expansion, generating employment and stimulating related industries. However, the cement industry also faces substantial challenges due to environmental concerns and sustainability issues.

Concrete, a primary building material composed of cement, is produced in vast quantities globally, averaging approximately one ton per person annually. Its ubiquity underscores the importance of understanding its environmental impact. While the cement industry has made strides in reducing carbon dioxide emissions through process improvements, the fundamental production process involving limestone calcination inherently generates CO₂.

Process of Cement Production

Cement production commences with the extraction and processing of raw materials. These materials are ground into a fine powder and homogenized. Subsequently, a high-temperature process known as calcination transforms the mixture into clinker, a key component of cement. Clinker, composed primarily of calcium oxide, silica, alumina, and iron oxide, is then finely ground with additional substances to create the final cement product.

Main Stages of Cement Production:

1. **Raw Material Extraction:** The initial phase involves sourcing raw materials through mining and quarrying. Key components include limestone (primarily calcium carbonate), along with silica, alumina, and iron oxide.
2. **Raw Material Preparation:** Extracted materials undergo a milling process to achieve a consistent composition and particle size. This preparation is essential for efficient kiln operation and the subsequent strength of the cement.

Cement Production Processes

Process Types

The cement manufacturing process primarily involves three core methods:

- **Dry Process:** Raw materials are dehydrated using compressed air, reducing moisture content to less than 1%. The dried materials are then pulverized and fed into a rotary kiln for drying, calcination, and carbonation.
- **Wet Process:** Raw materials are mixed with water to form a slurry, which is subsequently heated in a kiln. This method typically uses 35-50% water content.
- **Semi-Dry Process:** Raw materials are combined with water to create pallets, which are then dried and granulated. This process involves a lower water content of around 12% and requires higher temperatures (approximately 1450°C).

Clinker Production

Regardless of the initial process, the subsequent step involves clinker production. This occurs through a high-temperature process known as pyroprocessing, where the raw material mixture is transformed into hard, spherical nodules called clinker.

Cement Grinding and Packaging

The final stage entails grinding the clinker into a fine powder. Gypsum is added to control the setting time of the cement. The finished product is then packaged, typically in 50kg bags, and prepared for distribution.

Cement Industry Emissions

Cement production is a resource-intensive process demanding substantial quantities of raw materials, thermal fuels, and electricity. A primary environmental consequence of this industry is its significant contribution to air pollution.

Air Pollution from Cement Production

The cement industry is a major contributor to air pollution, releasing nitrogen oxides, sulfur dioxide, and particulate matter into the atmosphere. These emissions originate from the combustion of fuels and the processing of raw materials like limestone, chalk, shale, clay, and sand.

The production of clinker, a key component of cement, involves heating calcium carbonate in a rotary kiln, a process that releases carbon dioxide, nitrogen oxides, sulfur oxides, and volatile organic compounds. Sulfur dioxide primarily stems from sulfur compounds present in the raw materials and fuel. The levels of these emissions vary based on factors like fuel type, nitrogen content, and combustion temperature. Some nitrogen oxides and sulfur dioxide can be captured by the alkaline nature of the cement production process.

Dust Emissions from Cement Production

Dust emissions in cement plants primarily originate from the raw material grinding, kiln, clinker cooling, and cement grinding processes. These stages involve hot gases passing through finely divided materials, creating a mixture of gas and particulate matter. The composition of the dust particles is directly related to the specific raw materials used in the production process.

Noise Pollution from Cement Production

Noise pollution is a prevalent issue across the cement manufacturing process. Vibrational emissions often accompany noise, particularly from equipment such as chutes, hoppers, and machinery involved in crushing, milling, and screening raw

materials, fuels, clinker, and cement. Additionally, exhaust fans, blowers, and ducts contribute to the overall noise levels.

Odor Emissions from Cement Production

The gases produced during cement manufacturing can generate unpleasant odors due to the decomposition of organic matter present in the raw materials.

Environmental and Health Impacts of the Cement Industry

Climate change, characterized by shifts in temperature, precipitation, and ecosystems, poses significant global challenges. The cement industry is a major contributor to this crisis, accounting for approximately 5-6% of global carbon dioxide emissions. The production process consumes substantial amounts of raw materials and energy, resulting in air pollution comprised of dust, gases, and various pollutants including nitrogen oxides, carbon dioxide, sulfur dioxide, and heavy metals.

These emissions have detrimental effects on both the environment and human health. On a global scale, they contribute to greenhouse gas emissions, ozone depletion, acid rain, biodiversity loss, and reduced agricultural yields. Locally, air pollution from cement plants can lead to respiratory ailments such as asthma, bronchitis, and tuberculosis, as well as other health issues including eye irritation, cardiovascular diseases, and premature death.

Nitrogen oxides, a family of compounds including nitrogen dioxide, nitric acid, and nitrous oxide, pose significant environmental and health risks. Similar to sulfur dioxide, these compounds react with water to form acidic compounds, contributing to acid rain. This acidification harms aquatic ecosystems, impacting fish and other aquatic life. Additionally, acid rain damages forests by harming plant tissues.

Nitrogen oxides are potent greenhouse gases, contributing to global warming and climate change. They also play a role in the formation of ground-level ozone, a harmful air pollutant linked to respiratory diseases and other health problems. Chronic exposure to nitrogen oxides can lead to irreversible lung damage and premature aging of lung tissue.

Discussion and Conclusion

Cement production is linked to the release of fine dust particles, which have been associated with respiratory health issues in nearby communities. The growth of infrastructure and development has led to a surge in cement production, resulting in

significant environmental degradation and human health risks worldwide. Gaseous and particulate emissions from cement plants are primary contributors to air pollution.

This review assesses the environmental and health implications of cement manufacturing. By incorporating advanced technologies and modeling techniques, the industry can optimize production processes, minimize waste, and adhere to environmental regulations. Computer modeling is instrumental in identifying, quantifying, and controlling particulate matter emissions. Additionally, efficient energy utilization is crucial for improving air quality.

Air pollution poses a significant threat to both the environment and human health. The cement industry, a key player in infrastructure development and economic growth, has contributed substantially to this issue. Gaseous and particulate emissions from cement plants are primary culprits in deteriorating air quality. While the industry is shifting towards low-energy production and waste utilization to reduce carbon dioxide emissions, a comprehensive evaluation of environmental impacts remains crucial. Carbon dioxide is the primary driver of global warming, while nitrogen oxides, sulfur oxides, and ammonia contribute to acidification. Marine ecosystems are affected by emissions of fluorine, barium, and other heavy metals.

The cement industry is a significant contributor to global warming and climate change due to its substantial greenhouse gas emissions. These emissions contribute to rising global temperatures, glacial melting, and overall climate instability.

Particulate matter, generated throughout the cement production process, poses another critical environmental and health concern. These fine particles, including dust, soot, and liquid droplets, can reduce visibility, contaminate water bodies, and harm human health. Particulate matter can carry toxic metals such as lead, chromium, nickel, and barium. Inhalation of these particles can lead to respiratory issues, including bronchitis, lung damage, and increased mortality rates. Additionally, they can cause eye and throat irritation and contribute to heart disease.

Improving Worker Health in the Cement Industry

To safeguard the health of cement industry workers, several key strategies can be implemented:

- 1. Regular Health Monitoring:** Consistent health assessments can detect and address potential health issues early, mitigating long-term consequences.
- 2. Baseline Health Records:** Establishing comprehensive health profiles for workers provides a benchmark for tracking changes over time and identifying potential health risks.

3. **Periodic Check-ups:** Routine medical examinations for both workers and those in close proximity to cement plants are essential for maintaining optimal health.
4. **Comprehensive Assessments:** Regular evaluations of both the cement production process and worker health are necessary to identify and mitigate hazards effectively.
5. **Biological Monitoring:** Genetic testing can help detect potential health risks and environmental impacts associated with cement industry exposure.

By implementing these measures, the cement industry can prioritize worker health and well-being while minimizing environmental risks.

Practical Implications of the Study: Health Hazards and Environmental Impact of Cement Industries

A study on the health hazards and environmental impact of cement industries can lead to several practical implications:

For Public Health

- **Health Risk Assessment:** Identifying specific health risks to communities living near cement plants, including respiratory diseases, cancer, and reproductive issues.
- **Early Warning Systems:** Developing systems to monitor air and water quality in cement plant vicinity for early detection of pollutants.
- **Public Health Campaigns:** Creating awareness programs about the health risks associated with cement production and encouraging preventive measures.
- **Healthcare Infrastructure:** Strengthening healthcare facilities near cement plants to handle potential health emergencies.

For Environmental Protection

- **Pollution Control Measures:** Implementing stricter regulations on emissions, waste disposal, and water usage in cement plants.
- **Technology Adoption:** Encouraging the use of cleaner technologies and alternative fuels to reduce environmental impact.
- **Monitoring and Enforcement:** Establishing robust monitoring systems to ensure compliance with environmental regulations.

- **Land Use Planning:** Preventing the establishment of residential areas near cement plants and creating buffer zones.

For Industry and Policymakers

- **Sustainable Practices:** Promoting sustainable practices in cement production, such as resource efficiency and circular economy principles.
- **Economic Incentives:** Offering incentives for cement plants to adopt cleaner technologies and reduce their environmental footprint.
- **Research and Development:** Supporting research into low-carbon cement production and pollution control technologies.
- **Policy Framework:** Developing comprehensive policies to regulate the cement industry and protect public health and the environment.

For Communities

- **Compensation and Rehabilitation:** Providing compensation and rehabilitation services to communities affected by the negative impacts of cement plants.
- **Community Empowerment:** Empowering local communities to participate in decision-making processes related to cement plants.
- **Alternative Livelihoods:** Supporting the development of alternative livelihood options for communities dependent on the cement industry.

By addressing these areas, the findings of a study on health hazards and environmental impacts of cement industries can contribute to a healthier and more sustainable future.

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