Human Health Risk due to Cement Dust Exposure

Policy-Brief

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The Rajasthan State Pollution Control Board is a body corporate constituted under section 4 of the Water (Prevention and Control of Pollution) Act, 1974. It was first constituted on February 7, 1975, with the objectives of prevention, and control of water pollution and maintaining or restoring of wholesomeness of water. Later, it was also entrusted with the responsibilities of prevention, control and abatement of air pollution under the provisions of Air (Prevention and Control of Pollution) Act, 1981. Water (Prevention and Control of Pollution) Cess Act, 1977 has been enacted to make the State Board financially independent. Under this act the State Board has been given powers to collect cess on the basis of water consumed by the industries and others. Besides, the State Board is also implementing the provisions of the Public (Liability) Insurance Act, 1991. Enactment of the Environment (Protection) Act, 1986 has further widened the scope of the activities of the Board. This act being umbrella legislation, different rules for addressing the problems of various sectors have been enacted under this act. Currently, the State Board is engaged in implementation of the following rules under EPA, 1986:

- Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008.
- Manufacture, Storage & Import of Hazardous Chemical Rules, 1989.
- Public (Liability) Insurance Act, 1991.
- Environmental Impact Assessment (Aravali) Notification Dated 7.5.1992.
- Environmental Impact Assessment Notification dated 14.09.06.
- Bio Medical Waste (Management & Handling) Rules, 1998.
- Plastic Manufacture & Usage Rules, 1999.
- Noise (Pollution Control & Regulation) Rules, 2000.
- Municipal Solid Waste (Management & Handling) Rules, 2000.
- Batteries (Management & Handling) Rules, 2001.

Recently, **Climate Change and CDM Cell** has been established at RSPCB to facilitate the dissemination of knowledge relevant to climate change adaptation and mitigation in Rajasthan.

Human Health Risk due to Cement Dust Exposure

Key Facts in Brief

- Some of the initial studies have shown that the incremental individual risk due to emissions of the cement plant is very low not only with regard to health effects, but also in relation to toxicological and cancer risks produced by pollutants emitted by the cement kiln (see, for example, Schuhmacher et al. 2004), but that conclusion has been challenged. Similarly, earlier conclusion that long-term exposure to cement dust does not lead to higher morbidity of severe respiratory disease than other types of blue collar work (Vestbo and Rasmussen 1990) has also been challenged.
- Studies have shown that adverse respiratory health effects seen in the people exposed to cement dust, exemplified in increased frequency of respiratory symptoms and decreased ventilatory function, observed among cement workers could not be explained by age, BMI and smoking, thus are likely to be caused by exposure to cement dust (Al-Neaimi et al 2001).
- Cement dust contains heavy metals like nickel, cobalt, lead, chromium, pollutants hazardous to the biotic environment, with adverse impact for vegetation, human and animal health and ecosystems (Baby et al. 2008).
- The population most exposed to cement dust pollution includes workers and managers in cement plants and factories, families of workers and managers living in staff houses of factories, and other neighbourhood habitations. Children studying in the schools situated in proximity to factories are particularly prone to cement dust exposure.
- Several studies have demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population. Cement dust irritates the skin, the mucous membrane of the eyes and the respiratory system. Its deposition in the respiratory tract causes a basic reaction leading to

increased pH values that irritates the exposed mucous membranes (see, Zeleke et al. 2010, and references cited therein).

- Occupational cement dust exposure has been associated with an increased risk of liver abnormalities, pulmonary disorders, and carcinogenesis. Decreased antioxidant capacity and increased plasma lipid peroxidation have been posed as possible causal mechanisms of disease (Aydin et al. 2010).
- Total cement dust exposure has been found to be related to acute respiratory symptoms and acute ventilatory effects. Implementing measures to control dust and providing adequate personal respiratory protective equipment for the production workers are highly recommended (Zeleke et al. 2010).
- Chronic exposure to Portland cement dust has been reported to lead to a greater prevalence of chronic respiratory symptoms and a reduction of ventilatory capacity. The seriousness of pulmonary function impairment and respiratory disease has not been consistently associated with the degree of exposure (Al-Neaimi et al 2001).
- Inhalable dust concentrations in cement production plants, especially during cleaning tasks, are usually considerably higher than at the construction site (Peters et al. 2009).
- People of cement dust zone area badly affected by respiratory problems, gastrointestinal diseases etc (Adak et al. 2007).
- The observed acute respiratory health effects among the workers are most likely due to exposure to high concentrations of irritant cement dust. The results also highlight the usefulness of the questionnaire for health surveillance of the acute respiratory health effect (Mwaiselage et al. 2006).
- Diseases such as chest pain, cough, and eye problems in the villages affected by cement dust are likely to be derived due to cement dust. Indeed, the higher percentage of related diseases occurs near the source of pollutant. A relative risk ratio assessment indicates that the exposed subjects are 7.5 and 22.5 times as likely to develop the disease during the follow-up period compared to the unexposed subjects (Yhdego 1992).
- A study to evaluate the mutagenic effects of occupational exposure to cement dust in such workers concludes that the chromosomal damage was more pronounced in the workers who are also smokers when compared with the non-smokers both in control and exposed groups. A significant increase in the frequency of chromosomal aberrations

was also observed with increase in age in both control and exposed subjects (Fatima et al. 2001).

- There is good evidence for cement dust exposure acting as a tobacco, alcohol and asbestos independent risk factor for laryngeal carcinoma (Dietz et al. 2004).
- As the cement dust comes in contact with water, hydroxides are formed that impair natural water alkalinity. A fine layer of cement covers the surface of wells and ponds. The addition of salts of Ca, Na, K, Mg and Al as hydroxides, sulfates and silicates affect the hardness of the water that subsequently are responsible for the respiratory and gastro-intestinal diseases in the area (Mishra 1991).
- The results obtained from the analysis of the production process and of the exposure levels determined by the cement workers showed that it is possible to reconstruct the history of exposure to cement dust during each worker's occupational history. The results also showed that estimated exposure is related to respiratory damage; higher exposure resulted in more serious diseases (Alvear-Galindo et al. 1999).

Key Recommendations in Brief

- In order to minimize the human health risk due to cement dust exposure the factory managers are necessarily required to put in place the latest technology, management systems and continuous online monitoring, and routinely implement the activities that facilitate adherence to the emission norms prescribed under the pollution control legislation. In addition to implementing the technological and managerial measures to control dust and other emissions, it is also necessary to provide adequate personal respiratory protective equipment for the chronically exposed people.
- In doing business, it pays to be transparent. Companies that practice proactive disclosure of status of emissions are perceived to be more ethical and environmentally responsible. The state agencies responsible for enforcement of pollution control norms such as RSPCB, governments, social activists, and the media have become increasingly capable at holding business houses accountable for the social, economic and environmental consequences of their industrial operations. Thus, for the benefit of workers and family members living in staff houses located in the factory premises or in close proximity, companies must install both continuous real-time online emission monitoring systems in the factory as well as provide continuous

electronic display boards for that data in prominent places of factory premises including at the factory gate, schools and staff housing colonies.

- While deciding on the location of staff dwelling houses and schools new and upcoming cement plants should keep in mind the prevailing wind direction in the region. For example, as the predominant wind direction in Rajasthan is South West to North East, hence placement of schools and staff colonies ideally need to be located either in South West, South or South East of the cement plant. It should never ever be located in the North East direction. In addition, the staff houses and schools located in proximity to cement plants should be designed with the aim to achieve zero in-house dust exposure. As children studying in the schools situated in proximity to factories are particularly prone to cement dust exposure, the school buildings and rooms are required to be equipped with efficient and perpetually functioning dust capture devices.

- Staff colonies and schools in factory premises are also required to be isolated from the industrial production plants with robust green-belts, plantation strips and shelterbelts. The species with high pollution tolerance index can be planted in several rows. Among the trees, some of these species include *Azadirachta indica*, *Albizzia lebbek*, *Aegle marmelos*, *Annona squamosa*, *Bambusa bambos*, *Butea frondosa*, *Cassia fistula, Cordia myxa, Delonix regia*, *Ficus religiosa*, *Ficus bengalensis*, *Ficus glomerata*, *Ficus infectoria*, *Feronia elephantum*, *Holoptelea integrifolia*, *Mangifera indica*, *Moringa oleifera*, *Pithecolobium dulce*, *Phyllanthus emblica, Psidium guajava*, *Putranjiva roxburghii*, *Saraca asoka*, *Tamarindus indica, Terminalia arjuna, Zizyphus mauritiana,* and *Zizyphus jujube.* Among the shrubs, some of the species are *Bougainvillea spectabilis*, *Calotropis gigantia, Calotropis procera, Capparis zeylanica, Croton bomplandianum, Duranta plumieri, Hibiscus rosa-sinensis, Ricinus communis,* and *Nerium odorum.* Among the herbaceous plants *Achyranthus aspera* has a very high air pollution tolerance index.

- Creating green-belts takes time. However, some innovations in planting technology can generate instant green cover within a time span of six to 12 months. The good idea is to use 2.5 to 3 meters tall saplings for planting. In addition, stake planting for some species that are able to regenerate from stem cuttings can provide quick results. Experience in Rajasthan has shown that 2 to 3 meters tall stem cuttings of *Ficus* species (species such as Bargad and Peepal) can provide excellent results. Stem cuttings also develop more rapidly both above and belowground biomass than seedlings.

Annotated References

Adak, M. D., S. Adak and K. M. Purohit (2007). "**Ambient air quality and health hazards near mini cement plants**." Pollution Research **26**(3): 361-364.

Mandiakudar is a rural area near Rourkela, the steel city of Orissa. A large number of mini cement plants are in operation in and around Rourkela. The particulate matters of the dust exhausted from the cement plants are released to the air and it creates considerable environmental pollution. In order to monitor the ambient air quality of Mandiakudar based on suspended particulate, sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) a fact-finding survey was conducted for a period of three years from 2001 to 2003. The amount of different pollutants are compared with the standard limits recommended by Central Pollution Control Board (CPCB) and air quality parameters and/or air quality indices (AQI) are also worked out on that basis. **It is also found that the people of this area badly affected by respiratory problems, gastrointestinal diseases etc.**

Al-Neaimi, Y. I., J. Gomes and O. L. Lloyd (2001). "**Respiratory illnesses and ventilatory function among workers at a cement factory in a rapidly developing country**." Occupational Medicine **51**(6): 367-373.

Chronic exposure to Portland cement dust has been reported to lead to a greater prevalence of chronic respiratory symptoms and a reduction of ventilatory capacity. The seriousness of pulmonary function impairment and respiratory disease has not been consistently associated with the degree of exposure. Regular use of appropriate personal protective equipment, if available at the worksite, could protect cement workers from adverse respiratory health effects. For a variety of reasons, industrial workers in rapidly developing countries do not adequately protect themselves through personal protective equipment. This study explores the prevalence of chronic respiratory symptoms and ventilatory function among cement workers and the practice of use of personal protective equipment at work. An interviewer-administered questionnaire was used to collect information on sociodemographic characteristics, smoking profile and history of respiratory health among workers at a Portland cement plant (exposed) and workers occupationally unexposed to dust, fumes and gases (unexposed). Pulmonary function was assessed and pulmonary function impairment was calculated for the exposed and the unexposed workers. A higher percentage of the exposed workers reported recurrent and prolonged cough (30%), phlegm (25%), wheeze (8%),

dyspnoea (21%), bronchitis (13%), sinusitis (27%), shortness of breath (8%) and bronchial asthma (6%). Among the unexposed, prevalences of these symptoms were 10, 5, 3, 5, 4, 11, 4 and 3%, respectively. Ventilatory function (VC, FVC, FEV1, FEV1/VC, FEV1/FVC and PEF) was significantly lower in the exposed workers compared with unexposed workers. These differences could not be explained by age, body mass index (BMI) or pack-years smoked. Ventilatory function impairment, as measured by FEV1/FVC, showed that 36% of the exposed workers had some ventilatory function impairment compared with 10% of those unexposed. Certain jobs with greater exposure to cement dust had lower ventilatory function compared with others among the exposed workers. It was concluded that **adverse respiratory health effects (increased frequency of respiratory symptoms and decreased ventilatory function) observed among cement workers could not be explained by age, BMI and smoking, and were probably caused by exposure to cement dust.**

Alvear-Galindo, M.-G., I. Mendez-Ramirez, J.-A. Villegas-Rodriguez, R. Chapela-Mendoza, C.-A. Eslava-Campos and A.-C. Laurell (1999). "Risk Indicator of Dust Exposure and Health Effects in Cement Plant Workers." Journal of Occupational and Environmental Medicine **41**(8): 654-661.

A frequent practical problem of research in developing countries is the lack of reliable records on occupational hazards. To improve this situation, this article suggests and evaluates a two-phase method for estimating particle exposure. The first phase uses the focal group, or homogeneous group, technique to reconstruct the production process and estimate the level of dust exposure. The second phase applies the technique of individual history of exposure to hazards at work, an index that accumulates current and previous exposure. This method was introduced in a Portland cement plant to assess the dust-exposure levels of workers and to evaluate its usefulness in the association between estimated exposure levels and the frequency of health effects-particularly respiratory effects-that occurred as a result of such exposures. **The results obtained from the analysis of the production process and of the exposure levels determined by the cement workers showed that it is possible to reconstruct the history of exposure to cement dust during each worker's occupational history. The results also showed that estimated exposure is related to respiratory damage; higher exposure resulted in more serious diseases.** This supports the usefulness of the suggested methodology.

Aydin, S., S. Aydin, G. Croteau, Í. Sahin and C. Citil (2010). "**Ghrelin, Nitrite and Paraoxonase/Arylesterase Concentrations in Cement Plant Workers**." Journal of Medical Biochemistry **29**(2): 78-83.

Occupational cement dust exposure has been associated with an increased risk of liver abnormalities, pulmonary disorders, and carcinogenesis. Decreased antioxidant capacity and increased plasma lipid peroxidation have been posed as possible causal mechanisms of disease. Accordingly, this study examined the serum paraoxonase (PON1) arylesterase (AE), ghrelin, HDL-C, LDL-C and serum nitrite (NOx) levels in cement dust exposed workers. Twenty-eight volunteer male cement plant workers and 30 volunteer control male workers, aged 29-54 years, participated. The concentrations of serum PON1, AE, NOx, ghrelin, and HDL-cholesterol and LDL-cholesterol were measured in both groups. PON-1, AE, ghrelin and HDL-cholesterol were lower in the cement plant workers than in controls. Serum nitrite (NOx), and LDL-C levels in cement plant workers were higher ($p<0.05$) than in the control group workers. No correlation was observed between the serum levels of HDL-cholesterol and PON1 and between HDL-cholesterol and ghrelin. A weak negative correlation was detected between the serum ghrelin and NOx. The study results strongly suggest that HDL-paraoxonase, AE, ghrelin, HDL-C, and high NOx, and LDL-C levels may have a role in disease involving oxidative damage. However, some studies are necessary to address the association between occupational dust exposure and respiratory symptoms.

Baby, S., N. A. Singh, P. Shrivastava, S. R. Nath, S. S. Kumar, D. Singh and K. Vivek (2008). "**Impact of dust emission on plant vegetation of vicinity of cement plant**." Environmental Engineering and Management Journal **7**(1): 31-35.

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 plant vegetation. Cement industry is one of the 17 most polluting industries listed by the Central Pollution Control Board (CPCB). The Jaypee Rewa Cement industry, Rewa, Madhaya Pradesh is located between 24° 33' North longitude and 81° 10' east latitude and is situated at Jay Prakash Nagar 20 km from Rewa Town of Madhya Pradesh, India. The Jaypee Rewa Cement industry is the major source of particulate matters, SO_x, NO_x and CO_2, emissions. Cement dust contains heavy metals like nickel, cobalt, lead, chromium, pollutants hazardous to the biotic environment, with impact for vegetation, human and animal health and ecosystems. Present paper attempts to focus on impact of cement emission on plant vegetation.

Dietz, A., H. Ramroth, T. Urban, W. Ahrens and H. Becher (2004). **"Exposure to cement dust, related occupational groups and laryngeal cancer risk: Results of a population based case-control study."** International Journal of Cancer **108**(6): 907-911.

A population-based case-control study was performed in the Rhein-Neckar region, Germany, to evaluate occupational risk factors for the development of laryngeal cancer ("Rhein-Neckar-Larynx Study"). Between May 1998 and December 2000, 257 patients (236 males, 21 females), aged 37–80, with histologically confirmed laryngeal cancer, as well as 769 population control persons (702 males, 67 females), were included (1:3 frequency matched by age and sex). History of occupational exposures, as well as other risk factors (tobacco, alcohol), was obtained with face-to-face interviews using a detailed standardized questionnaire. The complete individual work history was assessed. A detailed assessment of work conditions was obtained by job-specific questionnaires (JSQs) for selected jobs known to be associated with exposure to potential laryngeal carcinogens. Estimates for total exposure hours by substance were calculated based on JSQs. Published occupational hygiene data were used to infer semiquantitative scores of exposure intensity for specific job tasks. After adjustment for tobacco and alcohol intake, a significant elevated odds ratios (OR) could be demonstrated for persons that were exposed to cement during their work as building and construction workers. An OR of 2.42 was calculated for workers of the high exposed subgroup (95% confidence interval: 1.14-5.15; $p < 0.001$). Smoking was the main confounding factor because the unadjusted cement OR of 3.20 dropped down to 2.42 after adjustment for tobacco intake. Authors conclude that **there is good evidence for cement dust exposure acting as a tobacco, alcohol and asbestos independent risk factor for laryngeal carcinoma**.

Fatima, S. K., P. A. Prabhavathi, P. Padmavathi and P. P. Reddy (2001). **"Analysis of chromosomal aberrations in men occupationally exposed to cement dust."** Mutation Research/Genetic Toxicology and Environmental Mutagenesis **490**(2): 179-186.

Cement industry is considered as a major pollution problem on account of dust and particulate matter emitted at various steps of cement manufacture. Cement dust consists of many toxic constituents. The workers who are employed in cement industries are exposed to cement dust for long periods. Therefore, it is mandatory to evaluate the mutagenic effects of occupational exposure to cement dust in such workers. In the present study, authors analyzed the samples of 124 male workers including 59 smokers and 65 non-smokers who were

employed in cement industry for a period of 1-17 years. For comparison, 106 controls (including 47 smokers and 59 non-smokers) of the same age group and socio-economic status were also studied. Controls had no exposure to cement dust or any known physical or chemical agent. A significant increase in the incidence of chromosomal aberrations was observed in the exposed group when compared to the control group. The results were analyzed separately for non-smokers and smokers. The chromosomal damage was more pronounced in the smokers when compared with the non-smokers both in control and exposed groups. A significant increase in the frequency of chromosomal aberrations was also observed with increase in age in both control and exposed subjects.

Fatima, S. K., C. V. Ramana Devi, P. A. Prabhavathi and P. P. Reddy (1997). "**Blood serum protein and calcium levels in Portland cement factory workers**." Indian Journal of Environment and Toxicology **7**(2): 56-57.

Serum, specimens from 78 workers exposed to cement dust were analysed for the level of total protein and compared with the levels of albumin and globulin. In addition the calcium levels were also monitoried. The total exposed population were categorized into 2 groups based on the duration of exposure (duration of service in cement factory). There was a significant increase in total protein and calcium levels in the exposed subjects when compared to the controls. The data also revealed that the maximum changes in serum proteins and calcium occurred within an exposure time limit of total eight years. Further exposure to seventeen years did not reveal any additional significant changes than exposed for eight years.

Kumar, S. S., N. A. Singh, V. Kumar, B. Sunisha, S. Preeti, S. Deepali and S. R. Nath (2008). "**Impact of dust emission on plant vegetation in the vicinity of cement plant**." Environmental Engineering and Management Journal **7**(1): 31-35.

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 plant vegetation. Cement industry is one of the 17 most polluting industries listed by the Central Pollution Control Board (CPCB). The Jaypee Rewa Cement Cement industry, Rewa, Madhaya Pradesh is located between 24° 33' North longitude and 81° 10' east latitude and is situated at Jay Prakash Nagar 20 km from Rewa Town of Madhya Pradesh, India. The Jaypee Rewa Cement industry is the major source of particulate matters, SOx, NOx and CO_2, emissions. Cement dust contains heavy metals like nickel, cobalt, lead, chromium, pollutants hazardous to the biotic environment, with impact for vegetation, human and animal health and ecosystems. Present paper attempts to focus on impact of cement emission on plant vegetation.

Lal, B. and R. S. Ambasht (1982). "**Impact of cement dust on the mineral and energy concentration of *Psidium guayava*.**" Environmental Pollution Series A, Ecological and Biological **29**(4): 241-247.

The impact of cement dust deposition on mineral and energy concentration of leaves of guava Psidium guayava growing in the vicinity of Churk Cement Factory situated at Churk, District-Mirzapur (India) was studied. Concentrations of calcium (Ca), potassium (K), sodium (Na) and phosphorus (P) were increased while energy content (cal g-1 dry weight) was reduced (12·3%) more in cement-dust-covered leaves than in dust-free leaves of Psidium guayava. Statistically it was found that the difference in the concentration of Ca, K, and P in dusty and dust-free leaves was highly correlated and significant with the amount of cement dust deposited (gm-2 leaf surface) on the leaf surface of P. guayava while the difference in the concentration of Na--although positively correlated--is not significant. Maximum values of concentrations of Ca, K, Na, P and energy were 5·20%, 0·48%, 0·25%, 0·15% and 4936·7 cal g-1 dry weight in dust-covered leaves and 3·50%, 0·30%, 0·018%, 0·12% and 5301·4 cal g-1 dry weight in dust-free leaves, respectively.

Mishra, G. P. (1991). "**Impact of industrial pollution from a cement factory on water quality parameters at Kymore**." Environment & Ecology **9**(4): 876-880.

When cement dust comes in contact with water hydroxides are formed which impare natural water alkalinity. A fine layer of cement covers the surface of wells and ponds. The addition of salts of Ca, Na, K, Mg and Al as hydroxides, sulfates and silicates affected the hardness of the water. These are responsible for the respiratory and gastro-intestinal diseases in the area.

Murugesan, M., A. Sivakumar, N. Jayanthi and K. Manonmani (2004). "**Effect of cement dust pollution on physiological and biochemical activities of certain plants**." Pollution Research **23**(2): 375-378.

Pollution has been a serious environmental threat for decades and various efforts are being undertaken to control it in various aspects. This paper discusses about air pollution and its effect on the physiological and biochemical characteristics of plants particularly in the near by areas of a cement factory. The cement factory chosen for study is 'Malabar Cement Factory', it is located at Walayar, the foothills of Western ghats, Kerala. The cement kiln exhaust of the cement factory deposits at the rate of 2.43 g/m^2/day on the vegetation around

the factory and the dust contains large amount of particulate and gaseous pollutants, which can cause some physiological and biochemical changes in the leaves of the plants. The continuous deposition of cement dust on the surface of the leaves of the plants reduces the chlorophyll content of the leaves and also acts as a barrier for the photosynthesis process to take place. The deposition also shows a subsequent reduction of starch, carbohydrates, proteins and aminoacids in those leaves when compared to that of with normal leaves. Since the physiological and biochemical characteristics are affected, the plant productivity gets badly affected and it results in collapsing the ecological food chain.

Mwaiselage, J., B. Moen and M. Bråtveit (2006). "**Acute respiratory health effects among cement factory workers in Tanzania: an evaluation of a simple health surveillance tool**." <u>International Archives of Occupational and Environmental Health</u> **79**(1): 49-56.

Objectives: The effects of cement dust exposure on acute respiratory health were assessed among 51 high exposed and 33 low exposed male cement workers. The ability of the questionnaire to diagnose acute decrease in ventilatory function was also assessed. Methods: Acute respiratory symptoms were recorded by interview using a structured optimal symptom score questionnaire. Peak expiratory flow (PEF) was measured preshift and postshift for each worker with a Mini-Wright PEF meter. Personal respirable dust (n=30) and total dust (n=15) were measured with 37-mm Cyclone and 37-mm closed-faced Millipore cassette. Twenty-nine workers had concurrent respirable dust, PEF and questionnaire on the same day. Results: The geometric means of personal respirable dust and total dust among high exposed were 4.0 and 13.2 mg/m3, respectively, and 0.7 and 1.0 mg/m3 among low exposed. High exposed workers had more acute cough, shortness of breath and stuffy nose than the low exposed. Mean percentage cross-shift decrease in PEF was significantly more pronounced among high exposed workers than low exposed (95% CI 1.1, 6.1%). For workers with concurrent respirable dust, PEF and questionnaire assessment, an exposure–response relationship was found between log-transformed respirable dust and percentage cross-shift decrease in PEF (4.5% per unit of log-respirable dust in mg/m3 ; 95% CI 3.3, 5.6%). Respirable dust exposure ≥2.0 mg/m3 versus <2.0 mg/m3 was associated with increased prevalence ratio for cough (7.9) and shortness of breath (4.2). Shortness of breath was associated with the highest sensitivity (0.87) and specificity (0.83) for diagnosing a percentage cross-shift decrease in PEF of ≥10%. Conclusion: The observed acute respiratory health effects among the workers are most likely due to exposure to high concentrations of irritant cement dust. The results also highlight the usefulness of the questionnaire for health surveillance of the acute respiratory health effect.

Peters, S., Y. Thomassen, E. Fechter-Rink and H. Kromhout (2009). "**Personal exposure to inhalable cement dust among construction workers**." Journal of Environmental Monitoring **11**(1): 174-180.

A case study was carried out to assess cement dust exposure and its determinants among construction workers and for comparison among workers in cement and concrete production. - Full-shift personal exposure measurements were performed and samples were analysed for inhalable dust and its cement content. Exposure variability was modelled with linear mixed models. - Inhalable dust concentrations at the construction site ranged from 0.05 to 34 mg/m, with a mean of 1.0 mg/m. Average concentration for inhalable cement dust was 0.3 mg/m (GM; range 0.02-17 mg/m). Levels in the ready-mix and pre-cast concrete plants were on average 0.5 mg/m (GM) for inhalable dust and 0.2 mg/m (GM) for inhalable cement dust. Highest concentrations were measured in cement production, particularly during cleaning tasks (inhalable dust GM = 55 mg/m; inhalable cement dust GM = 33 mg/m) at which point the workers wore personal protective equipment. Elemental measurements showed highest but very variable cement percentages in the cement plant and very low percentages during reinforcement work and pouring. Most likely other sources were contributing to dust concentrations, particularly at the construction site. Within job groups, temporal variability in exposure concentrations generally outweighed differences in average concentrations between workers. 'Using a broom', 'outdoor wind speed' and 'presence of rain' were overall the most influential factors affecting inhalable (cement) dust exposure. - Job type appeared to be the main predictor of exposure to inhalable (cement) dust at the construction site. **Inhalable dust concentrations in cement production plants, especially during cleaning tasks, are usually considerably higher than at the construction site.**

Prakash, J. and R. M. Mishra (2003). "**Effect of cement dust pollution on Calotropis procera species**." Indian Journal of Environmental Protection **23**(7): 764-767.

The effect of cement dust pollution on Calotripis procera have been assessed in Sarla Nagar Maihar Cement Plant, Madhya Pradesh. Results indicated the increasing trend of the deposition (mg/cm²) on plant leave surface with increasing distance from the emission source. Results indicate that there was considerable loss of total chlorophyll content 18.22% in the leaves of Calotropis procera growing in the polluted zone 54.77 and 20.33 leaves

of the species growing in the polluted zone were found chlorotic and necrotic, respectively. However, only 13.00% and 6.20% leaves of the species, growing in the pollution zone were found to be chlorotic and necrotic, respectively. Significant deduction in pollinators visit was also observed in the trees of polluted zone, and as a result total fruit output was found to be 35.14% less than in comparison to the trees of the pollution free zone.

Prasad, M. S. V. and J. A. Inamdar (1990). "**Effect of cement kiln dust pollution on black gram (*Vigna mungo* (L.) Hepper).**" Proceedings: Plant Sciences **100**(6): 435-443.

Effect of cement kiln dust pollution on black gram (Vigna mungo) has been studied by comparing plants of polluted as well as from non-polluted areas. Due to cement kiln dust accumulation on exposed parts of the plant, there was a decrease in height, phytomass, net primary productivity and chlorophyll content. Quantitative estimations and histo-chemical localization indicate lowering of metabolites in dusted plants as compared to control one. In polluted plants, damaged leaves show increase in stomatal index and trichome frequency and decrease in stomatal frequency. Cement kiln dust accumulation on plant surface showed decrease in the number and size of flowers which finally affected the yield to a great extent in the dusted plants.

Ramanathan, R., T. Jeyakavitha and M. Jeganathan (2006). "**Impact of cement dust on Azadirachta indica leaves - A measure of air pollution in and around Ariyalur.**" Journal of Industrial Pollution Control **22**(2): 273-276.

Ariyalur, situated in Tamilnadu is rich in limestone and there are many cement-factories in and around Ariyalur. Six lakes in and around Ariyalur was considered for the study and Azadirachta indica leaves commonly known as neem leaves from neem trees were collected for estimation of total chlorophyll content, chlorophyll 'a', chlorophyll 'b' and moisture content. The estimated chlorophyll and moisture contents were compared with control. It was found that both the chlorophyll and moisture levels in the leaves were less in all the six locations in and around Ariyalur. The reason is attributed to the accumulation of cement dust on the leaves resulting in retarded growth of the trees. Hence, the estimation of chlorophyll content and moisture content can be taken as a measure of air pollution. Water has to be sprinkled, if grown, on the leaves of trees or plants for removal of cement dust for the healthy growth of the plants.

Sai, V. S., M. P. Mishra and G. P. Mishra (1987). "**Effect of cement dust pollution on trees and agricultural crops.**" Asian Environment **9**(1): 11-14.

Measurements of cement dust deposits and chlorophyll content on leaves of Ficus bengalensis and Mangifera indica showed negative but nonsignificant correlation along the penalization gradient (downwind direction) from Kymore Cement Works, India. The crop yields of Cajanus cajan, Triticum aestivum and Linum usitatissimum, among others, were significantly affected along the gradient with crop measurements as height of plant and earhead length seen strongly correlated with crop yield.

Schuhmacher, M., J. L. J. L. Domingo and J. Garreta (2004). "**Pollutants emitted by a cement plant: health risks for the population living in the neighborhood**." Environmental Research **95**(2): 198-206.

The aim of this study was to investigate the health risks due to combustor emissions in the manufacturing of Portland cement for the population living in the neighborhood of a cement kiln in Catalonia, Spain. Pollutants emitted to the atmosphere in the course of cement production were modeled. The ISC3-ST model was applied to estimate air dispersion of the contaminants emitted by the cement plant. Air concentrations of NO_2, SO_2, PM_{10}, metals, and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), as well as the potential exposure in the vicinity of the facility, were assessed via models based on US EPA guidance documents. PCDD/F and metal concentrations were also modeled for soil and vegetation. Based on these concentrations, the levels of human exposure were calculated. Individual cancer and noncancer risks for the emissions of the cement kiln were assessed. Health effects due to NO_2, SO_2, and PM_{10} emissions were also evaluated. Risk assessment was performed as a deterministic analysis. The main individual risk in the population was evaluated in a central-tendency and a high-end approach. **The results show that the incremental individual risk due to emissions of the cement plant is very low not only with regard to health effects, but also in relation to toxicological and cancer risks produced by pollutants such as metals and PCDD/Fs emitted by the cement kiln.**

Vestbo, J. and F. V. Rasmussen (1990). "**Long-term exposure to cement dust and later hospitalization due to respiratory disease**." International Archives of Occupational and Environmental Health **62**(3): 217-220.

The relationship between exposure to cement dust in a Portland cement factory and later hospitalization due to respiratory disease and in particular chronic obstructive lung disease (COLD) was examined in a cohort initially examined in 1974. A total of 546 men with different lengths of employment in the cement factory were compared with 857 randomly sampled men of the same age from the same geographical area. Information on hospitalization was obtained from a nationwide register administered by the Danish National Board of Health. During a 9-year, 8-month period, 7.8% of the total population studied had been admitted to hospital at least once because of respiratory disease and 4.3% had been admitted because of COLD. Cement workers had no increased rates of hospitalization when compared with other blue collar workers from the random sample or the whole random sample. A vague tendency towards increasing rates of hospitalization due to COLD with increasing duration of exposure to cement dust up to 30 years was found. Given at least one hospitalization, exposure to cement dust was not related to the accumulated number of days in hospital in the observation period. Authors conclude that long-term exposure to cement dust does not lead to higher morbidity of severe respiratory disease than other types of blue collar work.

Yhdego, M. (1992). "**Epidemiology of industrial environmental health in Tanzania**." Environment International **18**(4): 381-387.

In this paper, environmental epidemiology data have been used in order to correlate air pollutants emitted from the Wazo Hill Cement Factory with the health of human communities. Tegeta and Boko villages, which surround the factory. In this study, descriptive routing data and retrospective and cross- sectional studies of environmental epidemiological approaches are used. Data are collected from three dispensaries and two hospitals. The cross-sectional studies were then applied to compare the diseases in selected places with predicted ground level air pollution concentration and the measured exposure. **Diseases such as PUO, chest pain, cough, RTI, and eye problems in the two- case study villages have shown that they may be environmentally derived due to cement dust. Moreover, the higher percentage of related diseases occurs near the source of pollutant. A relative risk ratio assessment indicates that in the two villages, the exposed subjects are 7.5 and 22.5 times in the two villages as likely to develop the disease during the follow-up period than the unexposed subjects.**

Zeleke, Z., B. Moen and M. Bratveit (2010). "**Cement dust exposure and acute lung function: A cross shift study**." BMC Pulmonary Medicine **10**(1): 19.

Few studies have been carried out on acute effects of cement dust exposure. This study is conducted to investigate the associations between current "total" dust exposure and acute respiratory symptoms and respiratory function among cement factory workers. A combined cross-sectional and cross-shift study was conducted in Dire Dawa cement factory in Ethiopia. 40 exposed production workers from the

crusher and packing sections and 20 controls from the guards were included. Personal "total" dust was measured in the workers' breathing zone and peak expiratory flow (PEF) was measured for all selected workers before and after the shift. When the day shift ended, the acute respiratory symptoms experienced were scored and recorded on a five-point Likert scale using a modified respiratory symptom score questionnaire. The highest geometric mean dust exposure was found in the crusher section (38.6 mg/m3) followed by the packing section (18.5 mg/m3) and the guards (0.4 mg/m3). The highest prevalence of respiratory symptoms for the high exposed workers was stuffy nose (85%) followed by shortness of breath (47%) and "sneezing" (45%). PEF decreased significantly across the shift in the high exposed group. Multiple linear regression showed a significant negative association between the percentage cross-shift change in PEF and total dust exposure. The number of years of work in high-exposure sections and current smoking were also associated with cross-shift decrease in PEF. **Total cement dust exposure was related to acute respiratory symptoms and acute ventilatory effects. Implementing measures to control dust and providing adequate personal respiratory protective equipment for the production workers are highly recommended.**

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