Effect of cement dust on residents in the vicinity of Bokajan factory, Assam, North East India

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Cement manufacturing industries are among the most common sources of air, water (surface and ground) and noise pollution, indirectly affecting those residing near cement plants. The present study was conducted to quantify the effect of cement dust emission from Cement Corporation of India's Bokajan factory in Assam, North East India, on the residences nearby, some selected household activities and the general well-being of people in its vicinity. An experiment was carried out to estimate the accumulated cement dust in households. The findings showed that household activities performed by the residents were dependent upon dust exposure, thus affecting the degree of cleaning and maintenance of their dwellings. Further, the adverse effect of cement dust was found to be more pronounced for people residing in the southern direction and lowest for those in the eastern direction.

Keywords: Cement industry, dust particles, household activities, pollution, residences.

THE Bokajan Cement Factory of the Cement Corporation of India (CCI) is located about 350 km from Guwahati and 21 km from the Dimapur Airport, Assam, North East India. The plant produces around 198,000 MT of cement per year using the dry process of manufacturing. The factory, mining area and township together form a unit. The Bokajan factory is one of the three functional units among ten cement industries in India, which is fully owned by the Government of India. The date of commencement of production from this factory was 1 April 1977.

Fresh air is vital to maintain life on Earth. However, sustaining a healthy life in a healthy environment has become tough because of pollutants emitted from different industries, power plants, agricultural activities, transportation, fuel burning, stone grinding factories and natural phenomenon[1,2]. Being the major component in building construction, cement manufacturing industries are one of the most common sources of air, surface and groundwater, and noise pollution. The European Environment Agency defines air pollution as 'the presence of contaminants or pollutant substances in the air[3] at a concentration that interferes with human health or welfare, or produces other harmful environmental effects'. Air pollution, according to the Florida Administrative Code, 1982, USA, is the 'presence of any one or more substances or pollutants in quantities which are or may be harmful or injurious to human health or welfare, animal or plant life, or property, or unreasonably interfere with the enjoyment of life or property including outdoor recreation'[4]. The process of cement manufacturing emits various types of hazardous substances such as particulate matter, sulphur oxide, nitrogen oxide and carbon dioxide, along with heavy metals like nickel, cobalt, lead, chromium, etc.[5]. These have significant consequences on the health of the workers in the cement factory as well as those who reside nearby[6]. According to Abdul-Wahab[7], Chukwu and Ubosi[8], dust is released into the environment during different stages of cement production. This may cause cardiovascular diseases, pulmonary diseases, gastrointestinal diseases, skin diseases, hair fall, eye infections, etc.[9–12]. A study by Yhdego[13] has revealed that a higher percentage of pollution-related diseases occur near the source of the pollutant.

It is a universal fact that frequent health problems can impact the income and well-being of any family. Mwai and Muriithi[14] found that non-communicable diseases (NCDs) significantly impact household income and can reduce it by 28.64%. In India, approximately 73 million working days are lost each year due to waterborne diseases[15]. Adekunle *et al.*[16] analysed the effect of cement externalities on the technical efficiency of cassava-based farmers in Ogun State, Nigeria, and concluded that there was a negative impact of cement emission on the working efficiency of people residing near the cement factory. As a significant risk factor, air pollution affects the general well-being of people who are continuously exposed to the pollutants. Darçin[1,17] reported that good air quality is positively and significantly correlated to the quality of life, happiness, life satisfaction and optimistic view of people. Arif *et al.*[18] reported that the relation between well-being and air quality is one of the essential factors in public policy formulation. Ng and Fisher[19] were concerned about the well-being of an individual as a critical issue for societal development. The well-being of every individual is important for society and the nation at large. Thus, the present study was aimed at determining if dust-emission from the Bokajan Cement Factory had any effect on the normal life of people residing in the vicinity, with the following objectives.

(i) To estimate the quantity of cement dust accumulated in the vicinity.
(ii) To observe the effect of cement dust on selected household activities in the vicinity.
(iii) To determine the effect of cement dust on the general well-being of the selected community.

Null hypothesis: The performance of the respondents in the vicinity is independent of exposure to dust.

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Effect: In this study, 'effect' refers to the direct or indirect influence of cement dust exposure on human health and performance.

Performance: In the study, 'performance' refers to the accomplishment of household activities by people in the vicinity with respect to preset standards.

Well-being: The general well-being here refers to good health and its influence on family, social satisfaction, a sense of accomplishment and personal fulfilment.

In order to choose samples for the present study, a total of 100 households (25 from each direction) were randomly selected from a 2 km radius in the vicinity of the cement factory, with respect to four directions, i.e. east, west, north and south. A total of 25 respondents from each household were selected from each direction, making a total of 100 respondents.

To estimate the accumulation of dust in the vicinity from the Bokajan Cement Factory, an experiment was carried out. Four equal-sized cardboard boxes with a removable, good-quality, glossy-white sheet of paper, 1 sq. ft in size, were placed in the open space in the houses of four respondents in the four directions, which were equidistant from the factory. All the boxes were placed in the specific location once for 24 h every month on the same day from January to December. After 24 h, the accumulated cement dust was collected, ensuring the dust particles did not remain stuck on the paper. They were carefully packaged in small plastic pouches and properly sealed. Next, the dust particles were measured and quantified in a digital gold weighing machine with a measuring calibration of 0.01–500 g scale.

To determine the effect of cement dust on household activities and the general well-being of the residents nearby, an interview-cum observation method was implemented using a structured questionnaire on 100 respondents from the selected households. Data were collected using a pretested structured schedule personally by the researchers, with care to note only reliable and valid information. Analysis of data to observe the effect of cement dust on household activities was done in three-point scale statements. The responses were recorded as 'always', 'sometimes' and 'never' with the corresponding scores of 3, 2 and 1. Similarly, to determine the effect of cement dust on the general well-being of the residents, information was collected on the basis of five point-rated statements, and the responses recorded as 'strongly agree', 'agree', 'neutral', 'disagree' and 'strongly disagree', with corresponding scores of 5, 4, 3, 2 and 1.

Based on the scores obtained, mean ± SD was computed and categorized into three groups, i.e. highly affected (score > mean + SD), moderately affected (score in between mean + SD and mean – SD), and less affected (score < mean – SD).

The performance of household activities was categorized into three groups from a list of 14 commonly performed household activities related to the upkeep of the dwellings as follows: high (>75%), medium (50–75%) and low (<50%).

The chi-square test was used to identify the association between accumulation rate of cement dust and performance of the respondents, as well as its association with the general well-being of residents in the vicinity.

To estimate the quantity of accumulated dust from the Bokajan Cement Factory in houses in the vicinity, direct measurements were done using the experimental method mentioned above (Table 1).

Table 1 shows that the dust accumulation rate is highest in the southern direction and lowest in the eastern direction. This might be due to the prevalent wind direction during the study period. Also, dust accumulation rate is higher during February–April, possibly due to more winds, and is comparatively low during June–August, associated with monsoonal rainfall. We observed during the study that residential areas in the south followed by the north were heavily covered with cement dust, including vegetation, roofs, houses, roads, etc. compared to the other directions.

Table 2 shows the opinions of respondents regarding the effect of cement dust on their household activities related to the cleaning and upkeep of the homes. The scores calculated based on the opinions of respondents indicated the maximum effect of cement dust on the household activities of those from the southern direction (high – 32%, medium – 56% and low – 12%) compared to the other directions. It was also observed that the least effect was among respondents from the eastern directions (high – 0%, medium – 64% and low – 36%). As reported by the respondents, when the factory is active during the manufacturing process, dust particles accumulate everywhere in the house. This requires constant cleaning and washing, thus affecting other constructive, supplementary, income-generating activities and personal care of the homemakers. They feel inefficient and lethargic to concentrate on other activities.

As mentioned earlier, the dust accumulation rate was high in the southern direction and low in the eastern direction. In this context, we wanted to identify the association between accumulation rate of cement dust and its effect on

Table 1. Quantification of accumulated dust (mg) from the Bokajan Cement Factory in houses in the vicinity with respect to their location

Months	East	West	North	South
January	120	190	280	350
February	130	280	350	400
March	170	290	360	420
April	110	290	350	400
May	95	200	270	370
June	90	200	260	340
July	80	180	250	320
August	90	190	270	360
September	90	200	280	360
October	100	210	250	385
November	110	250	310	395
December	90	200	290	360
Total	1275	2680	3530	4460

Table 2. Distribution of the respondents in the vicinity according to the effect of cement dust on their household activities in terms of direction ($N = 100$)

Direction	Category (level of effect)	Frequency	Percentage
East	High (above 35.04)	–	–
	Medium (19.03–35.04)	16	64
	Low (below 19.03)	9	36
West	High (above 32.86)	–	–
	Medium (29.05–32.86)	21	84
	Low (below 29.05)	4	16
North	High (above 34.28)	6	24
	Medium (20.11–34.28)	13	52
	Low (below 20.11)	6	24
South	High (above 31.78)	8	32
	Medium (18.45–31.78)	14	56
	Low (below 18.45)	3	12
Total			100

Table 3. Distribution of respondents according to household activities needed to be performed in terms of direction

	Observed value with respect to direction				
Observed category	South	North	West	East	Total
High (<75%)	14	10	7	3	34
Medium (50–75%)	8	10	10	9	37
Low (>50%)	3	5	8	13	29
Total	25	25	25	25	100

Table 4. Chi-square value showing the association between exposure to dust and household activities needed to be performed

Dependent variable	Independent variable	Chi-square value
Household activities performed for the upkeep of residences	Cement dust accumulation rate	15.71*

*Significant at 5% probability level.

Table 5. Distribution of the respondents in the vicinity according to the effect of cement dust on their general well-being in terms of direction ($N = 100$)

Direction	Category (level of effect)	Frequency	Percentage
East	High (above 25.09)	–	–
	Medium (19.70–25.09)	19	76
	Low (below 19.70)	6	24
West	High (above 40.03)	–	–
	Medium (32.20–40.03)	23	92
	Low (below 32.20)	2	8
North	High (above 26.55)	4	16
	Medium (18.88–26.55)	16	64
	Low (below 18.88)	5	20
South	High (above 27.47)	5	20
	Medium (20.44–27.47)	17	68
	Low (below 20.44)	3	12
Total			100

household performance of the respondents in the vicinity of the cement factory in terms of the four directions (Table 3).

Null hypothesis (H_0) = Performance of the respondents in the vicinity is independent of exposure to dust.

In the chi square test: Degrees of freedom (df) = (Number of rows – 1) (Number of columns – 1) = 6.

Table value for six degrees of freedom is 12.59. The calculated value (15.71) is greater than the table value and hence concluded as significant (Table 4). Therefore, we reject the null hypothesis and conclude that the household activities performed for the upkeep of the respondents are dependent upon the extent of dust exposure.

The effect of cement dust on the general well-being of residents near the cement factory was studied in terms of four directions. Scores were calculated based on the respondents' opinions regarding the effect of cement dust on their household environment, workspace and family budget. Most respondents reported that flowers and foliage, greens and vegetables did not grow well in their kitchen gardens due to dust accumulation. As a result, they had to depend entirely on the markets, which increased their family expenditure. Similar studies on the effect of cement dust on vegetation are reported in the literature[20–25]. Table 5 shows that the effect of cement dust on the general well-being of respondents living in the southern direction is maximum (high – 20%, medium – 68% and low – 12%). The least effect is observed among respondents in the eastern direction (high – 0%, medium – 76% and low – 24%).

The present study reveals that the area in the vicinity of the Bokajan Cement Factory is affected significantly by cement dust, thus having a direct or indirect impact on the well-being of the residents. People in the south and north were exposed to higher amounts of cement dust. This had a negative effect on their household activities and general well-being. This study recommends planting more trees in the dwellings of the residents to provide a barrier to prevent cement dust from entering their homes to a certain extent. Planning of industries should be done according to the wind-flow direction of the location, or residential areas should be planned where wind flow is relatively less. Since cement dust is continuously emitted from the Bokajan Cement Factory, efforts must also be directed towards preventing particulates from entering the atmosphere. Public awareness should be raised to minimize the hazardous impacts of cement dust. To control air pollution, more tall and evergreen trees should be planted around the factory and water sprinklers must be used to reduce dust in the area. Thus adequate protective measures will be good for the environment and ecosystem and for the residents living near the factory, as well as the cement industry to prosper economically and remain sustainable for a long time.

1. Darçın, M. (ed.), How air pollution affects subjective well-being. In *Well-being and Quality of Life: Medical Perspective*, 2017, p. 211 (open access peer reviewed chapter); doi:10.5772/67742.
2. Sharma, T., Rainey, R., Neumann, C., Shrestha, I., Shabi, K., Shakya, A. and Khatri, S., Roadside particulate levels at 30 locations in the Kathmandu Valley, Nepal. *Int. J. Environ. Pollut.*, 2002, **17**(4), 293–305.
3. https://www.eea.europa.eu› topics › in-depth › air-po... (accessed on 10 February 2023).
4. http://www.floridadep.org/air/about_us/local_contacts.htm (accessed on 11 February 2023).
5. Baby, S., Singh, N. A., Shrivastava, P., Nath, S. R., Kumar, S. S., Singh, D. and Vivek, K., Impact of dust emission on plant vegetation of vicinity of cement plant. *Environ. Eng. Manage. J.*, 2008, **7**(1), 31–35.
6. Afolabi, A., Francis, F. A. and Adejompo, F., Assessment of health and environmental challenges of cement factory on Ewekoro community residents, Ogun state, Nigeria. *Am. J. Hum. Ecol.*, 2012, **1**(2), 51–57.
7. Abdul-Wahab, S. A., Impact of fugitive dust emissions from cement plants on nearby communities. *Ecol. Modell.*, 2006, **195**, 338–348.
8. Chukwu, M. N. and Ubosi, N. I., Impact of cement dust pollution on respiratory systems of Lafarge cement workers, Ewekoro, Ogun State, Nigeria. *Global J. Pure Appl. Sci.*, 2016, **22**, 1–5.
9. Mehraj, S. S., Bhat, G. A. and Balkhi, H. M., Cement factories and human health. *Int. J. Curr. Res. Rev.*, 2013, **5**(18), 47–53.
10. Meo, S. A., Al-Drees, A. M., Masri, A. A. A., Rouq, F. A. and Azeem, M. A., Effect of duration of exposure to cement dust on respiratory function of non-smoking cement mill workers. *Int. J. Environ. Res. Public Health*, 2013, **10**, 390–398.
11. Adak, M. D., Adak, S. and Purohit, K. M., Ambient air quality and health hazards near mini cement plants. *Pollut. Res.*, 2007, **26**(3), 361–364.
12. Tajudeen, Y., Okpuzor, J. and Fausat, A. T., Investigation of general effects of cement dust to clear the controversy surrounding its toxicity. *Asian J. Sci. Res.*, 2011, **4**(4), 315–325.
13. Yhdego, M., Epidemiology of industrial environmental health in Tanzania. *Environ. Int.*, 1992, **18**(4), 381–387.
14. Mwai, D. and Muriithi, M., Economic effects of non-communicable diseases on household income in Kenya: a comparative analysis perspective. *Public Health Res.*, 2016, **6**(3), 83–90.
15. Pathak, H., Effect of water borne diseases on Indian economy: a cost–benefit analysis. *Environ. Sci.*, 2015, **1**, 74–78.
16. Adekunle, C. P., Ashaolu, O. F. and Obinka, C. A., Effect of industrial externalities on technical efficiency among cassava-based farming households in Ewekoro local government area, Ogun state, Nigeria. *Nigerian J. Agric. Food Environ.*, 2015, **11**(4), 82–89.
17. Darçın, M., Association between air quality and quality of life. *Environ. Sci. Pollut. Res.*, 2014, **21**(3), 1954–1959.
18. Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A. and Elsarrag, E., Impact of indoor environmental quality on occupant well-being and comfort: a review of the literature. *Int. J. Sustain. Built Environ.*, 2016, **5**(1), 1–11.
19. Ng, E. and Fisher, A. T., Understanding well-being in multi-levels: a review. *Health Cult. Soc.*, 2013, **5**(1), 308–323.
20. Ramanathan, R., Jeyakavitha, T. and Jeganathan, M., Impact of cement dust on *Azadirachta indica* leaves – a measure of air pollution in and around Ariyalur. *J. Ind. Pollut. Control*, 2006, **22**(2), 273–276.
21. Raajasubramanian, D. and Sundaramoorthy, P., Effect of cement dust pollution on germination and growth of groundnut (*Arachis hypogaea* L.). *Int. Multidiscip. Res. J.*, 2011, **1**(1), 25–30.
22. Oran, S. A. and Zahra, H. M. F. A., Impact of the cement dust emitted from the South Cement Factory in Tafila/Jordan on plant diversity of the surrounding area. *Int. J. Biodivers. Conserv.*, 2014, **6**(5), 400–414.
23. Rawat, V. and Katiyar, R., A review on the effects of cement dust on vegetation. *Int. J. Sci. Innov. Res. Stud.*, 2015, **3**(4), 39–45.
24. Romman, S. A. and Alzubi, J., Effects of cement dust on the physiological activities of *Arabidopsis thaliana*. *Am. J. Agric. Biol. Sci.*, 2015, **10**(4), 157–164.
25. Senthil, K. P., Sobana, K., Kavitha, K. K. and Jegadeesan, M., A study on the effect of cement dust pollution on certain physical and biological parameters of *Sessamum indicum* plant. *Asian J. Plant Sci. Res.*, 2015, **5**(1), 1–3.

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