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ASSESSMENT OF AIR POLLUTION SCENARIO IN CEMENT FACTORY: THE MONGLA PORT INDUSTRIAL ESTATE OF BANGLADESH AS A CASE STUDY

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Abstract: Cement industries are responsible for huge amount of air pollution, which is harmful for relevant workers health. This study was carried out to measure the emission rate of SPM, SO_2 and NO_2 and impact on the workers health of cement factories of the Mongla Port Industrial Estate of Bangladesh. It has been found that the emission rate of SPM, SO_2 and NO_2 is above the acceptable limit of the Environmental Conservation Rule, 1997 of Bangladesh Government. As a result of air pollution, most of the workers between 15 to 50 years age groups are affected by asthma (34%) and respiratory infection (35%). Bronchitis is a major threat to the workers of above 50 years age. Again, the workers working for the long time in the cement factories are highly susceptible to the diseases like bronchitis, asthma. Except respiratory infection, female workers are more at risk of diseases happened by air pollution than male workers. The results of the study imply that immediate remedial actions are crucial to minimize the air pollution of cement factories and its impact on the workers health.

Key words: Emission rate, health impacts, cement factories, Bangladesh

Introduction

Portland cement industry plays a vital role in the development of Bangladesh as it is the producer of the most important building material for construction (Sohel, 2000). A faster growth in demand for cement has been observed only since mid-1980s, especially with implementation of large infrastructure projects, increased pace of urbanization, construction of apartment buildings and multistoried shopping complexes in urban areas, and a shift in the taste of moneyed rural people for modern houses (Banglapedia, 2004).

In the developing countries, the environment of cement factory is full of noise, dust particles of different sizes and quantity and chemical pollutants (*Iyawe et al.*, 2000). The main environmental issues associated with cement production are emission to air (particulate matter, SO_x, NO_x), energy use, local nuisance (noise, vibration, dust, and visual impact), greenhouse gasses, land use and biodiversity. The industry experiences accident rates that are high compared with some other manufacturing industries. There are number of hazards inherent to the cement production process too. For example exposure to dust and high temperatures; contact with allergic substances and noise exposure (Marlowe and Mansfield, 2002).

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In Bangladesh, cement industries emit 0.03% toxic chemical to land, 0.01% toxic chemical, 10.42% SO_2 and 8.49% total particulate matter to air out of total pollution load annually (Hettige and Brandon, 1997). Therefore, cement industries are responsible for production of significant amount of air pollution that are harmful for human health (especially for workers) and local surroundings. As a result, identification, quantification and evaluation of potential impacts of air pollution on the workers health is important. This study was conducted to measure the current level of air pollution and possible health hazards of the workers.

Materials and Methods

Study area: Mongla Port Industrial Estate was selected as study area. Because the area is popularly known to cement manufacturing industries. The industrial area is owned by Mongla Port Authority which is adjacent to Mongla Port, the second largest sea port of Bangladesh. The area is situated under Bagerhat district of Khulna division. There are four cement factories in this industrial estate, namely Mongla, Meghna, Holcim and Dubai-Bangladesh cement factory respectively. All of these factories were studied for pollution quantification and health impact assessment.

Materials: High Volume Sampler was used to measure SPM (Suspended particulate matter), SO_2 (Sulpher dioxide) and NO_2 (Nitrogen dioxide) at different locations of Mongla, Meghna, Holcim, Dubai-Bangladesh cement factories. Sampling locations were jetty area, main gate and boundary wall of factories. For the assessment of air pollution from the cement factory, the Department of Environment (DoE) also collects samples from the above mentioned places. Sampling machine was run according to the advice of the senior scientific officer of the DoE, Khulna Division. The model of the High Volume Sampler machine was Envirotech APM-415. High Volume Sampler machine was run continuously for 24 hours to attain the most precise results of SPM, SO_2 and NO_2 emission rate to the ambient air. For SPM, PM_{10} † emission rate was considered. Sample of pollutant concentration (SPM, SO_2 and NO_2) was collected from the selected points. For ensuring accuracy, data was collected for three times in every point of each factory.

Methods: The emission rate of SPM, SO_2 and NO_2 in the ambient air from the cement factories were calculated by using the following methods:

SPM was calculated according to High volume Method (Anon, 2003).

$$\text{Conc. of SPM} = (W/V) \times 10^6 \ (\mu gm^{-3})$$

Where, W = Weight of the suspended particulates
V = Volume of air sample

NO_2 in the air sample was calculated by sodium arsenite method (Raju, 1997).

$$\text{Conc. of } NO_2 \ (\mu gm^{-3}) = \frac{(\mu g NO_2 ml^{-1}) \times 50}{V \times 0.35}$$

Where, $\mu g\ NO_2\ ml^{-1}$ = NO_2 concentration in analyzed sample
50 = Volume of absorbing reagent used in sampling, ml
V = Volume of air sampled, m^3
0.35 = Overall average efficiency

SO_2 in the air sample was determined by the Modified West and Geake Method (Anon, 2003).

$$\text{Conc. of } SO_2 \ (\mu gm^{-3}) = \frac{(A - A_0) \times 10^3 \times B}{V}$$

Where, A = Sample absorbance
A_0 = Reagent blank absorbance
10^3 = Conversion litres to cubic metres
B = Calibration factor, µg/absorbance
V = Volume of air sampled in liter

Workers of the cement factories were surveyed to know the health impacts. The survey tool was structured questionnaire. The analyzed result revealed that Mongla, Meghna, Dubai Bangladesh and Holcim cement

† Particles less than 10 micrometers in diameter that include both fine and coarse dust particles. These particles pose the greatest health concern because they can pass through the nose and throat and get into the lungs.

factory have 36.25%, 27.5%, 22.5% and 13.75% of the total workers of the study area. Sample size was determined according to the percentage of the workers, working in each cement factory. In the questionnaire survey, total 140 workers were surveyed. Among the respondents 51, 38, 32 and 19 workers were taken from the above mentioned industries, respectively. The workers were further sub divided into bellow 21, 21-30, 31-40, and 41-50 and above 50 years age group for facilitate health impact assessment. The method of sampling was random sampling. The data of SPM, SO_2, NO_2 and questionnaire survey was conducted from June to August, 2005.

Results

Sources of air pollution in cement factories: The source of air pollution in the cement factories is identified during the period of survey. Mill house is the prominent source of air pollution in the production process. The source of air pollution in the cement production is shown in the Table 1.

Table 1. Sources of air pollution in the cement factories

Source of air pollution	Releasing air pollutants
Raw material storage, grinding mill, Grinding mill, Kiln, Loading and unloading facilities, Packaging section, Storage silos, Conveyors	SPM
Sulfur compounds in the raw materials Raw materials, Sulfur in the fuel	SO_2
Burning zone of kiln, Combustion of fuel	NO_2

Source: Field survey, 2005

SPM (PM_{10}), NO_2, SO_2, CO (Carbon mono oxide), and CO_2 (Carbon dioxide) are the primary emissions during the production of Portland cement. Small quantities of VOC (Volatile Organic carbon), NH_3 (ammonia), chlorine, and hydrogen chloride may or may not be emitted. Emissions may include residual materials from the fuel and raw materials or products of the incomplete combustion that are considered to be hazardous. In addition, raw materials such as feed and fuels typically contain trace amounts of heavy metals that may be emitted as a particulate or vapor (Bounicore and Davis, 1992).

Measurement of Air pollutants: Air pollutants of cement factories are not easily measured, because it as almost invariably a mixture of different kinds of pollutants and some of which are more toxic than others (Anon, 2001). Measured emission rate of SPM, SO_2 and NO_2 from the cement factories are given in Table 2. It is clear from Table 2 that the concentration of SPM emission was the highest in the Meghna cement factory near boundary wall (655 $\mu g/m^3$) and the lowest in the Dubai Bangladesh cement factory near main gate (540 $\mu g/m^3$). Incase of SO_2, emission rate was the highest in the Holcim cement factory near jetty area (159 $\mu g/m^3$) and lowest in the Mongla cement factory near main gate (142 $\mu g/m^3$). Again, maximum (135 $\mu g/m^3$) and minimum (121 $\mu g/m^3$) emission rate of NO_2 was found in Meghna and Mongla cement factory respectively. At last it can be easily said that Meghna cement factory was the highest pollution emitting industry in the study area.

Health impact of air pollution on the workers: Certain population subgroups, such as the workers of cement factories are at increased risk from exposure to SPM**,** SO_2 and NO_2. Annual medical report of Meghna cement factory has showed that many workers are suffered from asthma, bronchitis, respiratory problem and allergy and all of these diseases are related to air pollutants emitted from factory (Anon, 2005). Survey has been done on the workers of the study area about the health impact of air pollution. Air pollution sharply increases the incidence of allergy. Percentage of workers attacked by various diseases is shown in the Figure 1.

From the figure 1, we have found that 35%, 34%, 5% and 14% of the workers are suffered from respiratory infection, asthma, bronchitis and allergy respectively. Apparently, the rest of the workers (12%) are free from disease. Therefore, this analysis reveals that, respiratory infection and asthma are major diseases among the workers of the study area. Attack of diseases among the workers may vary according to their age groups**.** Table 3 represents the percentage of the workers who suffered from various air pollution diseases in relation to age groups.

Table 2. Emission rate of SPM, SO_2 and NO_2 in the ambient air at Mongla Port, Bangladesh from nearby cement factories.

Name of factories	Location	Distance from factory in meter	SPM (PM_{10}) ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
Mongla	Near Jetty area	20	590	145	125
	Near main Gate	30	589	142	121
	Near boundary wall	5	593	142	121
Meghna	Near Jetty area	20	644	153	135
	Near main Gate	40	635	157	129
	Near boundary wall	5	655	155	127
Holcim	Near Jetty area	25	610	159	131
	Near main Gate	40	608	158	130
	Near boundary wall	10	611	155	128
Dubai-Bangla-desh	Near Jetty area	20	550	149	124
	Near main Gate	15	540	147	122
	Near boundary wall	10	555	145	122

Source: Field Survey, 2005

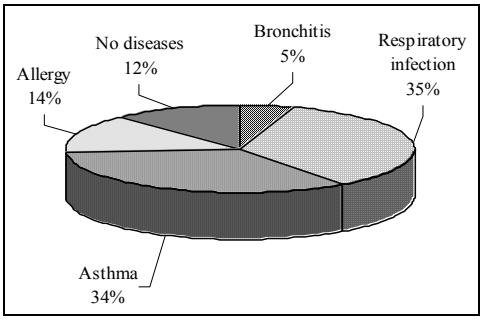

Fig.1. Percentage of workers suffered from various air pollution diseases.

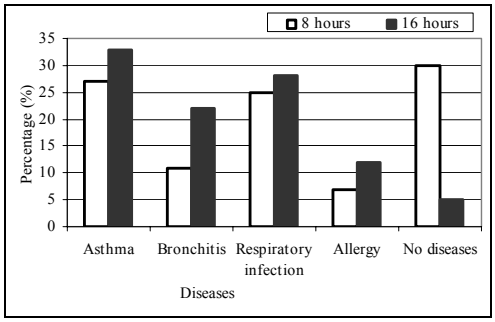

Fig. 2. Percentage of workers suffering from air pollution diseases in relation to daily working hours.

Table 3**.** Percentage of workers suffering from air pollution diseases in relation to age groups.

Age group (Years)	Percentage of workers suffered from air pollution diseases			
	Asthma (%)	Bronchitis (%)	Respiratory infection (%)	Allergy (%)
Below 21	40	10	30	20
21-30	24	6	49	9
31-40	42	6	29	3
41-50	30	0	20	0
Above 50	0	33	0	0

Source: Field Survey, 2005. * Percentage total does not add up to 100 as multiple answers are allowed.

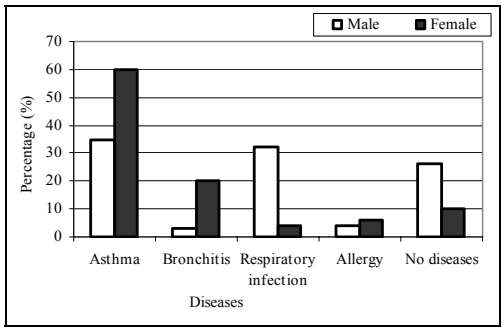

Fig. 3. Percentage of male and female workers suffering from air pollution diseases.

From the table 3, it is seen that bellow 21, 21-30, 31-40 and 41-50 years of age groups are mainly suffered from asthma and respiratory infection. According to the study findings, bronchitis is the only threat to above 50 years group. Here, low age groups (below 21 to 21-30) show high vulnerability to the diseases by air pollution.

In the cement factory, working hours vary from workers to workers. Mainly, they are 8 and 16 hours working groups. At the time of working, they are exposed to SPM**,** SO_2 and NO_2 of the cement factories. Therefore, risk of diseases may vary according to length of working hours. Figure 2 shows the percentage of the workers suffered from air pollution diseases in relation to daily working hours.

From the Figure 2, it seems that 33%, 22%, 28%, and 12% of the workers (work for 16 hours) are suffered from asthma, bronchitis, respiratory infection and allergy respectively. In case of 8 hours working group, 27%, 11%, 25%, and 7% of the workers are suffered from asthma, bronchitis, respiratory infection and allergy respectively.

Susceptibility of the diseases might differ on sex of the workers of the cement factories. Figure 3 shows Percentage of male and female workers who suffered from air pollution diseases.

Figure 3 shows that 60%, 20%, 4%, 6% of the female workers are suffered from asthma, bronchitis, respiratory infection and allergy respectively. But incase of male, 35%, 3%, 32%, 4% of the workers are suffered from asthma, bronchitis, respiratory infection and allergy respectively. From the analysis it seems that 26% male and 10% female are disease resistant caused by the pollution of cement industries.

Discussion

According to the Environmental Conservation Rule 1997, the acceptable limit of emission of SPM, SO_2 and NO_2 in the ambient air is 500, 120 and 100 $\mu g/m^3$ respectively for cement factories (Huq, 2002). The study shows that the emission rate of SPM, SO_2 and NO_2 from the cement factories is higher than this rule. This is because of lower number of dust collectors than they should be used to control dust. Their efficiency is also low because most of the dust collector model is old. Anon (1996) reported that dust collectors are generally installed in clinker and gypsum receiving hopper in the jetty, clinker and gypsum storage silos, clinker grinding section, cement storage silos , cement packaging and delivery section. But the study found that the dust collectors were less than the number should be. High cost was one of the major reasons behind lower number of dust collectors. For SO_2 and NO_2, there are no control devices at all. Here it is necessary to mention that all the industries were situated in the same area with little distance. Incase of Mongla and Meghna cement factory, the boundary is almost same. So there is possibility of overlapping of air pollution between the industries.

Survey in the study area reveals that workers who working for 16 hours are more susceptible to diseases than those working for 8 hours in a day. This is because of long time exposure to dust and polluted environment. Again, female workers are more susceptible to air pollution diseases than male except the case of respiratory infection. It should be included that no cancer affected worker had been found during the period of survey. However, some workers were affected by eye irritation. During the survey, it had been seen that very few workers were used dust musk, aprons and hand gloves. Also there was no health and safety training programmes and primary medical facilities for them. Therefore, the situation is harmful for the workers.

ISO 9001 (Quality management system) certification is important for construction products like cement (Kantner, 1994). Again ISO 14001 (Environmental management system) registration is required to cover the whole environmental issues of the cement industry (Saha, 2004). Cement

factories of the study area were not working properly to maintain the ISO 9001 and ISO 14001 documentation. Except Dubai Bangladesh cement factory, other three cement factories have achieved ISO 9001. None of them have qualified for ISO 14001. More interestingly, it is found that all of them have been maintained the BSTI (Bangladesh Standard and Testing Institute) standard for marketing their products legally. Therefore, a quick initiative is mandatory to improve the environmental management system of mentioned cement factories.

Conclusion

Air pollution of cement industries adds huge amount of SPM, SO_2 and NO_2 to ambient air. Besides, the pollutants have impact on the workers health as well as the surrounding ecological environment. It has been found that emission rate of SPM, SO_2 and NO_2 is above the acceptable limit of the Environmental Conservation Rule, 1997 of Bangladesh Government. Because of high level of air pollution, most of the workers are affected by respiratory infection (35%) and asthma (34%). Among them, female workers are more at risk. In summery, the overall condition is incompatible for environment and human health. This vulnerable situation could be reduced through the use of aprons, gloves and musk that protect the workers from air pollutants. Proper aeration in working place is enhanced for the healthy environment and helps to reduce the health problem. Therefore, the environmental impact of air pollution of cement factories should be minimized through the implementation of ISO 9001 and ISO 14001 and the Environmental Conservation Rule, 1997 for maintaining sustainable working condition in cement industries of Bangladesh.

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