Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 3, February : 2024

ASSESSMENT OF PARTICULATE MATTER (PM_{10}) EMISSIONS FROM BUILDING CONSTRUCTION ACTIVITIES.

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Abstract:
Construction industry has a significant risk from various types of occupational chemical hazards in the form of organic and inorganic dusts, solvents, gases, and vapours. Particulate matter PM_{10} is involved in some construction activities like bar cutting, concrete mixing and carpentry. Exposure to particulate matter results in diseases such as allergic disorders, respiratory disorders, irritation to nose, eyes, and throat in long-term. The age and experience (duration of exposure) and health of the worker are considerable factors for pollutant effects. The present study investigates PM_{10} in some of the building construction activities and comparison was done with NAAQ (National Ambient Air Quality) standards.

Keywords:
Particulate matter (PM_{10}), NAAQ standards, construction activities.

Introduction:

An average man breathes 22,000 times a day, with an intake of 16 kg of air each day. The inhaled air may or may not cause harm, depending on the chemical constituents present in small concentration or high concentrations. The effects of air pollution on human health depend on Pollutant nature, pollutant concentrations, exposure duration, health condition of the person, age group of the person exposed. Construction industry is a place where a lot of dusts and gases emitted /released and enter the workers body unknowingly and affect slowly. Respirable dust PM_{10} and $PM_{2.5}$ are the dust evolved during various activities. PM $_{10}$ is the particulate matter less than 10 micrometre(µm) in diameter. $PM_{2.5}$ is the finest particulate matter less than 2.5 micrometre(µm) in diameter, more dangerous in inhalation, person not able to feel or sense during inhalation. Construction workers are exposed to dusts in various construction activities like Bar cutting, concrete mixing, carpentry work etc. Particulate matter is dispersed matter either in solid or liquid form usually measured in particle size 10 and 2.5 affects the lungs. Deposition of these dust particles in air sacs of the lungs, causes Pneumoconiosis. Exposure to silica causes silicosis. Allergic disorders of respiratory system, asthma, bronchitis etc also result due to dust.

2.Review of Literature:

Rappaport et.al (2003) explained about the Respirable dust and silica dust was analyzed among construction workers in USA. Four trades, brick layers, painters operating engineers and labors are involved. The exposure levels of painters for respirable dust and silica are 1.35 and 1.28mg/m^3. brick layers are 2.13 and 3.20 mg/m3and operating engineers are 0.720 and 0.075 mg/m^3. The study assessed probabilities of overexposure as between 64.5 and 100% for respirable silica and between 8.2 and 89.2% for respirable dust and suggests that exposure to silica is completely intolerable in the US construction sector and use of wet dust suppression can decrease the silica dust and ventilated cabs by operating engineers can decrease the silica dust exposures.

Spee et.al (2007) reported a study conducted on 26 carpenters in 13 building projects. Task –based measurements with 8 hr time-weighted concentrations were evaluated. Wood dust was ranged between 0.8 to 11.6 mg $m^{-3.}$ The calculated concentrations are compared with Dutch standards. Using of substitute materials, preparing building materials in workshops outfitted with exposure controls,

utilizing substitute equipment, enhancing ventilation, maintaining proper housekeeping were suggested.

Carino et. al (2013) discussed about the significant risks among construction workers because of their physical labor and frequent exposure to dust, chemicals, and environmental factors. risks may also have an impact on their health. The paper focuses on the respiratory and occupational allergies in the construction industry. The most frequent factors that contribute to occupational asthma (OA) in developed nations are wood dust, glues, resins, cobalt, and chromium.

Johncy et.al (2015) discussed that construction industry is a dusty environment, where millions of people are exposed to various types of occupational hazards like dust , fumes , organic and inorganic dust , leading to lung diseases. Work at Building constructions develops impaired lung function. The present study identified 61 male workers. The study was carried using an electronic spirometer and results were compared by Student's unpaired *t* test. Study reported that there is a higher chance of occupationally associated pulmonary impairment among Indian construction workers. It was recommended that construction workers be required to wear personal protection equipment while working.

3.Methodology:

3.1: The following are the sample details for Particulate matter PM_{10}.

a) Concrete preparation:

Concrete is a mixture of cement, aggregates, and sand with water. During preparation of concrete the worker is exposed to dust particles while placing the individual constituents into the mixer. The generator is operated for continuous power supply where some stack emissions were observed. In the present study the dust exposure to the worker during the concrete mix was estimated.

Date of sample collection: 08/03/2022
Sample: Tarnaka, Apartments 2nd floor construction.
Name of the instrument: High Volume sampler.
Duration of sampling: 4hours (actual work time at the site).

b) Bar cutting:

Bar cutting is a construction activity done at ground level near the construction sites to the steel bars to obtain the required sizes. Some dusts are evolved which are invisible, but which can be felt by nose to an extent. The work done by the worker is not continuous. But the instrument is continuous in working condition to measure the effects of dust etc.

Date of sample collection: 15/09/2022
Sampling site: Vignana Bharathi Institute of Technology. Ghatkesar
Name of the instrument: High Volume sampler.
Duration of sampling: 4hours (actual work time at the site).

c) Carpentry:

Carpentry is the construction activity involved with cutting of the seasoned wood in required shapes and sizes to fit into the walls.

Date of sample collection: 14/04/2022
Sample collection Location: santhi gardens, Nacharam , Hyderabad
Name of the instrument: High Volume sampler.
Duration of sampling: 4 hours

3.2 Method of analysis.

Cylone attached High volume air sampler is used in collection of Particulate matter during construction activities. Greater than PM_{10} was collected in the hopper and PM_{10} and lesser particulate matter was

collected on the filter paper. The analysis was done in Gravimetric analysis followed the code IS: 5182 Part IV & I.

4.Results and Discussions

4.1 The following is the dust analysis(PM_{10}) during concrete preparation.

Initial Weight of filter Paper = (W1) 3.3372 gms
Weight Of Dust + Filter Paper(W2) = 3.4560 gms
Dust collected = W2-W1
= 0.1188 gms
= 0.1188 X 10^6 µgms
Average flow rate = 1.20 m^3 /min
Duration of sampling = 4 hours
= 240 mins
Volume of sampling = Average flow rate * time
= 1.2 * 240
= 288 m^3

$$PM_{10} \text{ concentration} = \frac{(W2 - W1)X\ 10^6}{\text{Volume of sampling}}$$

$$= \frac{(3.4560-3.3372)\ X10^6}{288}$$

= 409.72 µg/m^3 (or) 0.409 mg/m^3

4.2 The following is the dust analysis involved in carpentry work :

Initial Weight of filter Paper (W1) =3.316 gms
Weight Of Dust + Filter Paper(W2) = 3.450 gms
Dust collected = W2-W1
= 0.134 gms
= 0.134 X 10^6 µgms
Average flow rate = 1.20 m^3 /min
Duration of sampling = 4 hours
= 240 mins
Volume of sampling = Average flow rate * time
= 1.2 * 240
= 288 m^3

$$PM_{10} \text{ concentration} = \frac{(W2 - W1)\ X\ 10^6}{\text{Volume of sampling}}$$

$$= \frac{(3.450-3.316)\ X10^6}{288}$$

= 465 µg/m^3 (or) 0.465 mg/m^3

4.3 The following is the dust analysis involved during Bar cutting activity:

Initial Weight of filter Paper (W1) = 3.3339 gms
Weight Of Dust + Filter Paper(W2) = 3.3610 gms
Dust collected = W2-W1
= 0.0271 gms
= 0.0271 X 10^6 µgms
Average flow rate = 1.4 m^3 /min

Duration of sampling = 4 hours
= 240 mins
Volume of sampling = Average flow rate * time
= 1.4 * 240
= 336 m^3

PM_{10} concentration = $\frac{(W2 - W1)X\ 10^6}{\text{Volume of sampling}}$

$= \frac{(3.361-3.339)\ X10^6}{366}$

= 80.65 µg/m^3 (or) 0.08065 mg/m^3

Table 1: Results of Particulate matter PM_{10} in various construction activities.

Sl.no	Construction activity	PM_{10} Concentration	NAAQ standards
1	Concrete preparation	409.72 µg/m^3	100 µg/m^3
2	Bar cutting activity.	80.65 µg/m^3	
3	carpentry activity	465 µg/m^3	

5.Conclusions:

1) In concrete preparation, PM_{10} was reported as 409.72 µg/m^3 which is greater than NAAQ standards 100 µg/m^3.Thus particulate pollution was observed.
2) In bar cutting activity, the pollutants PM_{10} was within the limits of NAAQ .
3) In carpentry activity, PM_{10} is 465 µg/m^3 ,which is very much higher than NAAQ
4) Thus, the construction workers are prone to chemical hazards of dust pollution. Hence PPE (Personal protective Equipment) such as Respiratory masks are strongly recommended.

6.References :

1) Azarmi, F., Kumar, P., Marsh, D., & Fuller, G. (2016). Assessment of the long-term impacts of PM 10 and PM 2.5 particles from construction works on surrounding areas. *Environmental Science: Processes & Impacts*, *18*(2), 208-221.
2) Araújo, I. P., Costa, D. B., & De Moraes, R. J. (2014). Identification and characterization of particulate matter concentrations at construction jobsites. *Sustainability*, *6*(11), 7666-7688.
3) Carino, M., Romita, P., & Foti, C. (2013). Allergy-related disorders in the construction industry. *International Scholarly Research Notices*, *2013*.
4) Cheriyan, D., Hyun, K. Y., Jaegoo, H., & Choi, J. H. (2020). Assessing the distributional characteristics of PM10, PM2. 5, and PM1 exposure profile produced and propagated from a construction activity. *Journal of Cleaner Production*, *276*, 124335.
5) Johncy, S. S., Ajay, K. T., Dhanyakumar, G., Raj, N. P., & Samuel, T. V. (2011). Dust exposure and lung function impairment in construction workers. *Journal of Physiological and Biomedical Sciences*, *24*(1), 9-13.
6) Kowalik, T., Logoń, D., Maj, M., Rybak, J., Ubysz, A., & Wojtowicz, A. (2019). Chemical hazards in construction industry. In *E3S Web of Conferences* (Vol. 97, p. 03032). EDP Sciences.
7) Rappaport, S. M., Goldberg, M., Susi, P. A. M., & Herrick, R. F. (2003). Excessive exposure to silica in the US construction industry. *Annals of Occupational Hygiene*, *47*(2), 111-122.
8) Rosman, P. S., Samah, M. A. A., Yunus, K., & Hussain, M. R. M. (2019). Particulate Matter (PM2. 5) at construction site: a review. *Int. J. Recent Technol. Eng.(IJRTE)*, *8*, 255-259.
9) Spee, T., Hoof, E. V. D. R. V., Hoof, W. V., Noy, D., & Kromhout, H. (2007). Exposure to wood dust among carpenters in the construction industry in the Netherlands. *The Annals of Occupational Hygiene*, *51*(3), 241-248
10) Manual for NAAQ National Ambient Air Quality standards , Central Pollution control Board.

Acknowledgements:
Authors would like to acknowledge the Department of Civil Engineering, Andhra University and construction workers, contractors, and site Engineers.
The authors would like to thank the Pollu-Tech Laboratory & consultancy services, Hyderabad for providing necessary sampling and analysis facilities .