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Effect of Particulate Matter on Stone Crushing Sites

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Abstract: ***The present study deals with the emissions of the suspended particulates (silica dust) from stone crushing industry and its effect on workers and nearby residents. A detailed air pollution survey was conducted at Chitrakoot, Banda and Mahoba of Bundelkhand, U. P. India. High volume and respirable particulate samplers were used at fifteen locations to monitor RSPM and SPM (PM10) levels in ambient air. The particle size study indicates high percentage of finer particles and silica when compared to the occupational safety and health standards posing serious health problems to the people exposed for longer duration. These emitted suspended particulate affect the environment by lowering the visibility, producing hazy condition, the health of workers and nearby residents and affecting biotic population directly or indirectly. The investigation shows that the SPM (Suspended Particulate Matter) generated by silica mining and from the loose rock pieces on the side of mines, is posing threat to the health of workers and local environment.***

Keywords: Stone crusher worker, SPM, RSPM, High Volume Sampler, CPCB

1. Introduction

Air quality status in Indian environment is dominated by Suspended Particulate Matter (SPM) causing great concern to ecologist. Stone crushing operations emitting silica dust in general have adverse environmental impacts. Hall *et al*., (1993) and Fuglsang (2002), underground mining impacts directly on the health of those working underground, but opencast mining creates wider air quality deterioration due to dust and gaseous pollutants in and around the mining complexes. The dust can also pollute nearby surface waters and stunt crop growth by shading and clogging the pores of the plants and also creates the serious health hazards of living being. Suspended particulate matter (SPM) are the particulate having particle diameter less than 100 µm that tend to remain suspended in the atmosphere for a long period of time. Respirable Suspended Particulate Matter (RSPM) or PM10 are the particulate having diameter less than 10 µm and they are small enough to be inhaled and may enter deep into respiratory tract and pulmonary system of human beings. These particles are responsible for most of the airborne particle threat to human health because of their small size range and pose health hazard due to their inhalation and deep penetration in respiratory system during breathing.

Donaldson *et al*., (1982); Eisen *et al*., (1984); Koskela *et al*., (1987); Kullman *et al*., (1995); IARC (1997) studied exposure to respirable quartz dust in granite quarrying and processing, including crushed stone and related industries. Richard, *et al*., (2002), suspended particulate matter may be affecting more people globally than any other pollutant on a continuous basis. Bart, (1993); HEI, (1995), Even at relatively low concentration (not exceeding standard guideline of 150ug/m3 for 24 hours), inhalable particulate matter (PM10) have adverse effects on human health. Indeed, an increase of 50mg/m3 in particulates levels is shown to induce increase death Supporting this particulate level and health relationship, WHO (1994) indicated that daily mortality rates would increase by 20 percent with an increase of particulate level to 200mg/m3. NIOH Annual Report (1985 - 86), In Gujarat State Environmental and medical surveys carried out in eight quartz grinding units revealed that the mean values of total dust concentrations were between 81 and 660 times higher than the threshold limit suggested by ACGIH. Semple S., *et al., (*2002) studied exposure to particulate matter on an Indian stone - crushing site after correcting for the length of the working week, Real - time data showed peaks in exposure under certain environmental and/or working conditions.

Rees and Murray (2007), silica dust is widely prevalent in the atmosphere and more common than the other types of dust, thus making silicosis the most frequently occurring pneumoconiosis. In India also, studies carried out by National Institute of Occupational Health have shown high prevalence of silicosis in small factories and even in nonoccupational exposed subjects. Gulumian (2005) Silica is an example of fibrogenic dust. IARC (1996) classified crystalline silica dust as a human carcinogen (Group 1). The conversion of naturally occurring rock into crushed and broken stone products involves a series of distinct yet interdependent physical operations. These include quarrying or mining operations (such as drilling, other material handling, and transfer operations) emissions. The quantity of emissions depends on various aspects like climatic conditions, moisture in the soil, speed of the vehicle, frequency of the vehicles etc. Patil M. A., (2001) and APPCB (2003) the various sources of dust generation are Emissions during mining, crushing operations, transportation etc. According to Central Pollution Control Board (CPCB) These sources may be categorized as –

Table 1: Stone - Processing Emission Sources: (Source: CPCB)

Activity	Process Sources	Fugitive Dust Sources
Mining	Drilling	Blasting
		Loading and hauling
Transportation	N/A	Haul roads
Stone Crushing	Crushing	Stockpiles
	Screening	Conveying
	Conveyor transfer points	

2. Material and Methods

The study tries to assess working environmental conditions in and around the stone crusher units of Chitrakoot, Banda and Mahoba districts of Bundelkhand region. Since particles of SPM are small (1 to 10 µm) they remain mostly air borne and can not be trapped by a dust trap. They are sampled by Filtration Method (High Volume Sampler), (Jalees and Dave, 1979; IM, 2005) through which a known volume of air is sucked from the atmosphere and along with it come the SPM. By using this method, it is possible to measure the particles as small as 0.05µ. In this method, a large known volume of air is allowed to (Whatman GF/C). Then, this filter is weighed to know the trapped dust particles. From this it is pass through a preweighted glass fibre filter possible to calculate the particulate matter per unit volume of air. For Sampling of SPM and RSPM ambient air quality monitoring was carried out at 15 stone crusher units out of which 06 were selected from Chitrakoot (Bharatkoop), 03 from Banda (Mataudh) and 06 from Mahoba (Kabrai). The sampling locations were selected based on the prevalent wind direction and speed at the site, topography, location of stone crushing units, and their working schedule. Ambient air quality sample was carried out monthly covering the summer and winter seasons. Sampling for particulate matter were collected each day for 24 hours in two 12 hours shifts, corresponding to day and night time.

3. Result and Discussion

The monitoring was carried out with the using HVS (High Volume Sampler). For the collection of samples of suspended particulate matters (SPM), glass fiber filter paper was used in a high volume sampler (HVS). Air samples were drawn at the flow rate of 1.0 - 1.5m³/min, which allows the RSPM to deposit on the filter paper. Particulate with size range 0.1 - 100 μm diameter collected and weighted. The results are follows -

Table 2 and Figure 1 shows in the crushing sites of Chitrakoot (Bharatkoop), the RSPM ranges from maximum 214 µg/m³ and minimum 162 µg/m³, similarly SPM was maximum 513 µg/m³ and minimum 340 µg/m³. Table 3 and Figure 2 at crushing sites of Banda maximum RSPM recorded was 201 µg/m³ and minimum RSPM was 178 µg/m³, similarly the maximum SPM recorded was 428 µg/m³ and minimum was 362 µg/m³. Table 4 and Figure 3 at crushing sites of Mahoba (Kabrai) maximum RSPM recorded was 253 µg/m³ and minimum RSPM was 182 µg/m³, similarly the maximum SPM was 715 µg/m³ and minimum was 397 µg/m³. The mean concentration of RSPM recorded in the crushing sites of Bharatkoop, Banda and Kabrai was 189.3 µg/m³, 188.6 µg/m³ and 219.6 µg/m³ respectively. Similarly the mean concentration of SPM recorded in the crushing sites of Bharatkoop, Banda and Kabrai was 442.3 µg/m³, 395.3 µg/m³ and 541.8 µg/m³ respectively.

The values of RSPM in all the crushing sites exceeded the National Ambient Air Quality Standards, 150 µg/m³ (average 24 hours) prescribed for industrial areas by the Central Pollution Control Board (CPCB). During the same period of sampling corresponding concentration of the SPM recorded also exceeds in all the crushing sites as compared to NAAQS which is 500 µg/m³ (average 24 hours) prescribed for industrial areas by the CPCB.

Table 2: Concentration of SPM and RSPM in and around crushing units of Chitrakoot:

Number of Crushing sites	RSPM (µgm^{-3})	SPM (µgm^{-3})
1. Bharatkoop Crushing Site 1	207	502
2. Away From Crushing Site 1	184	442
3. Bharatkoop Crushing Site 2	214	513
4. Away From Crushing Site 2	176	385
5. Bharatkoop Crushing Site 3	193	472
6. Away From Crushing Site 3	162	340
Mean	189.3	442.3

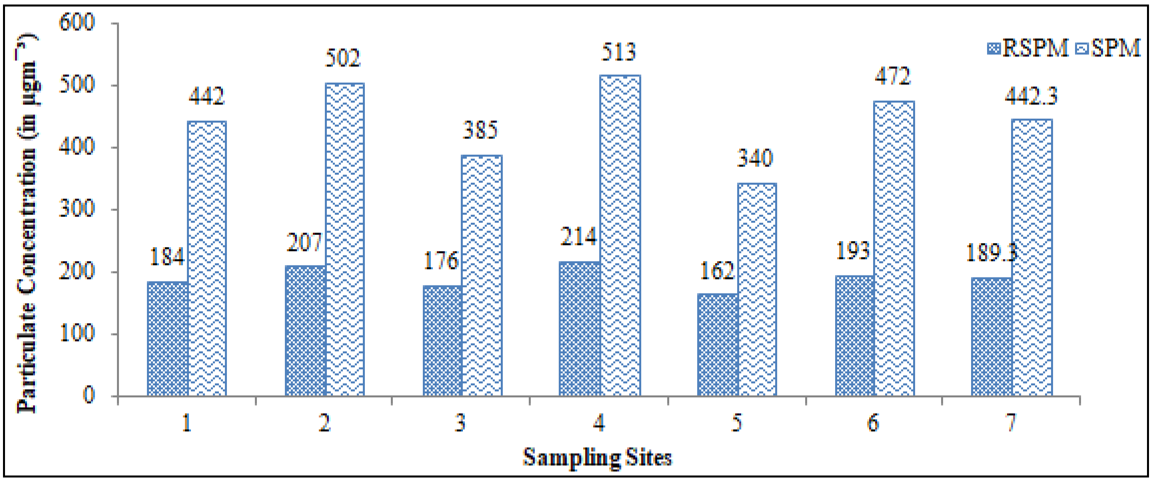

Figure 1: Concentration of SPM and RSPM in and around crushing units of Chitrakoot

Table 3: Concentration of SPM and RSPM in and around crushing units of Banda:

Number of Crushing sites	RSPM (µgm^{-3})	SPM (µgm^{-3})
1. Narayni Road Crushing Site1	187	396
2. Mataudh Crushing Site 2	201	428
3. Away From Mataudh Crushing Site 2	178	362
Mean	188.6	395.3

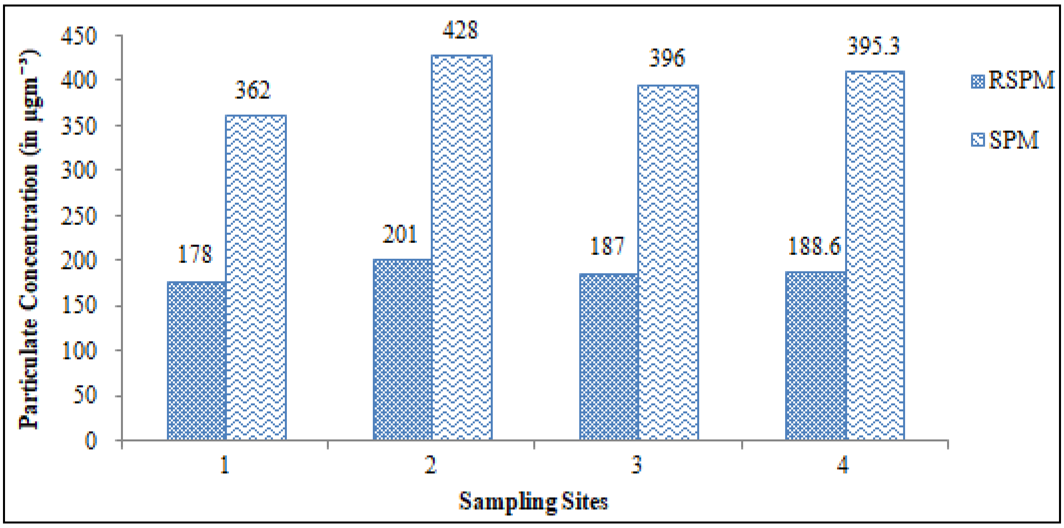

Figure 2: Concentration of SPM and RSPM in and around crushing units of Banda

Table 4: Concentration of SPM and RSPM in and around crushing units of Mahoba:

Number of Crushing sites	RSPM (μgm^{-3})	SPM (μgm^{-3})
1. Mahoba (Kabrai) Crushing Site 1	237	540
2. Away From Mahoba (Kabrai) Crushing Site 1	207	472
3. Mahoba (Kabrai) Crushing Site 3	182	397
4. Mahoba (Kabrai) Crushing Site 4	240	689
5. Mahoba (Kabrai) Crushing Site 5	253	715
6. Away From Mahoba (Kabrai) Crushing Site 5	199	438
Mean	219.6	541.8

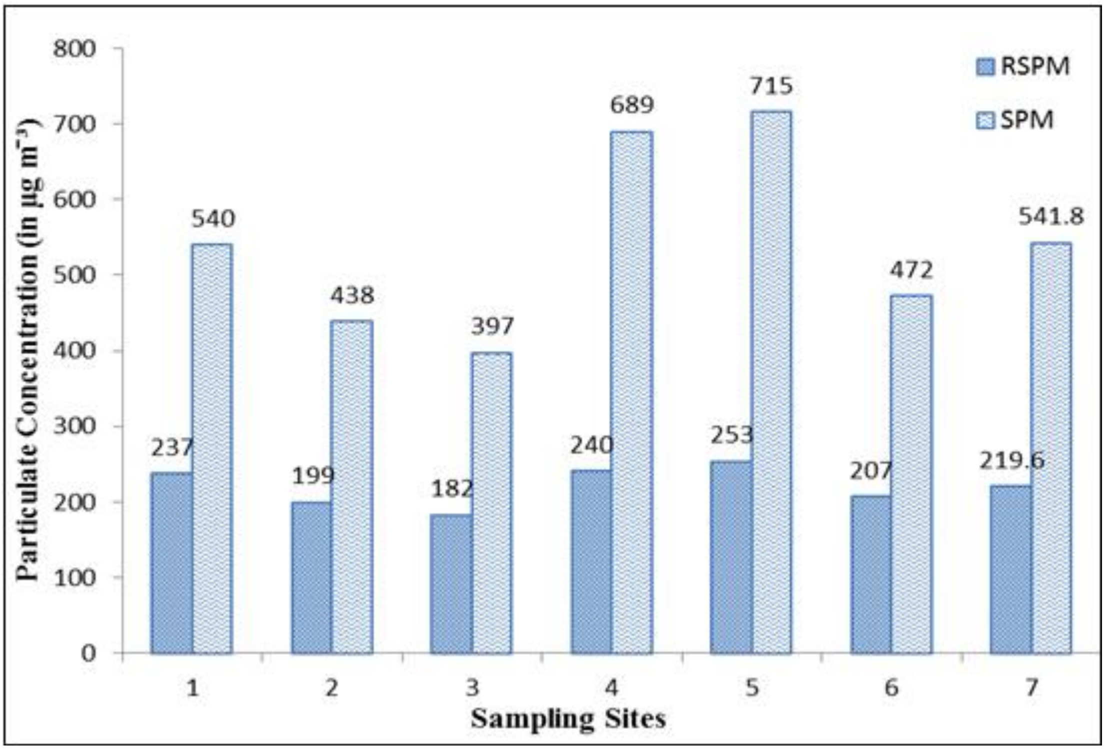

Figure 3: Concentration of SPM and RSPM in and around crushing units of Mahoba

The variation of SPM and RSPM in all the sampling sites of three districts depicted separately in Figures 1, 2 & 3 shows that the stone crushing sites of Mahoba and Chitrakoot was more polluted with RSPM and SPM as compared to crushing sites of Banda districts. It also shows that the SPM load in all the sampling sites was larger than the RSPM concentration and this is as per expectation. The level of particulate matters generated at each quarry site vary significantly ($p < 0.05$). It was examined that in the day time during which the crushers were working about SPM concentrations were about 2 - 3 times more than that of the during which there was no crusher activity but transportation activity was carried out. During the night time mostly there were no crushing and transportation activities, the SPM concentration measured was found to be very low of measured concentration for the period.

Thus air quality is a serious issue in these stone crushing sites where silica dust can affect sinuses, lungs, and entire respiratory system in stone crusher workers and nearby residents. Most of the stone crushers in these areas have inadequate dust control system so that dust emission is substantial which leads to adverse impact on workers health and as well as surrounding environment. No health facilities are being provided to the workers at most of the mining site. It is therefore suggested that the workers should be provided with suitable disposable type dust respirators for respiratory protection. Workers should be informed of the hazardous nature of silica dust, the results of workplace monitoring and medical tests, and the correct usage and maintenance of respirators. Adequate general ventilation must be provided to draw dust away from the workers. Spraying water can reduce the amount of silica dust. Growing the green belt along the periphery of the crushing unit or the crushing zone may reduce the dust in crushing units and nearby areas.

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