ASSESSMENT OF TEMPORAL PATERN OF DUST LEVEL IN DIFFERENT WORKPLACES OF STONE CRUSHER UNITS

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ABSTRACT *To ameliorate the probability of occupational respiratory problems of stone crushing workers, it is necessary to evaluate temporal dust concentration in the different working areas. The present study investigated occupational exposure to "Total silica dust" in different stone crusher factory workers in West Bengal, District Bankura, an Eastern part of India. This study also quantifies temporal dust concentration levels in four different locations of six different stone crushing units. Data obtained from the measurements were evaluated using statistical tools like analysis of variance (ANOVA) and the Tukey-Kramer procedure. The dust concentration levels in different locations were found to be high and exceeded PEL in most of the time of the day. Thus, those exposed workers prone to respiratory health problems during the course of their occupation exposure which may deteriorate their quality of life.*

Keywords: *Free Silica dust, Work Environment, TLV, Exposure assessment, Total dust, ANOVA, Tukey test.*

INTRODUCTION:

Work environment in stone crushing units are associated with a considerable numbers of occupational risk factors, such as high physical workload, noise, vibration, high temperature and humidity, and exposure to dust and gas phase hazardous substances [1, 2, 3]. Dust is generated and proliferates into the work environment during stone crushing, stone loading, transportation and unloading, through the flow of wind. Dust is produced in every step in stone breaking processes. The quantity of potential airborne dust is related with the quantity of broken stone [4]. Stone crusher operators are typically exposed to mixed stone dust containing air born crystalline free silica throughout the working period in the workplace. Stone dust containing air born crystalline free silica occur especially during stone crushing of bold stone [5]. Inhalation of crystalline free silica dust is associated with the development of pulmonary disease (COPD) or silicosis in stone crushing workers [6, 7]; an occupational respiratory disease of workers occurs due to exposure to respirable crystalline free silica dust generated during various operations at dusty prone work places [8]. But, unfortunately, there is dearth of data in temporal silica level in the work environment in unorganized sectors especially in stone crushing units [9]. In this study, data obtained from the temporal dust measurement studies done in various types of stone crushing units in 2014-2016 were evaluated with the analysis of variance (ANOVA) and the Tukey-Kramer procedure.

MATERIALS AND METHODS:

Sampling procedures: This study was conducted in the six different Stone crushing units in different times of day. Suspended particulate or dust containing crystalline free silica were collected at the breathing zone of the workers in four different sites of manual (one), semi-mechanized (one) and mechanized (four) stone breaking Units. Cyclone (Casella London make) separators were used for the collection of respirable dust [8]. Air born samples of stone dust were collected by using calibrated suction pumps (low volume sampler) and pre-weighted glass fiber filter paper [10]. Individual exposure of air borne dust has been measured from the differences in weight of the filter papers. Permissible level (PEL) of the air borne dust has been calculated from free silica content of the dust. Exposure of individual worker has been evaluated on comparison between permissible limit value and amount of dust exposure [11]. Dust measurements were done in four places in the units: Front of Crusher Operator, Near Dispatch Section, Under Stone Crusher (Right Side), Under Stone Crusher (Left Side) in six different types of stone crushing units.

Total and respirable dust samples were collected from workplace by the "NIOSH" method using Gillan-5000 (Sensedyne make) sampling pumps with flow rate 1.5 liter per minute and sampling periods were about 60-120 min. Sampling for total dust and respirable dust measurements were performed separately. The cyclones were fixed on the worker's clothes attached to the belt and collars at the breathing zone. For "Total dust" filter size 37 mm with 0.8 pores was done without Cyclone. To remove moisture from filter, it was placed in desiccators for 24 hours before and after sampling. Filter was weighted by a digital scale with precision Sartorius balance (10^{-6} g). The sampling pump was calibrated by a soap bubble flow meter. The correct volume of air at standard conditions of the following formula was used. V= r × t, (V = Volume of air sampled per liter), (r = rate of low volume sampler) (L/Min), (t= sampling time (Min.) and concentration of dust of the following formula was used: $C = \{(W_2 - W_1) / V\}$. C= Concentration of dust (mg/m3), W_2 = Filter with the sample weight per mg, W_1= Weight of filter before sampling in terms of mg, V = Volume of air sampled per liter [12].

RESULTS:

1. Statistical method:

The analysis of variance (ANOVA) is one of the powerful tools, was performed to the dust values of dust measurement monitoring from different locations of stone crusher units. This technique uses the sample data to test whether the values of two or more unknown means were likely to be equal and to compare variation with each group to variation within the group [13]. If the groups vary considerably from one to other in comparison to the within group variation, the null hypothesis that all the groups have similar levels of response variable can be rejected [14]. Two-way ANOVA is a procedure that examines the effects of two independent variables concurrently [15]. In the present study two ways ANOVA with replica have been performed where factor A has *h* levels and factor *B* has *g* levels, there will be *hg* treatment combinations. Assuming that for both factors the levels used are the only ones of interest, then a parametric model is appropriate. The model can be given as follows [16, 17].

$yij = \mu + \alpha i + \beta j + \varepsilon ij$,----------------- (1)

where $i = 1, ... , h$; $j = 1, ... , g$; yij- the response obtained when factor *A* is at level *i* and factor *B* is at level *j*; μ-overall mean; αi-the effect of level *i* of factor *A*; βj-the effect of level *j* of factor *B*; εij-random error term.

2. Data analysis:

The line diagrams have been drawn of total dust concentration in four different locations of six different stone crusher units with respect to different time of the day. The measurement of the total free crystalline silica dust was done from gravimetric dust sample. They were divided into four categories and the values were depicted in figures 1a, 1b, 1c and 1d. Figures 1a, 1b, 1c and 1d convey the 'Total dust' concentration of two hours interval starting from 8.00 A.M. to 6.00 P.M. of front of crusher operator, near dispatched section, under crusher (right side) and under crusher (left side), respectively. It can be observed from those figures that the dust concentration level did not have much variation with respect to time of the day and this is true for all the four locations and six different stone crusher units, and the level of the dust concentration was exceeded the level of permissible limit. It was investigated if those results indicated a significant variation either between the locations or between the areas. Two way ANOVA was employed to determine simultaneous comparisons between the mean values and also to determine whether there was significant relation between the variables. The basic information with reference to output of ANOVA analysis has been summarized in Table-1. This table was aimed to determine if there is a significant difference in the effect of locations or stone crusher units areas. And the following hypothesis can be written for locations as

$H_0: \alpha_1 = ... = \alpha_3 = 0$,

$H_1: \alpha_1 \neq ... \neq \alpha_3 \neq 0$.

The dust level in different locations changed at 0.05 significance levels. Similarly the following hypothesis can also be written for six different stone crushing establishment as

$H_0: \beta_1 = ... = \beta_5 = 0$,

$H_1: \beta_1 \neq ... \neq \beta_5 \neq 0$.

It can be concluded that there was a difference in the different area of the crusher unit a significance level of 0.05. Tukey Kramer procedure would be applied to ascertain which population means different significantly from other and to compare all means of group simultaneously.

The critical range of Tukey Kramer procedure has been calculated from Equation- 2 [18]:

Critical Value = $q_u\sqrt{(MES/r)}$ ------------------------- (2)

Where q_u-values obtained from Studentized range distribution table, MES-mean square error from the ANOVA output table and r- the number of levels [19, 20].

The critical range at α = 0.05 was worked out to be 0.01069 using q_u value from Q scores for Tukey's Method.

Figure-2 depicts the average 'Total dust' concentration level in different locations of stone crusher units where total thirty six number of sample were taken in each location of Six different stone crusher units.

Figure-3 summarizes the multiple comparisons of Tukey Kramer procedure and absolute difference of dust levels in four different locations of stone crusher units. It can be seen from the table-2 that the mean difference between 'front of crusher operator' sections to 'near dispatch' sections was found to be significantly different and this is also true for other pairs as depicted in the table-2.

From the results of the present study it is expected that the workers exposed to such a contaminated environment likely to develop respiratory disorders linking to silica dust.

Figure: 1a: Temporal variation of total dust concentrations at crusher operator section in different stone crushing units.

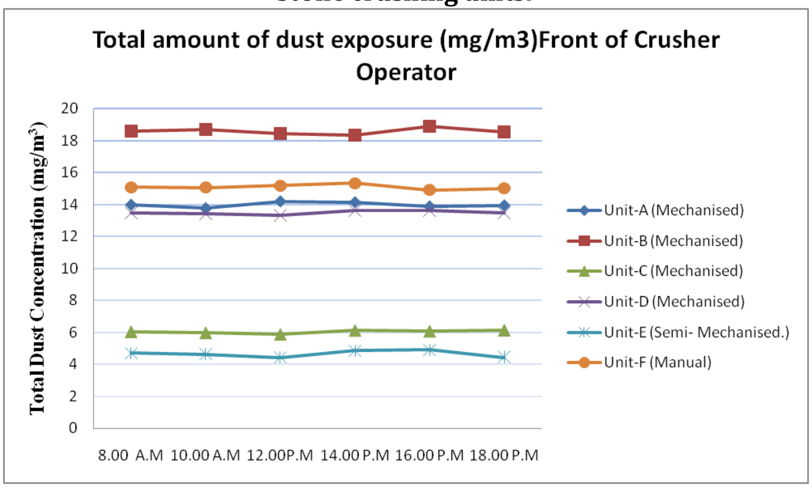

Figure: 1b: Temporal variation of total dust concentrations at near dispatch section in different stone crushing units.

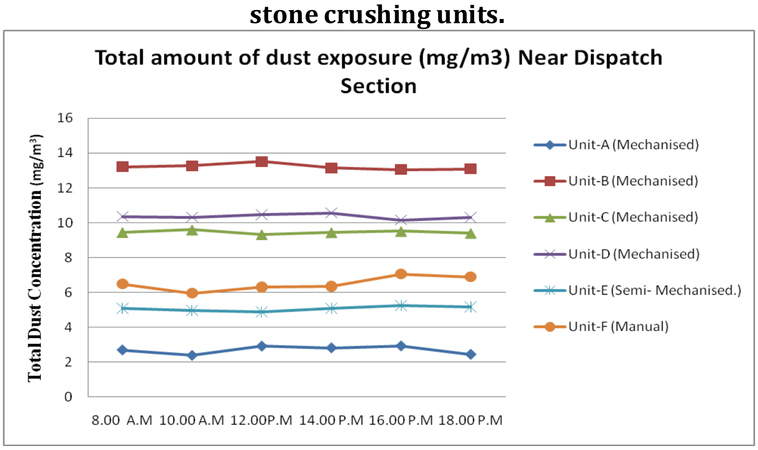

Figure: 1c: Temporal variation of total dust concentrations at under stone crusher (right side) section in different stone crushing units.

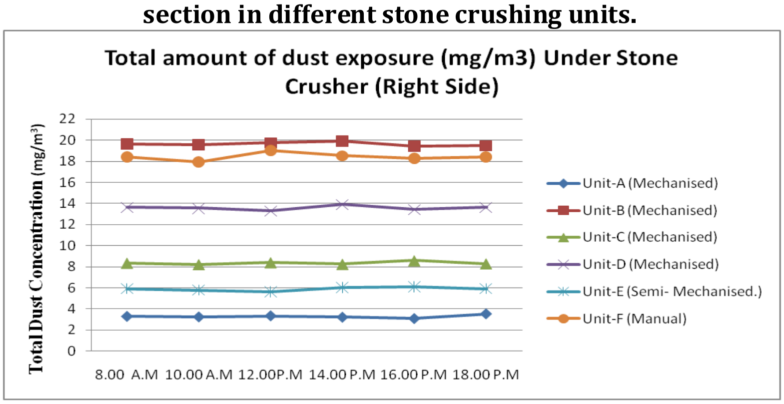

Figure: 1d: Temporal variation of total dust concentrations at under stone crusher (left side) section in different stone crushing units.

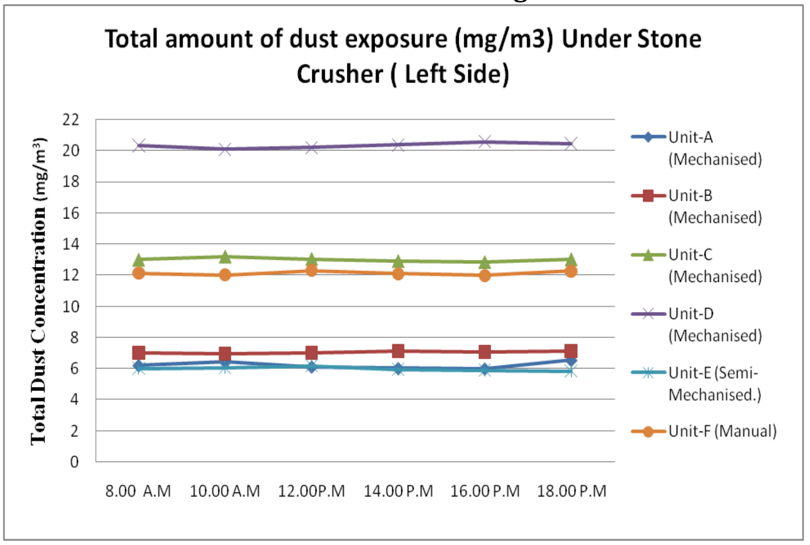

Figure: 2 Average total dust concentrations in different locations/areas of stone crushing units:

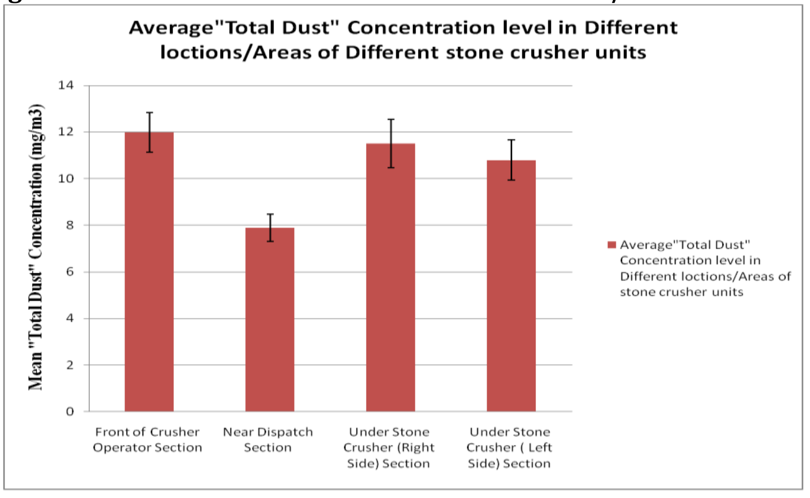

Figure: 3 Absolute differences of dust levels for different categories of stone crusher unit's areas:

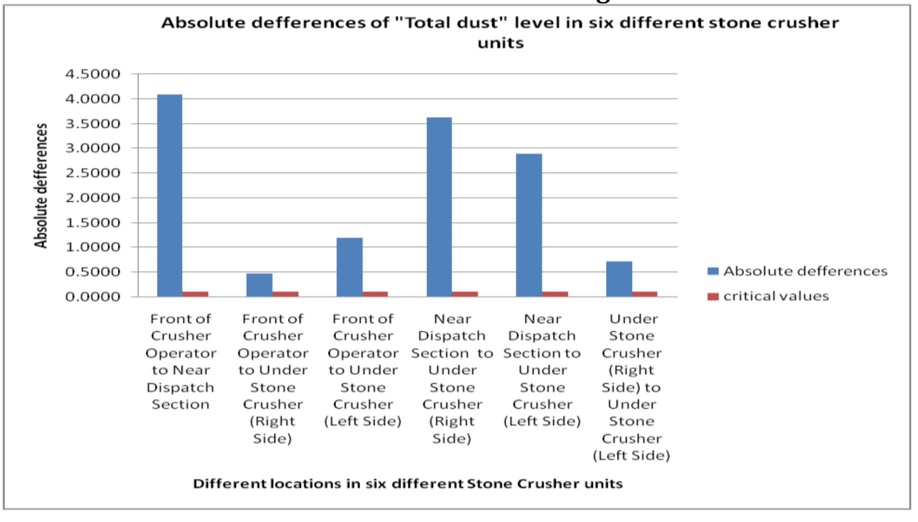

Table-1: Statistical Analysis for two ways ANOVA:

ANOVA TEST	Anova: Two-Factor With Replication					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	364.8066367	3	121.6022122	3432.752004	4.2163E-116	2.680167578
Columns	1970.840161	5	394.1680322	11127.10926	3.3824E-158	2.289851281
Interaction	1658.318696	15	110.5545797	3120.884465	8.1417E-148	1.750496961
Within	4.250894167	120	0.035424118			
Total	3998.216388	143				

Table-2: Multiple Comparisons of the Tukey-Kramer Procedure:

Comparison	Absolute different	Critical values	Remarks
Front of Crusher Operator to Near Dispatch Section	4.0972	0.1069	Mean are significantly different
Front of Crusher Operator to Under Stone Crusher (Right Side)	0.4708	0.1069	Mean are significantly different
Front of Crusher Operator to Under Stone Crusher (Left Side)	1.1956	0.1069	Mean are significantly different
Near Dispatch Section to Under Stone Crusher (Right Side)	3.6264	0.1069	Mean are significantly different
Near Dispatch Section to Under Stone Crusher (Left Side)	2.9017	0.1069	Mean are significantly different
Under Stone Crusher (Right Side) to Under Stone Crusher (Left Side)	0.7247	0.1069	Mean are significantly different

DISCUSSION:

In the stone crusher industries, exposure to free crystalline dust may cause diverse lung diseases with different severity of symptoms ranging from simple irritation to allergic rhinitis or occupational asthma. Long term exposure to silica dust can cause chronic lung problems[21]. According to the American Conference of Governmental Industrial Hygienists (ACGIH) standard, the threshold Limit Values of exposure to "Total silica dust" for quartz is 0.1 milligrams per cubic meter. In this study, the average exposure to "Total silica dust" in workers at various sections / locations was 11.98 ± 5.05 mg/m^3 followed by 11.51 ± 6.23, 10.79 ± 5.17 and 7.89 ± 3.57 mg/m^3 in Crusher operator, Under crusher (Right Side), Under crusher (Left Side), and near dispatch section respectively. These average concentrations of "Total crystalline silica dust" are near about one twenty to seventy eight times higher than the permissible limit. The maximum exposure to Silica dust was seen in the Front of crusher section due to direct contact with silica dust and the lowest exposure was in the near dispatched section. The statistical tests using two way ANNOVA tools and Tukey Kramer Tests convey that there was a statistically significant relationship between each location to other locations for total dust exposure throughout the stone crusher units.

CONCLUSIONS:

The aim of the study was to evaluate the dust concentration levels in four different working areas of six different stone crushing units with respect to different time of the day. The findings of this study conclude that all the locations were showing high concentration of dust levels containing free silica. In the statistical analyses, the comparisons of levels of dust between six different types of stone crushing units in four different locations of areas where workers are regularly working were made with average dust concentration values. It was concluded that in front of stone crusher operator and Under Stone Crusher (Right Side) were the maximum exposure took place of different stone crushing units by working methods. The workers exposed to such a condition may likely to acquire respiratory disorder during the course of their exposure. Hence, the dust concentration level should be controlled to reduce the incidence of disorder either by initiating adequate air velocity so that the dust can be blown away from the breathing zone of the workers and reduced the occupational respiratory disorder among the stone crusher workers.

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