RESPIRATORY HEALTH IN BRICK KILN WORKERS

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Abstract:

The objective of this cross-sectional study was to investigate the prevalence and determinants of respiratory symptoms and their association with occupational dust exposure among the brick kiln workers. Brick kiln workers are exposed to dust particles and are susceptible to multiple pulmonary complications. Problems like asthma, chronic obstructive pulmonary symptoms, and silicosis are more common among them. As brick kiln industry is an unorganized sector, so it was decided to evaluate the respiratory symptoms and lung capacities in these workers and compare them with controls. This study included 120 brick kiln factory workers occupationally exposed to dust and 80 unexposed workers as controls. Mean respirable dust exposure in firing section was the highest (19.51 mg/m^3) while mean respirable dust exposure in mixing & molding section was the lowest (10.08 mg/m^3). Implementation of industrial hygiene and proper and efficient use of personal protection equipment while at work could help to protect the respiratory health of brick kiln workers.

KEY WORDS: Cross-sectional study Brick kiln industry, Occupational exposure, Respiratory symptoms, Respirable dust.

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1. Introduction:

Brick manufacturing plant uses many different raw materials and produces many intermediates, by-products and products. Among these, there are many substances potentially harmful to the health of brick kiln workers. Hazardous dust is one of the most important exposures in brick kiln workers. There are only a few published studies on the respiratory health of brick kiln workers and these have showed that chronic bronchitis and decreased lung function values are associated with atmospheric pollution, especially in the firing and unloading section Alam et al. (2009), huang et al. (2000), Joshi et al. (2008), Myers et al. (1989).However, all of them lacked an appropriate assessment of dust exposure, especially the respirable fraction, leaving the question of association between actual amount and respiratory impairment still unanswered.

The purpose of this study was to investigate the relationship between respiratory health and dust exposure in brick kiln workers by applying standardized measurements. It was, hence, designed to determine levels of dust exposures in different job categories, to determine the prevalence of respiratory symptoms and to investigate their contributing factors including dust exposure.

The brick kiln industry is the largest producer in the world, has more than 73,000 operating units, producing about 900 billion sintered bricks annually, among which about 50% are fired clay bricks Wang et al. (2010).Fired clay brick is one of the most popular building materials in India. More than 1, 00,000 enterprises produce nearly 100 billion bricks per year.

1.1Occupational hazards:

Brick making involves crude techniques causing considerable worker drudgery. Brick workers, especially moulders are exposed to the sun for long hours. They are exposed to high concentration of dust while manual breaking of coal. There is also the risk of exposure to dust (from bottom ash spread on the kin) and open fire during manual coal feeding. The workers have to walk on hot surface (top of the furnace) while monitoring and regulating the fire. They are also exposed to high concentrations of respirable suspended particulate matters (RSPM), during monitoring and regulating the fire, as the furnace chamber is covered with ash (ash acts as insulator).

During the kiln unloading and shipping process it may produce a lot of dust and particulate matter pollutants that come from the surface of the bricks and have the same chemical components as brick itself. These main chemical components are SiO_2, Al_2O_3 and Fe_2O_3. Due to different geological formation conditions, components may also contain a small amount of alkali metal and alkaline earth metal oxides. The kilns are a semi tight environment and the average temperature in the kilns are from 50ºF to 77ºF (10 ºC to 25ºC) higher than out of the kilns.

Work exposure to the high temperature and the high density dust and particulate matter over a long time can result in occupational health problems, including serious disease (e.g. lung cancer) Spies et al. (2006).

2. Literature Survey:

C Edling et al. (1986) said that the results of the renal function tests indicate that the workers had been heavily exposed to cadmium, and to such a degree that tubular damage was evident in more than 40% of the exposed. Mwaiselage J et al. (2005), Faezeh Dehghan et al. (2009), Gholam Hossein Halvani et al. (2008), Jadranka Mustajbegovic et al. (2003), Hisham M. Aziz et al. (2010) , A Johnson et al. (1985) , Jonathan E Myers et al. (1989) , A. J. Ugheoke et al. (2006) , H Kakooei et al. (2005) and David A Groneberg et al. (2006) reported increased prevalence of respiratory complaints like cough, sputum, wheezing and dyspnea among exposed workers compared to executive employees and this difference was statistically significant.

According to YWS Law et al. (2001), the major cause of silicosis in Hong Kong is chronic silica dust exposure in the construction industry. According to L P Singh et al. (2000) and Lakhwinder Pal Singh et al. (2011), the results of the study revealed that 78% of the workers are not using PPE leading to the respiratory symptoms among the workers. Joshi SK et al. (2008) reported that statistically significant high odds ratios for respiratory problems like tonsillitis (4.17 95% CI 2.05, 8.45) and acute pharyngitis (4.08 95% CI 2.01, 8.33) were observed.

C. O. Nku et al. (2005) reported higher prevalence of back pain (40.5% vs. 2.0%; P<0.001), cough (25.5% vs. 12.0%; P<0.001), chest pain (13.0% vs. 4.0%; P<0.001); Catarrh and sneezing (6.0% vs. 0.5%; P<0.01) among the street sweepers than in their control. P. L. Jayawardana et al. (1997) concluded that chronic tea dust exposure causes increased prevalence of respiratory

symptoms and a significant degree of small airways obstruction. T. A. Smith et al. (1998) reported the prevalence of work-related symptoms in bread bakery and cake bakery ingredient handlers was 20.4% and 10.4% respectively. Ulf Hedlund B et al. (2006) reported that chronic productive cough and physician-diagnosed chronic bronchitis were significantly more common among ex-miners (P, 0.05 and, 0.01, respectively).According to C. Linaker et al. (2002) the most common respiratory symptoms reported by farm workers (wheeze, dyspnea and cough) are relatively non-specific and can be associated with several occupational respiratory disorders.

Hairdressers had a higher prevalence of asthma symptoms, diagnosed asthma, and asthma attacks in the previous 12 months, but these differences reduced markedly when adjusted for age, gender and smoking as given by T. Slater et al. (2000). The results of the study revealed that occupational heat exposure significantly exceeds the limits as prescribed by NIOSH/ACGIH. The results revealed that 68% of the workers were not wearing personal protective equipment (PPE) as given by L.P.Singh et al. (2009).

The results showed a consistent syndrome of work-related eye, nose and throat irritation followed after a variable period by shortness of breath as given by S. B. Gordon et al. (1998).

3. Materials and Methods:

3.1 Population

The sample contains two categories of people; one is the controlled group (120) which includes persons from the service industry in which people is rarely exposed to dust and other pollutants and second is the exposed group (80) which includes the brick kiln workers.

3.2 Questionnaire

A standardized, self-reporting questionnaire was used and interviews were performed after the lung function tests. The questions included demographic information, occupational history, past medical history, use of drugs, respiratory symptoms (cough, wheezing, Breathlessness, Phlegm), asthma history, smoking habits, and allergies. The body mass index (BMI) was calculated as a ratio of the weight in kilograms and the height in meters squared.

3.3 Data Analysis

All statistical analyses were performed using SPSS 16 for Windows (Statistical Products and Service Solutions, Inc., Chicago). For testing differences between the means, we used Student's t-test or analysis of variance. In all statistical tests the confidence interval (CI) was 95% and $p<0.05$ (two-tailed) was considered as significant. The ANOVA test was used for testing differences in the prevalence of respiratory symptoms between groups.

3.4 Dust Sampling

Respirable dust was collected from following sites: mixing & moulding, loading, unloading and firing. The dust concentration in the work environment was measured by SKC Leland Legacy pump on 2.0 µm pore size PTFE (Teflon) filter at flow rate of 9.0 liters/min. The machine was attached to the worker and as such 20 dust samples were collected in four separate areas in the plant over the 8-h day work shift. The dust concentration was then derived as follows:

Calculations used

a) Mass of particles found on the sample filter:

$$M_s = (M_2-M_1)\ mg$$

Where M_s= mass found on sample filter, mg, M_1= tare weight of the clean filter before sampling, mg, M_2= weight of the sample filter containing dust, mg. Note: The blank filters must be subjected to the same equilibrium conditions.

b) The sampled volume is:

$$V_s=Q*T/1000$$

Where V_s= volume of air sampled, m^3, Q=average flow rate of air sampled, L/min, T= sampling time, min, 1000= conversion from L to m^3.

c) The concentration of the particulate matter in the sampled air is expressed in micrograms/m^3.

Dust concentration mg/m^3 = Mass found on the sample filter (mg)/ Volume of air sampled (m^3)

4. Results:

This study evaluated 120 personnel working in a brick kiln factory were working in the production units and comprised the study group and 80 were executive employees and were considered as the control group.

It is very evident from table 4.1 that there was no significant difference in the mean age, height, weight, and smoking habits between the 2 groups ($p>0.05$). However there exists significant difference in work experience between the exposed and the controlled groups, and the reason is that the entry age for job in the offices is after graduation but there is no such criteria in brick kiln industry. The male exposed smokers were 35 (38.8%) and that of controlled were 19 (37.2%). The mean age of exposed male was 31.6 yrs (range 21-50 yrs), the mean duration of employment was 13.3 yrs (range 4-30 yrs), the mean height was 168.5 cm (range 160-177 cm) and the mean weight was 62.4 kg (range 46-75 kg). The mean age of exposed female was 30.1 yrs (range 24-37 yrs), the mean duration of employment was 10.4 yrs (range 5-21 yrs), the mean height was 160 cm (range 154-165 cm) and the mean weight was 56.2 kg (range 46-71 kg).

Table 4.2 and figure 4.1compare the frequency of respiratory complaints between the exposed and controlled groups. As shown in table, the exposed and control group differed significantly in the prevalence of all respiratory complaints. In case of exposed workers, respiratory symptoms in males such as cough frequently , cough chronic , phlegm frequently , chronic phlegm , wheezing , breathlessness , running nose , throat irritation , asthma) are 46%, 32%, 22%, 24%, 15%, 28%, 19%, 27%, and11% respectively and in females results are 66 %, 43%, 53%, 33%, 20%, 30%, 23%, 23%, and 13% respectively and in case of control workers, results are 14%, 1%, 1%, 1%, 0%, 0%, 1%, 12%, and 0% respectively and in females results are 14 %, 1%, 1%, 0%, 0%, 0 %, 0%, 1%, and 0% respectively.

It is evident from table 4.3 that out of four sections, the percentage of symptoms in firing section was maximum (95%), whereas in unloading section the percentage was 80% , in loading it was 47% and in mixing & molding it was 42%.Overall 55% of the workers reported frequent cough, 42% workers reported chronic cough, about 40% reported frequent phlegm, 39% reported chronic phlegm, 38% reported wheezing, 34% reported breathlessness, running nose was reported by 24%, and throat irritation was reported by 31% whereas asthma was reported by 14%

of the workers only. These workers were mainly from firing and unloading section where dust concentration was very high.

As shown in table 4.5, respirable dust exposure in firing section was the highest (19.51 mg/m^3) while respirable dust exposure in mixing & molding section was the lowest (10.08 mg/m^3). However respirable dust exposures in unloading and loading section are 17.14 mg/m^3 and 14.11 mg/m^3 respectively.

5. Discussion:

5.1 Exposed Vs Control

Results reveal increased prevalence of respiratory complaints like cough, phlegm, wheezing, breathlessness and asthma among brick kiln workers compared to controls and this difference was statistically significant. The reason for this could be that the workers are exposed to respirable dust limits which exceed the respirable dust limit of 5.0 mg/m^3 as given by OSHA and the Indian Union Ministry of Labour. Another reason for this is that the workers working in brick kiln are not wearing proper protective equipment causing serious health problems. Other studies also reported prevalence's of cough frequently, chronic cough, phlegm frequently, chronic phlegm, wheezing occasionally, and breathlessness Ugheoke et al. (2006), Mwaiselage et al. (2005), Mustajbegovic et al. (2003), Dehghan et al. (2009), Singh et al. (2011). Myers et al. (1989) showed a high prevalence of wheezing, shortness of breath, dyspnea, and chronic phlegm in brick manufacturing workers.

5.2 Section wise comparison of respiratory symptoms

Sectionwise comparison of respiratory symptoms among brick kiln workers showed that maximum symptoms among workers were mainly in firing and unloading section and the reason for this is that workers are exposed to respirable dust limits (as calculated by dust sampling technique) which exceed the respirable dust limit of 5.0 mg/m^3 as given by OSHA and the Indian Union Ministry of Labour. Meo et al. (1994) reported that adequate ventilation appears to be a significant factor in the health and lung function of welders.

5.3 Effect of Dust

It is clear from subjective data that the brick kiln workers are exposed to high levels of dust and temperature as they showed unnecessarily tiredness and weakness in daily routine life. This is evident from the results of dust sampling technique which revealed that respirable dust exposure in all sections exceed the respirable dust limit as given by OSHA and the Indian Union Ministry of Labour. According to American Conference of Governmental Industrial Hygienists (ACGIH) 1988, a general dust hazard is considered to exist in jobs whose respirable dust concentration exceeded 5 mg/m^3. Exposure to silica dust amounts is insufficient to produce pulmonary fibrosis, but it can result in chronic obstructive pulmonary disease as reflected in aggravated reduction of expiratory flow rates in workers participated in this study Golshan et al. (2003).

The whole discussion on the basis of results of measurements and subjective responses it is concluded that workers in brick kiln industry is at high risk of chronic effects of dust exposure.

6. Conclusions:

The study concludes that there is strong association between hazardous environmental conditions and the physical and respiratory health of industrial workers. The decrease in lung function values of industrial workers as compared to control workers can be attributed mainly to respiratory disorders. The absence of pollution control and monitoring devices at workplace add to the hazardous environmental conditions. Moreover most of industrial workers showed reluctance in use of safety equipment which indicates lack of safety awareness and appropriate managerial steps. This is either due to negligence of the company or due to them being uneducated. This resulted in prevalence of occupational health disorders in lungs, eyes and skin among industrial workers. This brings 14 workers in brick kiln industries under risk of developing Chronic Obstructive Pulmonary Diseases like asthma.

7. Acknowledgement:

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Demographic data	Exposed Male (90) Mean ± SD	Controlled Male (51) Mean ± SD	P-value	Exposed Female (30) Mean ± SD	Controlled Female (29) Mean ± SD	P-value
Age (year)	31.6±5.8	30.2±4.5	NS	30.1±3.3	29.8±3.6	NS
Exp (year)	13.3±6.0	6.3±4.0	< 0.05	10.4±3.9	7.1±3.4	< 0.05
Height (cm)	168.5±3.9	169.9±2.5	NS	160.4±3.2	161.3±2.2	NS
Weight (kg)	62.4±6.5	62.0±3.4	NS	56.2±3.9	57.9±3.9	NS
Smokers	35 (38.8%)	19 (37.2%)	NS	0 (0%)	0 (0%)	NS
Non-smokers	55 (61.1%)	32 (62.7%)	NS	30(100%)	29 (100%)	NS

Table.4.1 Demographics of the exposed brick kiln workers and controls (n=200)
Data are presented as mean ± standard deviation
NS – statistically not significant

Table 4.2 Prevalence of respiratory symptoms in exposed and controlled groups

Respiratory Symptoms	Exposed Male (90) N (%)	Controlled Male (51) N (%)	P-value	Exposed Female (30) N (%)	Controlled Female (29) N (%)	P-value
CF	38 (42.2)	7 (13.7)	< 0.05	17 (56.6)	4(13.7)	< 0.05
CC	29 (32.2)	2 (0.3)	< 0.05	13 (43.3)	2 (.7)	< 0.05
PF	25 (27.7)	2 (0.3)	< 0.05	15 (50.0)	2 (.7)	< 0.05
CP	22 (24.4)	0 (0.3)	< 0.05	10 (33.3)	0 (0)	< 0.05
W	18 (19.8)	0 (0)	< 0.05	20 (66.6)	0 (0)	< 0.05
B	25 (27.7)	0 (0)	< 0.05	9 (30.0)	3 (0)	< 0.05
RN	17 (18.8)	2 (0.3)	< 0.05	7 (23.3)	5 (17.2)	< 0.05
TI	24 (26.6)	6 (11.7)	< 0.05	7 (23.3)	7 (13.7)	< 0.05
A	10 (11.1)	0 (0)	< 0.05	4 (13.3)	0 (0)	< 0.05

CF-Cough Frequently , CC-Cough chronic , PF-Phlegm Frequently , CP- Chronic Phlegm ,
W- Wheezing, B-Breathlessness, RN-Running Nose, TI-Throat Irritation, A-Asthma.
Data are presented as the absolute number and percent of subjects.

Table 4.3 Section wise respiratory symptoms

Table 4.4 Respirable dust readings in (mg/m^3) in different sections

Name of section	Initial weight of filter	Final weight of filter	volume of air (ltrs)	V= volume of air (m3)	M=Net wt of Dust (mg)	C=M/V	Pump Running Time (8 hrs)	Dust in 8 hrs
Mixing & Molding	60.5	61.1	545	0.545	0.6	1.10092	1.00	8.72
Mixing & Molding	59.2	59.8	485	0.485	0.6	1.23711	0.89	11.01
Mixing & Molding	56.8	57.5	521	0.521	0.7	1.34357	0.96	11.14
Mixing & Molding	58.9	59.4	475	0.475	0.5	1.05263	0.87	9.57
Mixing & Molding	56.8	57.4	510	0.51	0.6	1.17647	0.94	9.96
Loading	59.4	60.2	497	0.497	0.8	1.60966	0.92	13.99
Loading	57.8	58.6	531	0.531	0.8	1.50659	0.98	12.25
Loading	58.3	59.2	544	0.544	0.9	1.65441	1.00	13.13
Loading	56.3	57.2	481	0.481	0.9	1.8711	0.89	16.80
Loading	58.2	59.1	520	0.52	0.9	1.73077	0.96	14.37
Unloading	60.8	61.8	515	0.515	1.0	1.94175	0.95	16.28
Unloading	59.5	60.5	510	0.51	1.0	1.96078	0.94	16.60
Unloading	60.5	61.6	517	0.517	1.1	2.12766	0.95	17.77
Unloading	56.9	58.2	551	0.551	1.3	2.35935	1.02	18.49
Unloading	58.4	59.3	485	0.485	0.9	1.85567	0.89	16.52
Firing	58.9	60.1	495	0.495	1.2	2.42424	0.91	21.15
Firing	60.6	62	557	0.557	1.4	2.51346	1.03	19.49
Firing	61.2	62.4	535	0.535	1.2	2.24299	0.99	18.11
Firing	58.8	60.2	521	0.521	1.4	2.68714	0.96	22.28
Firing	59.1	60	485	0.485	0.9	1.85567	0.89	16.52

Process/Symptoms	CF	CC	PF	PC	W	B	RN	TI	A	Total Symptoms	Percent of symptoms
Unloading (30)	19	11	11	13	12	12	6	9	3	96	80
Loading (33)	11	9	8	7	5	7	4	4	2	57	47
Mixing & Molding (30)	7	6	4	6	6	7	5	6	3	50	42
Firing (27)	18	16	17	13	15	8	9	12	6	114	95
Total Symptoms	55	42	40	39	38	34	24	31	14	324	

Table 4.5 Respirable dust exposure in (mg/m^3) in different sections (Mean ± SD)

Exposure section	Respirable dust (mg/m^3)
Mixing & Molding	10.08 ± 1.01
Loading	14.11 ± 1.77
Unloading	17.14 ± 0.95
Firing	19.51 ± 2.30

Figure 3.1 Pictures showing dust sampling being done at different sections

Figure 3.2 Shows Dust sampling machine and dust sampler

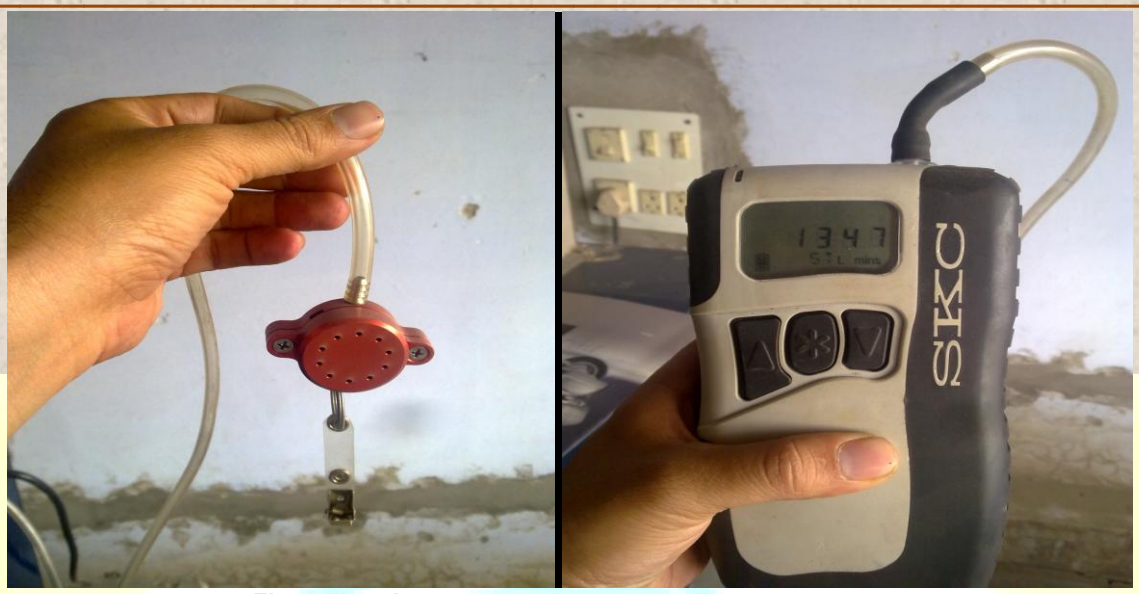


Figure 3.3 shows workers without complete PPE

Figure 4.1 Chart showing respiratory symptoms in exposed and controlled groups

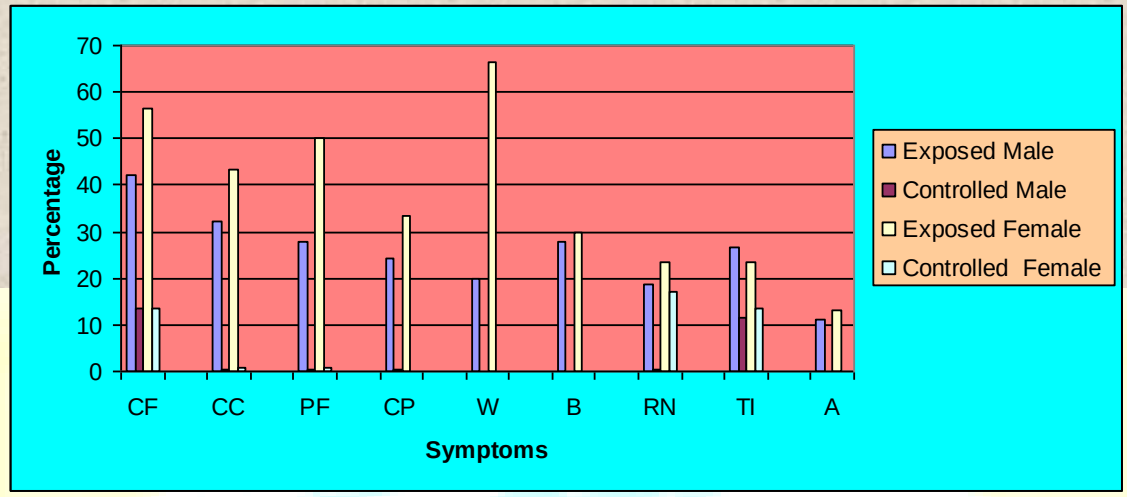


Figure 4.2 Chart showing section wise respiratory symptoms

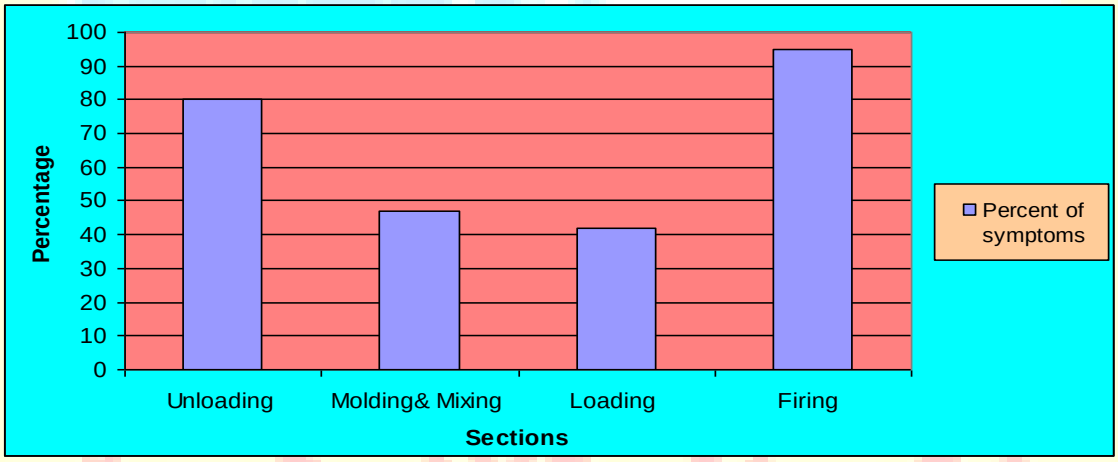
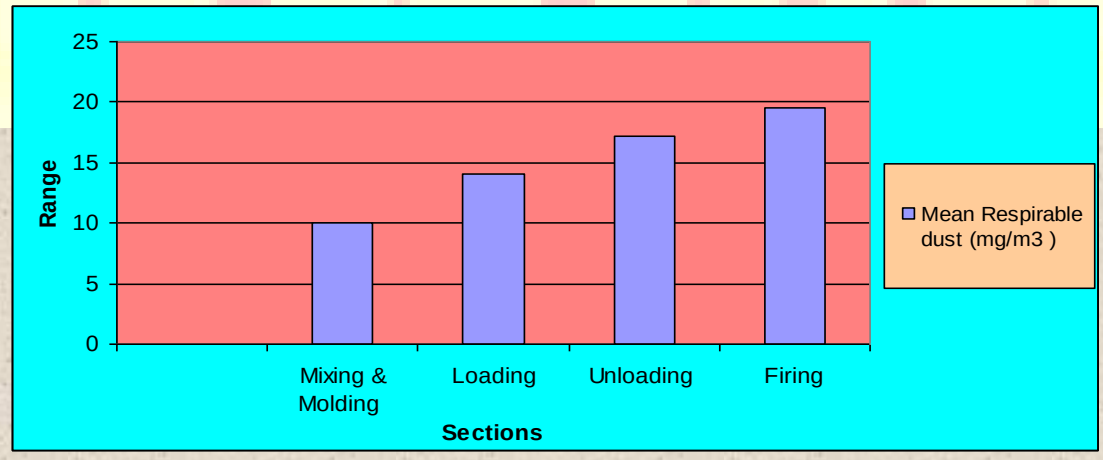


Figure 4.4 Chart showing mean respirable dust (mg/m^3) in various sections



Appendix-A

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Questionnaire for assessment occupational conditions/ Ergonomical and physiological Parameters of Brick kiln workers

PART - A (Demographic Data)

1. Name of the Person: .....……..
2. Address: ……
3. Age/weight/Height/ Level of Education: ……..
4. Marital status: ……Married/……Unmarried……....
5. Nature of Job and Associated Industry/Section: ……

   a) Specify your designation: Supervisor / Skilled Worker / Semi-Skilled Worker / Un-Skilled Worker

6. **Work Exposure:**

Experience Recent to latest						
	Dust/Fumes			**Temperature**		
Year	High	Medium	Low	High	Medium	Low

High Temperature: (WBGT) > 28.5°C heavy sweating (need to drink water and salt) in summer season

7. Work Schedule: i) Day time ☐ ii) Working in Shift ☐
7.1 Shift Schedule Rotation*: i) Forward ☐ ii) Backward ☐
*Forward Schedule (Morning - Evening - Night), Backward Schedule (Night – Evening – Morning)
7.2 Rotation of Shift i) Three days ☐ ii) Weekly ☐
iii) Bi Weekly ☐ iv) Monthly ☐ iv) Other ☐
8. Do you feel disturbed due to change in shift? (Always, Often, Sometime, Seldom, Never)
9. Working Time /Day i) 8 Hours ☐ ii) > 8 Hours ☐
10. Overtime/week: i) 5-10 Hour ☐ ii) 11-15 hours ☐ iii) 16-20 hours ☐
11. How many Cigarettes or Bidis/day……/None you take?
12. How many sachets of Tobacco, Paan, Gutkha, Chutki etc. /day…….. None you take?
13. Do you drink? Yes ☐ No ☐
    a) If yes then which quality of liquor? Local / Branded
    b) How frequently you drink? (Daily, Twice a week, Once in a week, Once in a month, Once in six months)
    c) Specify the quantity (40-70 ml, 70-100 ml, 100-150ml, 150-250 ml, >250 ml)
14. After working do you feel un-necessary tiredness? (Always, Often, Sometime, Seldom, Never)
15. Do you feel weakness in daily routine life? (Always, Often, Sometime, Seldom, Never)
16. How much water you drink water at work place in a day?
    a) 1-2 liters, b) 3-4 liters, c) 5-6 liters, d) 7-8 liters, e) ≥ 9 liters
17. Do you take glucose/salt or any supplement during work? Yes ☐ No ☐
    If yes then, is the supplement is provided by the company? Yes ☐ No ☐
18. Do you have problem of blood pressure? Yes No ☐ ☐
    If yes then specify (High, Low, High and Low)
19. Do management enforce you to wear the protective equipments? (Always, Often, Sometime, Seldom, Never)
20. Do you use protective equipments at work place? Yes No ☐ ☐

Sr No.	Never	Seldom	Sometime	Often	Always
Gloves					
Goggles					
Nose/ Mouth mask					
Others					

a) If you do not use the protective equipments, then specify the reason?
i) Feel uncomfortable, ii) You do not have habit, iii) Due to negligence, iv) Reduces performance, v) Due to inferior quality, vi) Not Provided.

21. Do you suffer from any of the following due to Dust/Smoke/Fumes Yes No?
If yes then specify

Sr. No.	Cough Frequently	Cough Chronic	Phlegm Frequently	Chronic Phlegm	Wheezing	Breathless ness	Running Nose	Throat irritation	Asthma
Years									

(Signature of Worker)