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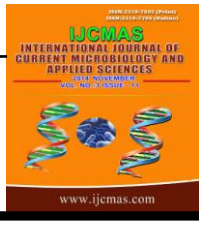

Original Research Article

Assessment of dust level in working environment and study of impact of dust on health of workers in steel industry

S.B.Parameswarappa* and J.Narayana

Department of Environmental Science, Kuvempu University, Shankaraghatta, Shimoga Dist, Karnataka, India
**Corresponding author*

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Respirable particulate matter, Total suspended particulate matter, Spirometry, Respiratory disorders, Dust respirator

A B S T R A C T

The impact of dust on workers' health in the steel industry has been examined in the present study. The main objectives of the present study were to assess the dust level in the various sections of the plant and to examine the effect of dust on lung functions of employees. The dust level in the working area was measured at 10 sections and dust level was found in the range of 4.1 mg/m^3–6.4 mg/m^3 at energy optimizing furnace, continuous casting machine, ladle refining furnace and ore yard which is more than permissible limit i.e. 4 mg/m^3. This indicates workers in these departments are at high risk of respiratory disorders. The dust level in general environment was found 1.9 mg/m^3. This is within the permissible limit. Out of 560 employees exposed to dust hazard, 337 employees were subjected to spirometry test. Workers were interviewed and information regarding respiratory problems was collected through questionnaire. About 25% of workers have reported respiratory symptoms such as cough, phlegm, breathlessness, throat irritation, asthma, wheezing, etc. During filed study workers were found not using dust guard to protect them from dust hazard. Spirometry test results indicate that 38.73 % of employees of experiment group (exposed to dust) have mild to severe respiratory problems, where as it is 23.52% in control group employees. This study reveals that there is significant association between dust exposure at workplace and respiratory disorders among employees (X^2 = 6.64, P < 0.05). This study indicates the dust level in the working atmosphere of many departments is high and workers are at high risk of respiratory problems.

Introduction

Emissions of fumes and particulates are a major potential health problem for employees working in steel plant. Sources of dust generation are many. Raw material processing units involving crushing, screening, conveying and other production operations such as charging and tapping of furnace, sintering process, handling of molten metal, grinding operations, etc., are potential sources of dust and fumes in steel plant affecting health of workers.

There is evidence that exposure to irritant dust and fumes may make steel workers more susceptible to reversible narrowing of air ways (Asthma) which overtime may become permanent (Johnson *et al.,* 1985). Exposure to silica with resultant silicosis is quite common among workers in such jobs as furnace lining, ladle bricks breaking, etc. Asbestos once used extensively for thermal and noise insulation in steel plant can cause respiratory disorders. A recent cross sectional study found pleural pathology in 20 out 900 steel workers (2%) much of which was diagnosed as restrictive lung disease characteristic of asbestosis (Kronenberg *et al.,* 1991).

Emissions generated in steel making may contain heavy metals (lead, chromium, nickel and manganese) in the form of fumes and particulates and these vaporized metals may cause "metal fume fever" which is characterized by fever, chills, nausea, respiratory difficulties and fatigue (ILO report).

In steel plant, the raw materials (iron ore, coal, lime stone, coke) processing activities such as crushing, screening, conveying, etc., are being carried out extensively. Research study shows that inhalation of iron compounds causes siderosis (WR Parks 1994). There are epidemiological and experimental indications that workers are exposed to coal dust have high risk of black pneumoconiosis (Black lung).

Dust consists of tiny solid particles carried by air currents. A wide range of particle size is produced during various processes in steel industry. Particles that are too large to remain air borne settle while others remain in the air indefinitely. Total dust includes all air borne particles regardless of their size and composition. Respirable dust refers to those dust particles that are small enough (less than 10 μ) to penetrate the nose and upper respiratory system and deep into the lungs.

The present study, which was carried out in an integrated steel plant in south India is an attempt to study dust problems and their effect on lung functions among steel workers. The main objectives of this study as follows:

a. To assess dust level in the working atmosphere in various sections of manufacturing units and in general environment and to know whether dust level is exceeds the permissible exposure limit.
b. To study the impact of dust inhalation on lung functions of employees exposed to dust hazard.
c. To recommend control measures to combat dust hazard in the steel industry.

Materials and Methods

Study design: case control study

Walk through survey: A walk through survey was carried out in the plant to understand the process and main source of dust emissions. Thereafter monitoring locations were identified. Air monitoring was carried out during plant in full operation condition. Samples were collected from each working area.

A self-designed questionnaire was given to workers and collected information such as age, weight, smoking habits, drinking habits, the amount of work exposure and the diseases they are suffering from, etc. Around 337 workers were personally interviewed from different sections of an industry like blast furnace, energy optimizing furnace,

continuous casting machine, ladle refining furnace, power plant, ore yard and from administration group.

The information regarding respiratory symptoms suffered by employees such as cough, phlegm, wheezing, breathlessness, throat irritation, running nose, and asthma were collected through questionnaire and interview.

Age composition of workers participated in the study

Table 1 shows the age composition of the subjects participated in the study. Among 337 workers participated in the study 46 were contract employees and 8 were women employees. Out of 337 participants 235 employees were working in manufacturing units exposed to dust and 102 employees were selected from administration, stores, finance, medical, etc., as control group who visit manufacturing sections intermittently. The participants are from all age group, but the maximum number of workers was in the age group of 41–50 years i.e. 59.94%.

Measurement of dust level in working environment

The sections covered for monitoring dust were blast furnace, energy optimizing furnace, continuous casting machine, ladle refining furnace, ore yard, power plant (production units) and administration section. The administration section was included as a reference control area, since it is located away from other production units but situated within the factory premises.

The total suspended particulate matter (TSPM) and respirable particulate matter (RPM) were evaluated by using dust sampling equipments Envirotech APM -400 DL and Envirotech APM-550. The sampling was done for 24 hours from 6:00 AM to 6:00 AM of next day. The sample instrument was placed at breathing level. Multi pore filter was used with a pore size of 0.8µm and pre weight was recorded. At the end of sampling, filter paper was taken out and weighed. Final calculations were made.

Spirometry test: To know the impact of dust inhalation on function of lungs, spirometry test was conducted for employees exposed to dust. Spirometry is a powerful tool that can be used to detect the problems in the lung functions. Spirometry measures the rate at which the lung changes volume during forced breathing manoeuvres.

Spirometry measurements were made by using a portable computerized spirometer (makeBPL-ARPEMIN – PC based) designed for pulmonary function measurements. The device measures actual respiratory flow in addition to predicted values according to age, sex, height, weight as follows:-

- Forced vital capacity (FVC %)
- Forced expiratory volume at the first second (FEVI %)
- Forced expiratory ratio (FEVI/FVC %)
- Forced expiratory flow during 25–75% of FVC (FEF 25–75%)

Based on above results, the respiratory disorders were classified as mild, moderate, severe restrictive/obstructive.

Statistical analysis: Data from completed questionnaire and field results were entered in Microsoft excel spread sheets and analyzed with the help of MINITAB statistical software package. Mean of values was determined and Chi square test was done for statistical analysis. Frequency distribution tables and percentage were used to summarize study data in tabular formats.

Results and Discussion

Particulate Monitoring: Total suspended particulate matter (SPM) and respirable particulate matter (RPM) were evaluated by using dust sampling equipment envirotech APM-400 DL and envirotech APM-550. The results are given below:

The distribution of mean suspended particulate matter and respirable particulate concentration in the working atmosphere of various areas are given in Table 1. The average SPM in the air at some work places such as MBF-3, MBF-2, RMS-1, VD boiler and power plant was found in the range of 1.9 mg/m^3–3.6 mg/m^3. This is within the permissible limit (4 mg/m^3) prescribed by central pollution control board (CPCB). Whereas the dust level was found in the range of 4.5 mg/m^3–6.4 mg/m^3 at work places in various sections such as continuous casting machine, ladle refining furnace, energy optimizing furnace and ore yard.

The highest dust level i.e. 6.4 mg/m^3 were found at Ladle refining furnace (LRF-1). It is found that the dust level in the above production units/sections was very high and exceeded the permissible dust level of 4 mg/m^3. This indicates that the workers are at high risk of respiratory and other health disorders. The dust concentration in general environment was found 1.9 mg/m^3 which are very minimal. These results are presented in graphical bar chart in Figure 1.

Spirometry test results

To know the impact of dust on respiratory problems the employees exposed to dust were subjected to spirometry test and test reports of pulmonary function were examined and results are tabulated and given in Table 2.

The results obtained from pulmonary function test were classified as normal, mild obstructive, mild restrictive, moderate and severe respiratory problems. These tests were done both for experimental group and control group. It can be seen that number of employees working in production units exposed to dust (experiment group) have respiratory problems more than the number of employees in control group who were exposed to dust hazard intermittently.

It is found from the above table that 38.73 % of employees of experiment group exposed to dust have mild to severe respiratory problems, where as it is 23.52% in control group employees ($X^2 = 6.64$, $P < 0.05$). The results indicate that employees who were exposed to dust have high risk of respiratory diseases when compared to employees not exposed to dust continuously.

Even though dust concentration in working environment at Administration offices is less i.e. 1.9 mg/m^3, the respiratory disorders were found in 23.52% of employees in control group. This may be due to sedentary jobs, obesity, Poor physical exercises and personal habits such as smoking, alcohol consumption, etc.

Respiratory symptoms

The information collected from employees reveals that about 25% employees exposed to dust hazard were found to have respiratory problems such as cough (23.2%), phlegm (18.3%), wheezing (15.6%), breathlessness (13.2%), running nose (26.1%), throat irritation (22.2%), asthma (8.3%), etc. Among employees who were suffering from above respiratory symptoms, 80% of them were from production units.

Table.1 Mean particulate concentration according to different sections

Sl.No.	Section	SPM(mg/m^3) Avg.	RSPM(mg/m^3) Avg.	Proportion of RPM in TSPM (%)
01	MBF-2	2.8	1.9	67.85%
02	MBF-3	1.9	1.3	68.42%
03	RMS-1	3.6	2.2.	61.11%
04	EOF	5.6	3.7	66.07%
05	LRF-1	6.4	3.8	59.37 %
06	LRF-2	6.1	4.9	80.32%
07	CCM	4.5	4.0	88.88%
08	Power plant	2.0	1.1	55.0 %
09	VD Boiler	2.5	1.5	60.0%
09	Ore yard	4.5	2.9	64.44%
10	General environment	1.9	1.7	89.47%

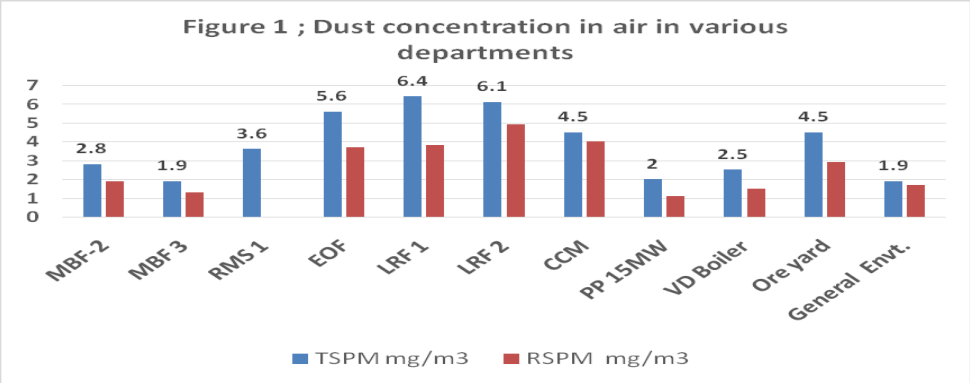

Figure.2 Respiratory symptoms of employees exposed to dust

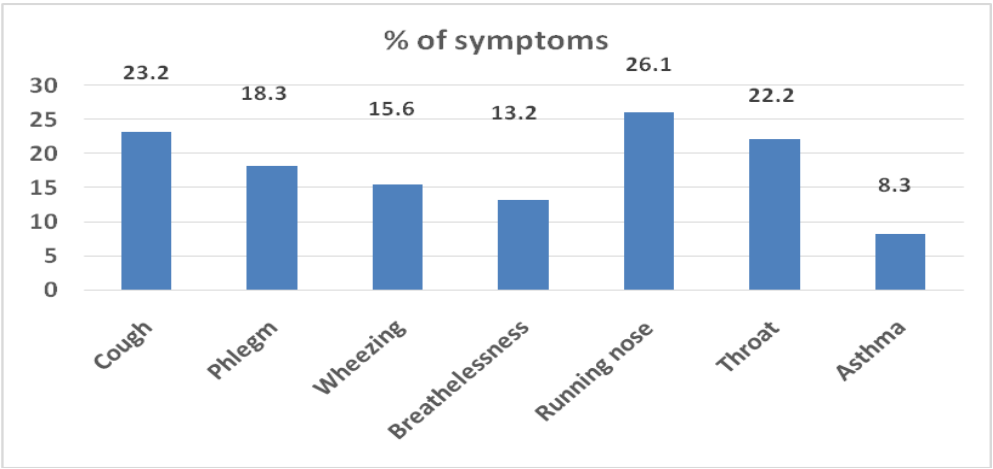

Table.2 Pulmonary function test results (PFT) (Age wise)

	Experiment group					**Control group**					
Age	**Normal**	**Mild obst.**	**Mild rest.**	**Moderate rest.**	**Severe Rest.**	**Normal**	**Mild obst.**	**Mild rest.**	**Moderate**	**Severe**	Total
20-30	16	06	01	01	0	08	02	01	00	00	33
31-40	16	02	10	02	0	17	04	03	00	00	53
41-50	99	14	29	07	03	34	05	05	02	00	202
51-60	13	03	09	03	01	19	00	02	00	00	49
Total	**144**	**25**	**49**	**13**	**04**	**78**	**11**	**11**	**02**	**00**	**337**

Usage of PPE's

Use of PPE's such as dust guards/respirator is very essential to prevent entry of dust into body. But it was found during field study that majority of workers were unaware of benefits of using PPE's. Only 25% of workers were found using dust respirator/guard at workplace. There was no strict enforcement of usage of personal protective equipment in general and use of dust respirator in particular. Therefore the risk of respiratory disorders is quite obvious.

Smoking and alcohol drinking habit

During interview with employees, about 28% of workers admitted that they smoke cigarettes and biddies and about 38 % workers reported that they were habitual tobacco consumers. About 21% of workers were habit of chewing gutka and jardha. It was learnt that 33% of workers consume alcoholic drinks every day. It is well established that, the habits such as smoking, tobacco consumption will have adverse effect on health and will aggravate the respiratory and other health disorders. Hence there is a need to create awareness among employees regarding adverse effect of smoking and tobacco consumption and to educate employees on benefits of physical exercise and good life style.

The following conclusion and recommendations described for this study that includes, Dust in the working atmosphere at many places like Energy optimizing furnace, ladle refining furnace 1&2, Continuous casting machine & ore handling area was found in the range of 4.5 mg/m3 to 6.4 mg/m3. This is more than permissible limit (4 mg/m3). Workers in these departments are exposed to high level of dust having risk of respiratory disorders. Excessive or long term exposure to harmful respirable dust may result in respiratory disease called pneumoconiosis. This disease is caused by buildup of dust particles in the lungs and the tissue reactions to their presence.

Pulmonary function test reports reveal that nearly 38% of employees working in production units are suffering from mild to moderate respiratory problems. Workers exposed to dust were found to have cough, throat irritation, wheezing, Breathlessness & other respiratory problems. This study indicate that there is a significant dust hazard at many work places in the plant.

Dust generation in iron & steel industry is inevitable, but the effective dust control measures would minimize workers' risk to dust. A properly designed bulk material handling with dust extraction system will definitely reduce dust generation, emission & dispersion. In addition to dust extraction & collection system, the wet dust suppression system greatly helps in minimizing dust dispersion in the working atmosphere. Isolation of workers from dust generation points by providing control rooms with fresh

air supply facility is necessary to prevent workers' exposure to dust.

Workers especially crane drivers & other operators working near furnaces & raw material handling plant were found not using dust respirator even though they were exposed high level of dust & fumes. Usage of dust respirator should be made mandatory where dust level is more than permissible limit.

Nearly 25% of employees have the habits of smoking, chewing tobacco & alcohol consumption. These habits will aggravate the respiratory & other health related disorders. Hence health awareness programme is very essential to develop good habits & life style and to promote good nutrition & physical exercises among employees to promote safety & health among workers in steel plant.

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