Assessment of Air Pollution and its Effects on Health of Workers of Steel Re-Rolling Mills in Hyderabad

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ABSTRACT

The SRRMs (Steel Re-Rolling Mills) are being releasing air pollutants in the environment. In order to evaluate their effect on the health of the workers, health and safety issues were analyzed by first measuring the concentrations of SO_x (OIxides of Sulphur), NO_x (Oxides of Nitrogen), CO (Carbon Monoxide) and O_2 (Oxygen) produced in the three SRRMs located in SITE area Hyderabad. The mean concentration of SO_x, NO_x and CO were in the order of 0.35, 0.280, 6.333 ppm, respectively, whereas the mean concentration of O_2 was 203.53 thousand ppm. As per results, the concentration of air pollutants, including SO_x and NO_x were significantly higher than to the NEQS (National Environmental Quality Standards) and NAAQS (National Ambient Air Quality Standards). The concentration of CO was lower than to the NAAQS, but higher than to the NEQs, while the concentration of O_2 was slightly lower than to the standard value. The workers who were exposed to these air pollutants are being suffering from chronic diseases related to breathing and allergies. Moreover, labour staff was lifting heavy loads manually, which causes them to muscular and joint problems. In all the SRRMs under study, the electrical and mechanical equipments were used without any safety. The MSDS were not displayed on the workstations, the housekeeping was inadequate and most of the workers were performing their jobs without personal protective equipment. In addition to these, the other serious issues related to the occupational health and safety were an unhygienic supply of water, higher noise level, placement of explosive cylinders in the open atmosphere and unavailability of the first aid facilities in the Mill premises.

Key Words: Steel Re-Rolling Mills, Air Pollution, Health Impacts, Occupational Health and Safety.

1. INTRODUCTION

Globally, about 54% of the world's population living in urban areas [1]. Speedy industrialization and urbanization are the major cause of increase in environmental pollution [2].Steel is the principal constituent of development and its use ranges from the ordinary household to the complex construction and defense equipment [3]. Steel is an alloy of iron and carbon. Raw steel is available in large size blooms and billets, which are being further brought into different shapes and sizes by using hot rolling processes. The hot rolling processes are carried out in SRRMs. The standard procedure of the steel re-rolling is illustrated in

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Fig. 1. The procedure starts with the desired shape steel ingot as a raw material, followed by cutting ingots in sharing machine, heating of ingot pieces to about 1000-1200°C in the furnaces, sizes reduction of heated ingot pieces in different types of rolling mills, cooling of reduces size products through quenching and finally after inspection, the finished products are being either bended or folded and stored in the dispatch yard of the mill.

The SRRMs have significant adverse impacts on the biotic and abiotic environment [4]. SOx, NOx and CO are major air pollutants [5]. When the concentration of these pollutants increases beyond a certain level, the resultant effects may cause human health problems especially the breathing problems that may even lead to death [6-7]. The workers of SRRMs are also exposed to chemical hazards including vapors and fumes, physical hazards like noise, vibration, temperature, and the heavy load of occupational injuries [8]. Since 1995, Pakistan is a TWO (World Trade Organization) member. In order to review and update the existing laws, the Government of Pakistan in 2001 announces a Labor Policy Initiative and proposed to develop a NOSHC (National Occupational Safety and Health Council). However, nothing has been come true [9].Most of the industries are yet to invest in facilities for improving the production and are reluctant to install pollution controlling devices [10].

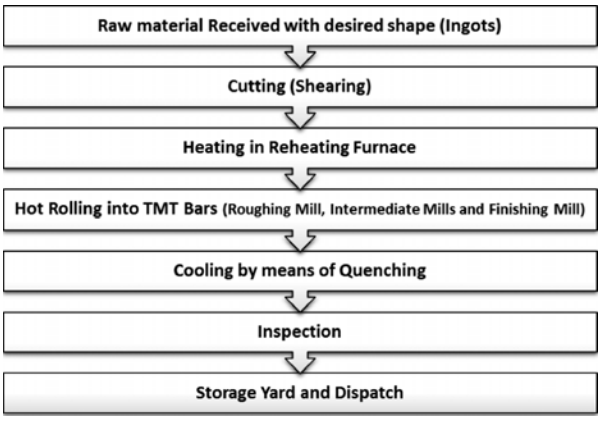

FIG. 1. STANDARD PROCEDURE OF STEEL RE-ROLLING

In order to overcome environmental pollution, worldwide all the new projects are required to pass through the procedures of IEE (Initial Environmental Examination) or EIA (Environmental Impact Assessment) [11].Pakistan had also implemented the IEE/EIA legislation since 2000 [12]. As per Pakistan Environmental Protection Act, a complete EIA study is required to construct and install any kind of Steel Mill. Moreover, all the industries are required to control the environmental pollution as per Pakistan NEQS and NAAQS. Emissions from stacks, effluent discharge and open burning of waste are common practices within the industries [13]. On the other hand, the work related injuries can be costly to employers due to loss of life or permanent disability [14]. OH&S (Occupational Health and Safety) and ergonomics applications therefore work together to satisfy the needs of changing local people's behaviors, habitual work methods and/or traditional ways of doing things [15].

Keeping in view the above facts, the present study was conducted to assess the quality of the air at workstations of three SRRMs located in SITE area Hyderabad Sindh and to weigh the worker's health and Safety issues.

2. METHODOLOGY

2.1 Measurement of Air Quality Parameters

In the present study, air quality parameters including the SO_x, NO_x, CO and O_2 were measured at the work place of the SRRMs. The concentrations of emissions of SO_x and NO_x were measured using the portable detection instruments Drager (Pac-III, Standard) as per standard procedure [16-17]. For the concentrations of CO and O_2, Multi Gas Detector named Gas Alert Microclip-XT was used as per procedure stated by David and Ismail [18]. All the instruments contained the sensing electrode, which is based on a porous Au-solid polymer electrolyte and was in direct contact with the atmospheric gaseous stream [19-20]. Moreover, the measuring range of range instruments for the SO_x, NO_x and

CO were in the order of 0-100, 0-50 and 0-1000 ppm, respectively. All the measurements were done on the hourly basis for 11 hours a day starting from 0800-1800 PST (Pakistan Standard Time). In the present study, the concentration of the air quality parameters in each of the selected SRRMs was measured for a month. The data obtained from the instruments was recorded and the average values of the concentration of the SO_x, NO_x, CO and O_2 were determined by the weighted average method. In addition to the weighted average method, concentrations of the SO_x, NO_x, CO and O_2 were also statistically analyzed for Median, Standard Deviation, Skewness, Kurtosis, Minimum and Maximum values. All the statistical analysis was done by using the Statistical Data Analysis Pack of MS Excel 2013 and the quality of the air was compared with NEQS and NAAQS standards.

2.2 Assessing Health and Safety Issues of Workers

The impact of air pollution on the health of the workers of SRRMs was investigated through the data obtained from the questionnaire, which was based on the questionnaire designed by Malik and Cheema [8]. The questionnaire was specifically designed to collect the data of the workers, which are either exposed or not exposed to the air pollution generated during the steel re-rolling process. The exposed worker means the labour staff, whereas the non-exposed workers means the managerial staff. Out of the five working SRRMs in the SITE area Hyderabad three mills, namely Al-Islam, Basharat and Mehran were selected for the study.

Moreover, in order to know the existing environmental conditions in the selected SRRMs, a walk through survey was conducted for OH&S issues. The OH&S issues include the use of PPEs (Personal Protective Equipment), first aid facilities and fire extinguishers, the MSDS (Material Safety Data Sheet), safety guards and devices of electrical and mechanical equipment, cooling fans, emergency exits [9]. Finally, the information collected was analyzed and then compared with OHSAS (Occupational Health and Safety Assessment Series of Standards). The OHSAS 18001:2007 is the sets out the necessary requirements for an OH&S management system.

3. RESULTS AND DISCUSSION

3.1 Air Quality at Workstations

3.1.1 Concentration of the SO_x

The concentration of SO_x at the selected SRRMs along with standard values of NEQS and NAAQS is shown in Fig. 2, whereas it's statistical analysis is given in the Table 1. The concentration of the SO_x was in the range of 0.21-0.43 ppm. The mean concentration of the SO_x in Al-Islam, Basharat and Mehran re-rolling steel mills were in the order of 0.343 ± 0.063, 0.337 ± 0.064,0.307 ± 0.056 ppm, respectively. The maximum allowable concentration of the SO_x is only 0.042 ppm/hour (NAAQS). But, unfortunately the hourly concentration at all the selected SRRMs were greater than to the maximum allowable concentration of eight hours, i.e. 0.06 ppm (NEQS). The emissions of the SO_x are violating the NEQS, but are very low as reported by Chaudhary and Atimtay [21]. The Higher concentration of SO_x is a respiratory irritant and results in the formation of acid aerosol, which can cause asthma [22-25]. The formation of SO_x emissions were mostly because of the combustion of coal, used in the furnaces for heating the steel billets. Occasionally, the combustion of the used Tyres contributes in to the formation of the SO_x.

All the values of Skewness were negative, which shows that the concentration of the SO_x at different hours a day have an asymmetric tail and extending towards negative values. All the values of Kurtosis were negative, which shows that the concentration of the SO_x at the different hour a day have relatively flat distribution. The concentration of the SO_x at 1300 PST was minimum in all the selected SRRMs because of the lunch break, whereas the higher concentration of the SO_x was observed at the furnace startup at 0800 PST and furnace re-startup at 1400 PST.

3.1.2 Concentration of NO_x

The concentration of NO_x at the selected steel re-rolling mills along with the standard values of NEQS and NAAQS is shown in Fig. 3, whereas it's statistical analysis is given in Table 2. The concentration of NO_x was in the range of 0.22-0.39 ppm. The mean concentration of NO_x in Al-Islam, Basharat and Mehran re-rolling steel mills were in the order of 0.278±0.043, 0.273±0.029, 0.288±0.048ppm, respectively. The maximum allowable concentration of NO_x is only 0.042 ppm/hour (NAAQS). But, unfortunately the hourly concentration at all the selected SRRMs were greater than to the maximum allowable concentration of eight hours, i.e. 0.1 ppm (NEQS). The emissions of NO_x are exceeding the NEQS and NAAQS and are also higher as reported by Chaudhary and Atimtay [21]. The development of NO_x emissions were due to the reaction of nitrogen with oxygen at higher temperatures during the combustion of fuel in the furnaces. The temperature in the furnaces of the selected SRRMs were range in the range of 1100-1400°C, whereas the lower limit of the hot rolling mills is about 1090°C [26]. Thus, keeping the higher temperature in the furnaces was the main reason for the higher concentration of NO_x in the selected SRRMs.

The higher concentration of NO_x was observed at the lunch break time at 1300 and at 1800 PST, because of the shutdown of the furnaces. All the values of Skewness were positive, which shows that the concentration of NO_x at different hours a day have an asymmetric tail and extending towards positive values. The values of Kurtosis for Al-Islam and Basharat mills were negative, which shows that the concentration of NO_x at the different hour a day have relatively flat distribution. The Kurtosis for the Mehran mill was positive, which shows that the concentration of NO_x at the different hour a day have

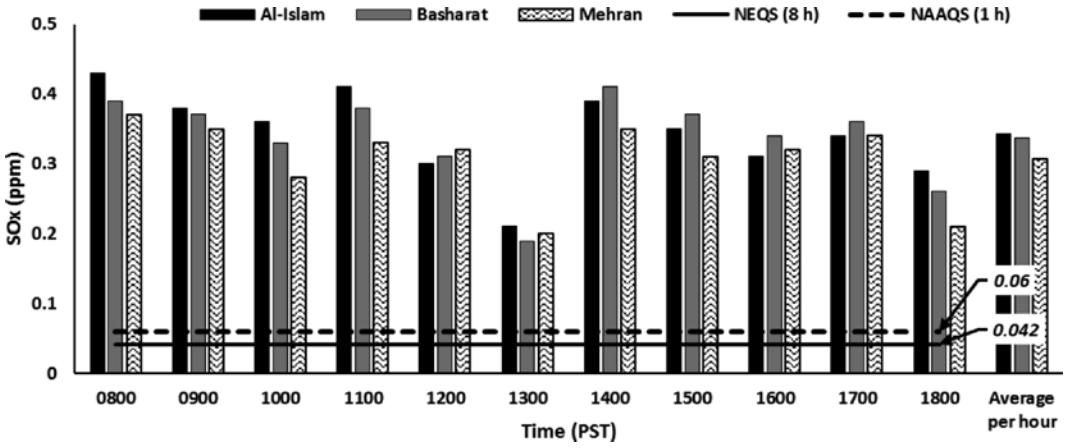

FIG. 2. CONCENTRATION OF SO_x AT THE SELECTED SRRMS ALONG WITH STANDARD VALUES OF THE NEQS AND NAAQS

TABLE 1. STATISTICAL ANALYSIS OF THE CONCENTRATION OF THE SO_x IN THE DIFFERENT SRRMs

Statistical Analysis (ppm)	Name of Steel Re-Rolling Mill		
	Al-Islam	Basharat	Mehran
Mean	0.343	0.337	0.307
Standard Deviation	0.063	0.064	0.056
Kurtosis	0.648	1.807	0.463
Skewness	-0.724	-1.389	-1.206
Minimum	0.210	0.190	0.200
Maximum	0.430	0.410	0.370

relatively peaked distribution. Moreover, the higher concentration of NO_x may cause respiratory infection, wheezing, nose and throat irritation and allergy [27-29].

3.1.3 Concentration of CO

The concentration of CO at selected steel re-rolling mills along with the standard values of NEQS and NAAQS is shown in Fig. 4, whereas it's statistical analysis is given in Table 3. The concentration of the CO was in the range of 6.150-6.490 ppm. The mean concentration of the CO in Al-Islam, Basharat and Mehran re-rolling steel mills were in the order of 6.305±0.100, 6.328±0.144, 6.365±0.091ppm, respectively. The maximum allowable concentration of the CO is only 9.0 ppm/hour (NAAQS). The concentration of the CO on the hourly basis at all the selected SRRMs were lesser than to the maximum allowable concentration. The development of CO emissions were due to the incomplete combustion of the fuel burnt in the furnaces. The lesser formation of CO during the combustion of fuel in the heating furnaces of the SRRMs shows almost the complete combustion.

The concentration of the CO was almost constant in all the three selected SRRMs throughout a day, which shows almost stable combustion in the furnaces. All the values of Skewness were negative, which shows that the concentration of the CO at different hours a day have an asymmetric tail and extending towards negative values. The values of Kurtosis for Al-Islam and Mehran mills were negative, which shows that the concentration of CO at the different hour a day have relatively flat distribution. The Kurtosis for the Basharat mill was positive, which shows that the concentration of CO at the different hour a day have relatively peaked distribution.

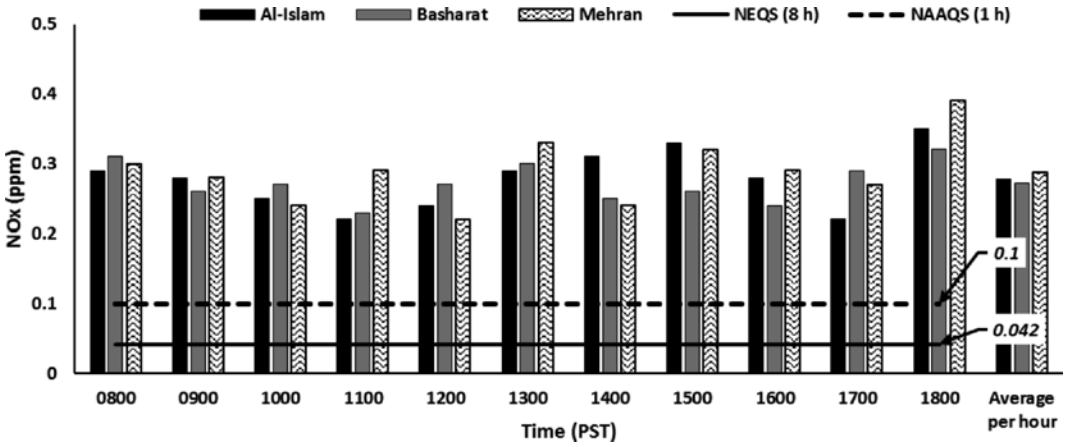

FIG. 3. CONCENTRATION OF NO_X AT THE SELECTED SRRMS ALONG WITH STANDARD VALUES OF THE NEQS AND NAAQS

TABLE 2. STATISTICAL ANALYSIS OF THE CONCENTRATION OF NO_x IN THE DIFFERENT SRRMs

Statistical Analysis (ppm)	Name of Steel Re-Rolling Mill		
	Al-Islam	Basharat	Mehran
Mean	0.278	0.273	0.288
Standard Deviation	0.043	0.029	0.048
Kurtosis	-0.802	-0.968	0.842
Skewness	0.115	0.270	0.683
Minimum	0.220	0.230	0.220
Maximum	0.350	0.320	0.390

3.1.4 Concentration of O_2

The concentration of O_2 at the selected steel re-rolling mills along with the standard values of NEQS is shown in Fig. 5, whereas the statistical analysis is given in Table 4. The concentration of O_2 were in the range of 201.1-206.8 thousand ppm. The mean concentration of O_2 in Al-Islam, Basharat and Mehran re-rolling steel mills were in the order of 204.2±1.744, 203.5±1.546, 202.9±1.809thousand ppm, respectively. The recommended concentration of O_2 is 209.5thousand ppm per hour. But, unfortunately the hourly concentration at all the selected SRRMs was less than to the recommended.

The higher concentration of O_2 was observed at the lunch break time at 1300 and at 1800 PST, because of the shutdown of the furnaces. All the values of Skewness were positive, which shows that the concentration of O_2 at different hours a day have an asymmetric tail and extending towards positive values. All the values of Kurtosis were also positive, which shows that the concentration of O_2 at the different hour a day have relatively peaked distribution.

3.2 Health Status of Workers

The total number of workers in all the three selected SRRMs were 168, out of those the interview through the questionnaire was conducted for 120 workers, which is more than 70% to the total workers. Out of 120 interviewed workers, 96 were the labour staff, whereas the rest of 24 workers were managerial staff category. The effects on the health of the Managerial Staff at selected SRRMs is shown in Fig. 6. As per the result of the data analysis, about 80% of the Managerial Staff were not suffering from any kind of diseases,

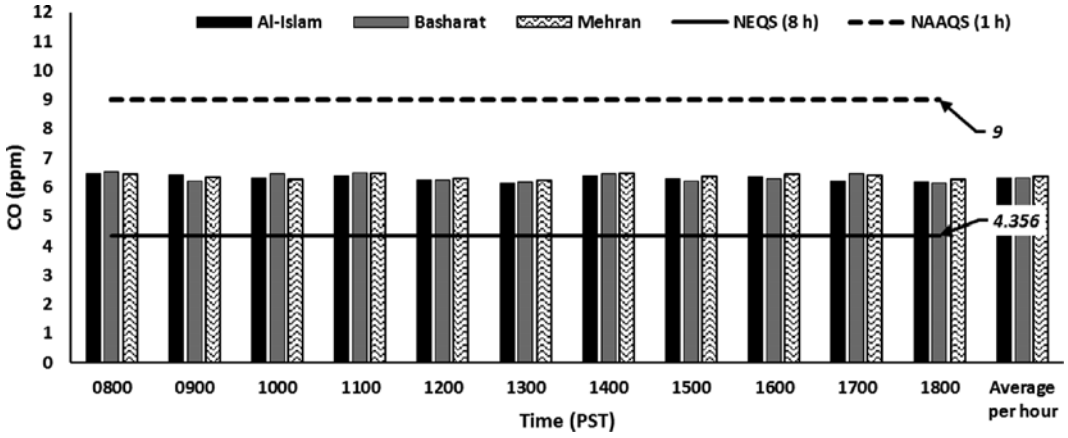

FIG. 4. CONCENTRATION OF CO AT SELECTED SRRMS ALONG WITH STANDARD VALUES OF NEQS AND NAAQS

TABLE 3. STATISTICAL ANALYSIS OF THE CONCENTRATION OF CO IN DIFFERENT SRRMs

Statistical Analysis (ppm)	Name of Steel Re-Rolling Mill		
	Al-Islam	Basharat	Mehran
Mean	6.305	6.328	6.365
Standard Deviation	0.100	0.144	0.091
Kurtosis	-1.155	-2.012	-1.492
Skewness	-0.111	0.087	-0.077
Minimum	6.150	6.140	6.230
Maximum	6.460	6.520	6.490

whereas the rest of 14% were blood pressure patients and 6% were diabetic patients. According to Liu, et. al. [30], the higher concentrations of SO_2 and NO_2 is associated with an increase in pulse rate and blood pressure to the people, which are residing near the steel plant.

The effects on the health of the Labour Staff at selected SRRMs is shown in Fig. 7. As per the result of the data analysis, about 31% of the Labour Staff were not suffering from any kind of diseases, whereas the rest of 69% were suffering from various health problems. The most important health problem faced by the Labour Staff was muscular and joint problems, which comprises to about 28%. The reason of the pain in muscles and joints is because of the manual handling of the heavy steel pre-rolled and post-rolled bars. During the manual handling of the heavy loads, workers were also facing the problem of higher sweetening. Pain in the neck, shoulders and back were also included in muscular and joint type problems [31].

The second important health problems to the Labour Staff was related to the breathing including tuberculosis (TB), cough and asthma, which collectively contributes to 24%,

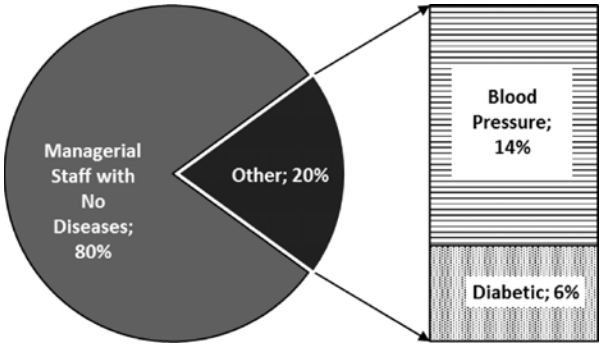

FIG. 6. HEALTH EFFECTS ON THE MANAGERIAL STAFF AT SELECTED SRRMS

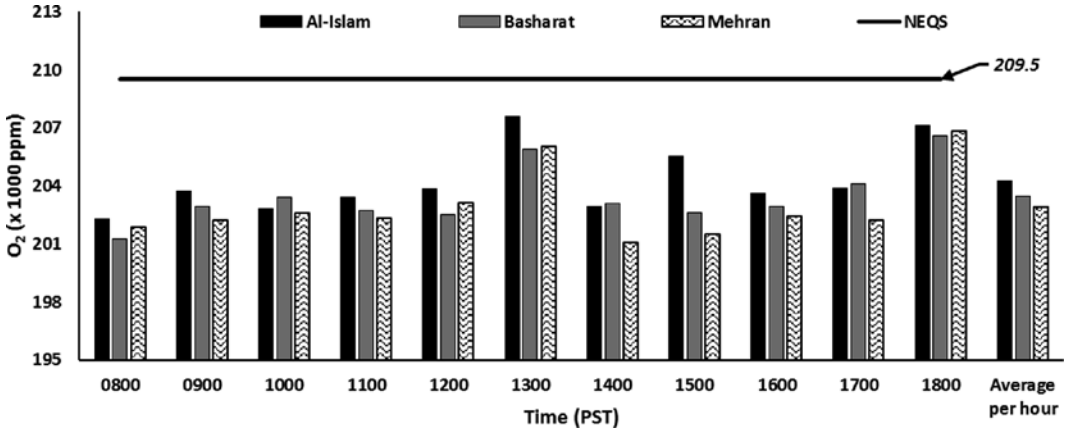

FIG. 5. CONCENTRATION OF O_2 AT THE SELECTED SRRMS ALONG WITH STANDARD NEQS VALUE

TABLE 4. STATISTICAL ANALYSIS OF THE CONCENTRATION OF O_2 IN THE DIFFERENT SRRMs

Statistical Analysis (ppm)	Name of Steel Re-Rolling Mill		
	Al-Islam	Basharat	Mehran
Mean	204.2	203.5	202.9
Standard Deviation	1.744	1.546	1.809
Kurtosis	0.198	0.886	1.548
Skewness	1.149	1.116	1.583
Minimum	202.3	201.3	201.1
Maximum	207.6	206.6	206.8

whereas the allergies in eye, throat, nose were accounts about 8%. In comparison to the Managerial Staff, the Labour Staff are being suffering from severe kind of diseases, which are related to air pollution. This deduce that health of employees is effected by air pollution. On the contrary the employees, which are mostly not exposed to air pollution, were healthy. This outcome is in correspondence with the findings of Rafiei, et. al. [5]. The other health problems account 9% and include Hepatitis B and C, decreases in exercise performance and neuropsychological. The breathing and other problems were because of the smoke containing the higher concentration of SO_x and NO_x. All the selected SRRMs were in operation for ten hours a day, including nine working hours and one hour lunch break. It was also observed that the workers were taking their lunch at the workstations and due to this they were not only exposed to the air pollutants during the working, but also exposed at the lunch time. Epidemiological studies are also in evidence of heart, respiratory and lung diseases by human exposure to SO_2 and NO_2 [32-34]. Moreover, the higher level of noise at the size reduction sub-process of steel re-rolling was also the cause of neuropsychological problems. These results are in correspondence with the results of Malik and Cheema [8].

3.3 Issues of Occupational Health and Safety

The mill workers are being working ten hours a day and are exposed to the polluted environment. The majority of workers have either primary education or were illiterate. Most of the workers were unaware of health and safety procedures, which is in correspondence to the observations of the Gardner, et. al. [35]. The selected SRRMs does not have any training program related to the health of the workers and safety of the person or machine. Thus, a number of occupational health and safety issues were observed.

The workstations were poorly designed and required obdurate and repetitive stances, which was the foremost reason of musculoskeletal disorders. Most of the workers were performing their jobs without PPEs, even those who were dealing with very hot objects or lifting heavy loads. Though a few accidents were recorded since the commissioning of the selected SRRMs, but first aid facilities were not available. On any recurrence of an accident, workers were leaded to the nearby hospital. The MSDS were not displayed on the workstations and thus, the workers were unaware of health and safety risk associated with them. Electrical objects like cables, plugs, and mechanical equipment like fans, rollers were running without safety protectors. Besides, hot areas were not insulated. The use of the mechanical equipment for the lifting the loads were only restricted to raw billets, whereas the rest of the heavy loads were lifted/ shifted manually. Somewhat similar results were obtained by Amjad, et. al. [9].

A number of physical hazards were observed in selected SRRMs. The selected SRRMs does not have fire alarm, firefighting backup water supply or even the emergency exits. Regarding the housekeeping, the conditions of the mills were not adequate. Oxygen and acetylene gas cylinders

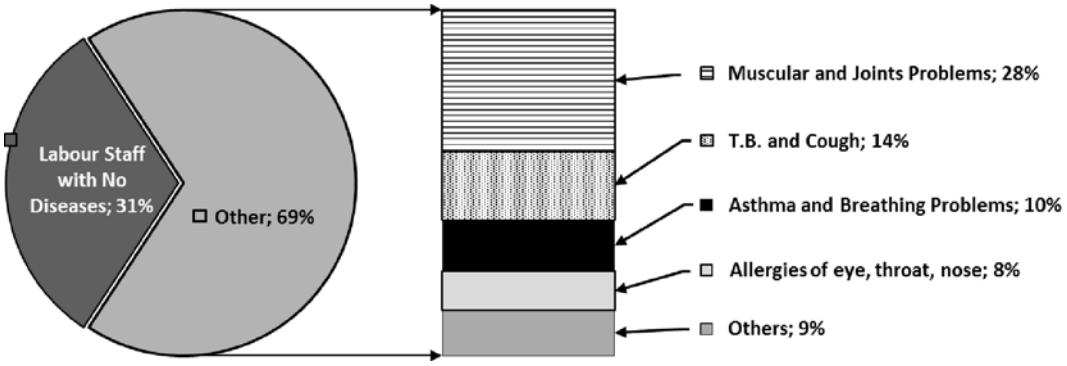

FIG. 7. HEALTH EFFECTS ON THE LABOUR STAFF AT SELECTED SRRMS

were exposed to the sunlight, whereas scrap metallic pieces were also spread on the working area. Though the cold water was available, but it was served in unhygienic used lubricating oil bottles and muddy glasses. Moreover, the condition of the toilets were very poor. The noise level at the workstations, especially at the size reduction unit were very high.

4. CONCLUSION

In the selected SRRMs, the concentration of air pollutants including SO_x and NO_x were significantly higher than to the NEQS and NAAQS. The workers who were exposed to these air pollutants are being suffering from chronic diseases related to breathing and allergies. Moreover, labour staff was also involved in the raising heavy loads manually, which causes them to a muscular and joint problems. In all the SRRMs under study, the electrical and mechanical equipments were used without any safety. The MSDS were not displayed on the workstations, the housekeeping was inadequate and most of the workers were performing their jobs without PPEs. In addition to these, the other serious issues related to the OH&S were unhygienic supply of water, higher noise level, placement of explosive cylinders in the open atmosphere and unavailability of the first aid facilities in the Mill premises. The health and safety of the workers at the selected SRRMs can be upgraded by improving the workstation's environment, an intermittent medical checkup of workers and installing the induced draft fans in the stakes, followed by air pollution controlling devices.

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