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Yamini Tekam
Department of Farm
Machinery and Power
Engineering, Faculty of
Agricultural Engineering,
Indira Gandhi Krishi
Vishwavidyalaya Raipur,
Chhattisgarh, India

AK Dave
Department of Farm
Machinery and Power
Engineering, Faculty of
Agricultural Engineering,
Indira Gandhi Krishi
Vishwavidyalaya Raipur,
Chhattisgarh, India

AK Shrivastava
Department of Farm
Machinery and Power
Engineering, Faculty of
Agricultural Engineering,
Indira Gandhi Krishi
Vishwavidyalaya Raipur,
Chhattisgarh, India

Purvi Tiwari
Department of Farm
Machinery and Power
Engineering, Faculty of
Agricultural Engineering,
Indira Gandhi Krishi
Vishwavidyalaya Raipur,
Chhattisgarh, India

Corresponding Author:
Department of Farm
Machinery and Power
Engineering, Faculty of
Agricultural Engineering,
Indira Gandhi Krishi
Vishwavidyalaya Raipur,
Chhattisgarh, India

Assessment of environmental parameters of workplace of selected sugar industries of Chhattisgarh

Yamini Tekam, AK Dave, AK Shrivastava and Purvi Tiwari

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Abstract

Sugar industry, based on sugarcane is a tropical plant which highly depends upon the amount of rainfall. It is an important cash crop in the country which impacts the rural livelihood. A purposive survey was conducted in sugar industries of Kabirdham district of Chhattisgarh. As the workplace is a significant source of both demands and pressures that causes stress this may also cause health hazards. This study investigates the impact of workplace environmental parameters such as illumination, noise, temperature, relative humidity, vibration, and particulate matter, on workers of sugar industries of Chhattisgarh which are directly correlated to the performance and productivity of sugar industry workers. Results of monitoring signify the role of environmental parameters, which were found significantly higher in many places of activities than the permissible limits. It also raises the concern to safety and wellbeing of workers, whom are directly responsible in block chain of productivity and turnover of the sugar industry.

Keywords: Sugar industry, workplace, environmental parameters, safety

Introduction

Sugarcane (*Saccharum officinarum*) is a tropical plant and an important cash crop in the country. India is the 2nd largest producer of sugarcane in the world next to Brazil (NITI Aayog, 2020) [19]. About 50 million sugarcane farmers and about 0.5 million workers are directly employed in sugar factories. It generates an annual output worth approximately 800 billion. There are more than 700 installed sugar factories in the country (NITI Aayog, 2020) [19]. There are several industries in Chhattisgarh that provide major impetus to the growing economy of the state consist of steel, aluminium, cement, thermal power, mining and various specialized industrial area. More over Chhattisgarh is set to create a niche for itself in the sugar production. Chhattisgarh is making every possible effort to promote the agriculture-based industries in the state to improve the economic condition of the farmers.

Chhattisgarh receives an average annual rainfall about 1400 mm which is more than national average rainfall i.e. 1193 mm. This rainfall is the only factor that drives the sugar industry in Chhattisgarh. The more amount of rainfall in, the better would be sugar production. Sugarcane is being cultivated in the area of 0.032 million ha with the production of 0.074 MT (DESCG, 2021).

Kabirdham (Formally known as Kawardha), Surguja and Balod are the major districts of Chhattisgarh where sugarcane cultivated predominantly. Kabirdham is the major sugarcane growing district of state where sugarcane was cultivated in 0.021 million ha area in the year 2019-20. The production of sugarcane in Kabirdham district reported for the same year was 1.66 MT (Deshmukh *et al.* 2021) [15].

After much advancement in sugar industries and millions of workers involved in sugar factories, it has been reported that workers are exposed to physical, chemical, and biological hazards that may lead to occupational disease which resulted from several activities involved in sugar production. The workers who indulge in sugar industries are highly associated with occupational health i.e. accidents, injury, disability and illness. Industrial safety means elimination and/or prevention of hazardous situations to the workers, the management and the whole firm. Industrial workers face a variety of occupational hazards, with particulate matter, excessive noise, vibration, and heat stress being the most frequently mentioned (Jilcha and Kitaw 2016) [15].

Sugarcane factory workers are significantly less protected than workers in other industries and face significantly higher rates of occupational exposure (ILO and WHO 2010) [13]. Environmental considerations play a significant role in a variety of industries around the world, including health institutes, textiles, mining, and micro industries, which highlight a variety of concerns and ultimately result in a decrease in system efficiency (Wong *et al.* 2010).

According to Nayakawadi (2014), workers in the sugar industry are subjected to a variety of stresses. Employees at sugar mills would develop flu-like symptoms several hours after reporting to work at the start of a new season or even after a free weekend; repeated attacks cause fine scarring of the lungs and impaired breathing. Cleanliness, light, temperature, ventilation, noise, vibration, physical energy required, length of work day, and irregularity of work hours such as night shifts, physical hazards, exposure to possible industrial stressors, and similar conditions that directly or indirectly influence the worker's happiness, satisfaction, and dissatisfaction at work are all examples of working conditions in the sugar industry.

Further, it has been observed that most of the sugar industries have poor occupational health and safety measures, inadequate policies and infrastructure to meet the health hazards.

The workers working in the sugar industry are prone to face a number of stresses which leads to severe health and economic problem (Fatima and Shahid 2017) [8].

Similarly, workers are exposed to workplace accidents, repetitive strain injury (RSI) and musculoskeletal disorders (MSDs) in neck, upper back, lower back and arms due to continuous movements in India (Pawar *et al.* 2019) [22]. The incompetent process of sugar production indicates a breakdown of substantial mechanism and energy that come out and affects the environment and workers. Prolonged exposure to very fine bagasse dust (mouldy molasses) causes respiratory and ocular disorders, skin rash, nasal and lung cancer (Le Blond *et al.* 2017) [17]. Edmund (2015) [7] reported that noise at work caused hearing loss, due to continuous exposed in noise levels above 90 dB (A).

Sen and Das (2000) [25] reported that the traditional ergonomic and safety hazards affect 20–30% of workers in developed countries and 50–70% of workers in developing countries. In India, limited work has been done for workers safety in sugar industries.

It learnt from the preliminary survey of industries located at Kabirdham district that sugarcane industries are also facing such issue from the workers side. Further, it understood that, there is no such work has been address so far in Chhattisgarh. Therefore, the present study is undertaken to address the occupational health problems of sugar industries workers of Chhattisgarh as well as to investigate the impact of workplace environmental parameters such as illumination, noise, temperature, relative humidity, vibration, and particulate matter, which are directly correlated to the performance and productivity of sugar industry workers.

Materials and Method

Selection of study area

This study was carried out during season of 2021-22 in Kabirdham district (formally Kawardha) of Chhattisgarh state in two of four cooperative sugar factories in Chhattisgarh namely: (A) Lauh Purush Sardar Vallabh Bhai

Patel Sahakari Shakkar Karkhana Maryadit, Pandariya, (B) Bhoramdeo Sahakari Shakkar Utpadak Karkhana Maryadit, Kawardha. Kabirdham district was selected on the basis of its higher production of sugarcane.

Data collection

Standard procedures were followed during gathering of information and data. The industry detail was asked by the General Manager of the sugar industry A and B. Environmental parameters were monitored during the study with the help of necessary instruments. Following instruments were used during the study for monitoring.

Instruments

There are four instruments were used, namely:

1. A Lux Meter
2. A real time air quality detector
3. A sound level meter
4. A vibration meter

Assessment of environmental parameters of workplace

The workplace environmental parameters such as illumination level, temperature, relative humidity, particulate matter, noise level and vibration were measured in different sections of the sugar industry at the time of experiment.

1. Illumination: It is the intensity of light in the sugar industry. Lux Meter is used to measure the illuminance level. Lux is its unit of measurement which stands for lumen per square meter. The recommended light intensity for the sugar industry workplace is 500-1000 lux. (Preto and Gomes 2019) [23]. According to Kumar (2018), general lighting for rooms and areas used either infrequently and/or casual or simple visual task should be between 20-150 lux while general lighting for interiors should be between 200-1500 lux and for additional localized lighting for visually exacting task around 3000 lux is required. The actual required amount of illuminance is also depends on area of activity.

2. Temperature: It is the degree of coldness or heat in the atmosphere of the sugar industry. A real time air quality detector is used to measure indoor temperature. OSHA recommends the temperature control in the range for an industrial workplace is 20-25 °C. Also Clark (1987) reported that at the temprature below 10 °C and above 30 °C, hand strength and touch sensitivity decreases.

3. Relative humidity: It is the amount of water vapours in the air represented as a percentage of what is required for saturation at the same temperature in different sections of sugar industry. A real time air quality detector is used to measure the indoor RH. OSHA recommends humidity control in the range of 20%-60%.

4. Particulate matter: The dust or particle pollution PM 2.5, and PM 10 readings were taken by an Air Quality Detector at different section of sugar industry. Instrument E-Air-060 is a kind of air quality detector, which can monitor temperature, humidity and the concentration of particulate matter (PM 1.0, PM 2.5 and PM 10).

Table 1: Standard exposure limits of particulate matter

Particulate matter	NAAQS($\mu\text{g}/\text{m}^3$)	EPA ($\mu\text{g}/\text{m}^3$)
PM 2.5	40-60	71
PM 10	60-100	115

5. Noise: A sound level meter is a device that monitors the amount of noise in a workplace. It aids in identifying work places with noise issues and workers who may be affected by noise. The intensity of noise pressure was assessed by a sound level meter by using grid methods at the operator ear level height. The National Institute of Occupational Safety and Health (NIOSH) recommends an exposure limit of 85 dB (A) for a maximum exposure time of 8 hours per working day. Noise limit values differ between developed and developing countries, ranging from 85 dB (A) in developed countries to 90 dB (A) in developing countries.

6. Mechanical vibration: Mechanical vibration is the measurement of a periodic process of oscillations with respect to an equilibrium point of some machines which are directly coupled to motor or some through gear boxes. Some shafts are inclined or horizontal or vertical, some are rigidly mounted or some are mounted on flexible mounts. According to ISO 10816-1:1995, the acceptable limits of mechanical vibration should be in between 2.8 mm/s to 4.5 mm/s for large and medium machines.

7. Standard exposure limits of environmental parameters of workplace

The measured levels of environmental parameters of sugar industry were compared with standard exposure limits given by different authorities. The standard exposure limits are given in Table 2.

Table 2: Standard value of environmental parameters of workplace

Environmental parameters	Authority	Standard value
Humidity	OSHA	20-60%
Illumination	IES	500-1000 lux
Noise	OSHA	85 dB(A)
Particulate matter	PM2.5	40-60 $\mu\text{g}/\text{m}^3$
	PM10	60-100 $\mu\text{g}/\text{m}^3$
Temperature	OSHA	25°C
Vibration	ISO 10816-1:1995	2.8 mm/s to 4.5 mm/s

Results and Discussions

Assessment of existing workplace parameters and workload of workers of sugar industry

Existing workplace parameters such as temperature, noise, humidity, illumination, particulate matter, and vibration have the extreme effect on activity and reduce the efficiency and efficacy. Environmental comfort is an important factor in productivity. Any dissatisfaction with the work environment is likely to reduce efficiency, causes premature fatigue, carelessness, or inattentiveness, all of which can lead to accidents or occupational disease. These measurements were made using standard instruments available to the experimenter, the details of which are explained in the respective sections.

(A) Measurement of existing workplace parameters of sugar industry A

1. Illumination: Sufficient light is necessary at the workplace to have better and safe performance for the

workers It was found that the average light intensity of 498 lux, 396 lux, 393 lux, 386 lux and 326 lux respectively in different sections of sugar industry A which was found less than the recommended value. As suggested by Gandotra *et al.* (2005) that 500 lux to 1000 lux gives satisfaction to the workers shown in Table.3 below.

Table 3: Assessment of illumination level in sugar industry A

Section	Illumination, lux
Mill house	498
Boiler section	326
Process house	389
Packing house	393
Turbine section	396

2. Temperature: According to Singh (2016) the comfortable temperature range for workers in industries is 20°C to 29 °C. Results in Table.4 further depict that the higher temperature of sugar industry A was recorded in process house i.e. 36.3 °C due to the boiling of juice and by the continuous supply of steam followed by mill house temperature as 35.5 °C by the supply of steam in milling machines while the temperature in cane carrier section and boiler house was 34.5 °C and 34°C respectively. The minimum temperature was recorded in packing house i.e. 29.6°C was shows that temperature in industry is above the range. According to Pheasant (1987) ^[24], the maximum permissible temperature for manual workers was 25°C. He also stated that the temperature will rise in the summer, posing health risks.

Table.4 Assessment of temperature in sugar industry A

Section	Temperature, °C
Cane carrier	34.5
Mill house	35.5
Boiler section	34
Process house	36.3
Packing house	29.6
Turbine section	27.2

3. Relative humidity: According to Gandotra *et al.* (2013) ^[10], the comfortable relative humidity level in the summer for Indian climate is 40-60 %. The recorded humidity level in sugar industry A in all the section of the industry was under the permissible limit i.e. below 40%. Recommended the humidity level for summer and winter season was 40-50 %, 40-60% respectively (Bakshi, 1997) ^[3].

Table 5: Assessment of relative humidity in sugar industry A

Section	Humidity, %
Cane carrier	30.40
Mill house	33
Boiler section	37.2
Process house	39
Packing house	30.20
Turbine section	35.80

4. Particulate matter: In sugar industry A the workers are exposed by bagasse dust during industrial operation. So, the

concentration of particulate matter PM_{2.5} and PM₁₀ was measured in different section of sugar industry, data on particulate matter is given in Table.6 below.

(i) **PM_{2.5}:** Concentration of PM_{2.5} in sugar industry A was found highest in process house i.e., 84.33 µg/m³ followed by mill house section i.e., 83.67 µg/m³, which was higher than the permissible limit. The minimum concentration was found in turbine section i.e. 21.33 µg/m³ which was below the permissible limit.

(ii) **PM₁₀:** Concentration of PM₁₀ was found highest in mill house section of sugar industry A i.e., 109.33 µg/m³, which reflects very poor as per AQI category followed by process house i.e., 93.67 µg/m³. The minimum concentration was found in turbine section i.e., 23 µg/m³.

Table 6: Assessment of particulate matter in sugar industry A

Section	PM _{2.5} , µg/m ³	PM ₁₀ , µg/m ³
Cane carrier	47	59.33
Mill house	83.67	109.33
Boiler section	38.33	47.00
Process house	84.33	93.67
Packing house	36.67	50.67
Turbine section	21.33	23

5. Noise: The comfortable sound level is 30 to 60 dB and it should not increase 90 dB as it may create hearing problems if continued for the duration of 8 hours or more (Aggarwal 2001) [1]. Results shows that in sugar industry A the higher noise level observed in turbine section was 88 dB due to the excessive sound of motor followed by mill house i.e. 86 db by the sound of milling machine and these value are over than the exposure limit. In other section boiler house, process house and packing the sound level is under the exposure limit i.e. 85 dB, 85 dB and 84 dB respectively depicted in Table.7 below. The National Institute of Occupational Safety and Health (NIOSH) recommends an exposure limit of 85 dB (A) for a maximum exposure time of 8 hours per working day.

Table 7: Assessment of noise level in sugar industry A

Sections	Noise dB(A)
Cane carrier	85
Mill house	86
Boiler section	85
Process house	85
Packing house	84
Turbine section	88

6. Mechanical vibration: One of the occupational hazard to which a worker is exposed in machine operation is mechanical vibration. According to ISO 10816-1 velocity severity of the centrifugal machine was found more than the satisfactory limit i.e. 4.64 mm/s. The satisfactory limit of machines for mechanical vibration is 2.8 mm/s to 4.5 mm/s. Mechanical vibration of turbine and fibrizer was found between the satisfactory limit i.e. 2.54 mm/s and 2.10 mm/s.

Table 8: Assessment of mechanical vibration in sugar industry A

Machine	Acceleration, m/s ²	Velocity, mm/s	Displacement, mm
Centrifugal machine	4.2	4.64	2.1
Turbine	2.3	2.54	1.1
Fibrizer	1.9	2.10	0.9

(B) Measurement of existing workplace parameters of sugar industry B

1. Illumination: In sugar industry B the average light intensity of different section of the industry was 435 lux, 399 lux, 371 and 264 lux, which was also less than the recommended value. Table.9 shows the above mentioned data. For work in open space during day time, there is always sufficient light in normal working hours. However, in closed spaces the lighting is often poor and which may lead to accidents. As per IS: 6665 the minimum light intensity of 150 to 300 lux depending on type of work should be made available at the work place. Grandjean (1975) [11] also recommended that the light level for rough work 50-100 Lux, for moderately precise work 250-500 lux, for precise work 500-1000 lux and for very fine work it is range between 1000-2000lux.

Table 9: Assessment of illumination level in sugar industry B

Section	Illumination, lux
Mill house	435
Boiler section	294
Process house	435
Packing house	371
Turbine section	399

2. Temperature: Saha (1980) recommends that the comfortable body temperature ranges between 20 and 23 °C, and temperatures below and above this limit reduce work efficiency. Similarly, in sugar industry B the maximum temperature was recorded in boiler house i.e. 39.4 °C due to boiler fire in this section workers were highly exposed by temperature followed by process house temperature and mill house temperature i.e. 38.2 °C and 38 °C respectively. The minimum temperature recorded in the packing house was 30 °C. The following result shows that the recorded temperature range in both the industry was more than the permissible limits. Malagie *et al.* (2012) [18] discovered that workers in food processing enterprises are sometimes required to work in large freezing rooms at temperatures of around -18 °C or even lower, so protective clothing is highly recommended.

Table 10: Assessment of temperature in sugar industry B

Section	Temperature, °C
Cane carrier	34
Mill house	38
Boiler section	39.4
Process house	38.2
Packing house	30
Turbine section	31.5

3. Relative humidity: The humidity level is more than the permissible limit were recorded in the boiler section of the sugar industry B i.e. 61.40% due to leakage of steam and the higher temperature of boiler. In other sections the humidity level in under the permissible limit. The relative humidity levels below 30% cause unfavourable health effects such as mucosal, eye, and skin irritation, dizziness, and headaches (Padmini, 2012) [21].

Table 11: Assessment of relative humidity in sugar industry B

Section	Humidity, %
Cane carrier	32.60
Mill house	34.60
Boiler section	61.40
Process house	41.60
Packing house	33
Turbine section	57

4. Particulate matter: During industrial operations, workers in sugar industry B are exposed to bagasse dust. As a result, the concentrations of particulate matter PM_{2.5} and PM₁₀ were measured in various sections of the sugar industry; data on particulate matter are provided in Table.12 below.

(i) **PM_{2.5}:** In sugar industry B the highest concentration was found in process house and followed by mill house i.e., 87.67 µg/m³ and 84.67 µg/m³, respectively which was higher than the recommended permissible limit and comes under the poor category as per Air Quality Index (AQI). National Ambient Air Quality Standards recommended the exposure limit for PM_{2.5} is 40-60 µg/m³.

(ii) **PM₁₀:** In sugar industry B the concentration of PM₁₀ was found higher in mill house i.e., 115.67 µg/m³ due to the bagasse dust which was higher than the permissible limit and comes under the very poor category as per AQI. In other sections of the sugar industries the concentration was found below the permissible limit. The dust causes irritation in eyes, to the skin and within lungs.

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5. Noise: The maximum noise level in sugar industry B was observed in mill house i.e. 88 db due to excessive sound of fibrizer and milling machines while sound level in boiler section, process house and turbine section was observed 87 db due to excessive noise generated from mud roller which was higher than the permissible limit; it is hazardous to human but the workers were habituated with this and they don't have any problem regarding noise. Prolonged exposure to noise level 85-95 dB (A) is a threat to human (Pheasant, 1987) [24]. In packing house sound level recorded was 85 dB (A) which is under the permissible limit. Prolonged exposure to loud sound will cause noise induced hearing loss but it is preventable one. The extent of auditory damage

not only depends on loudness or intensity of sound but also depends on duration of exposure; besides this loud noise also causes such problems like tinnitus, auditory fatigue, sleep disturbance, decreased work performance and impaired cognition (Haines *et al.* 2003) [12].

Table 13: Assessment of noise level in sugar industry B

Section	Noise, dB(A)
Cane carrier	86
Mill house	88
Boiler section	87
Process house	87
Packing house	85
Turbine section	87

Table 13: Assessment of noise level in sugar industry B

Section	Noise, dB(A)
Cane carrier	86
Mill house	88
Boiler section	87
Process house	87
Packing house	85
Turbine section	87

6. Mechanical Vibration: Mechanical vibration is one of the occupational hazards to which a worker is exposed during machine operation. According to ISO 10816-1, the centrifugal machine's velocity severity was found to be greater than the acceptable limit of 7.06 mm/s. Machines' acceptable mechanical vibration limits range from 2.8 mm/s to 4.5 mm/s. Mechanical vibration of the turbine and fibrizer was found to be between the acceptable limits of 3.86 mm/s and 4.08 mm/s.

Table 14: Assessment of mechanical vibration in sugar industry B

Machine	Acceleration, m/s ²	Velocity, mm/s rms	Displacement, mm
Centrifugal machine	6.4	7.06	3.2
Turbine	3.5	3.86	1.7
Fibrizer	3.7	4.08	1.8

Conclusions

From the results of the study, it can be concluded that:

- After much advancement in sugar industries and technology, we are still facing the problem related to workplace safety.
- Environmental parameters such as illumination, temperature, relative humidity, mechanical vibration, noise and amount of particulate matter were found higher than the acceptable limit, which should be under the exposure and permissible limits.
- A proper working environment is very important for improving productivity and safety of workers and also to promote the workers' morale ensuring lowering in worker truancy and worker prolificacy.

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