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Assessment and analysis of noise levels in and around Ib river coalfield, Orissa, India

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Abstract

Heavy earth moving machineries, different capacities of dumpers and loaders, blasting and drilling make the mining environment noisy. A study was carried out to assess the noise level in different opencast projects in and around Belpahar and Brajarajnagar areas of Ib river coalfield. Noise assessment was carried out in various residential, commercial and industrial places. The noise levels, especially L_{eq} values of different wheel loaders, dumpers, shovel and crusher units were also assessed and were more than permissible limit (90dB) in some of their operating conditions. Sound ressure level measurements while drilling into coal and overburden at Lakhanpur opencast project yielded noise levels (L_{eq}) of 81.33 to 96.2 dB. Thus, these L_{eq} values of drilling machines in most of the operating conditions were above permissible limit. The average noise intensities (6 a.m.-10 p.m.: 51.6-60.875dB and 10 p.m.-6 a.m.: 42.6-49.8dB) and L_{eq} values (6 a.m.-10 p.m.: 50.9-67.0dB and 10 p.m.-6 a.m.: 40.8-53.3dB) during both day and night time of the residential areas around the Ib river coalfield were in close proximity or beyond the permissible limit. The L_{eq} values at some of the commercial and industrial places were beyond (6 a.m.-10 p.m.: 61.6-88.3 dB and 10 p.m.-6 a.m.: 55.4-64.8dB) permissible limit. However, in most of the cases, the L_{max} noise values were more (6 a.m.-10 p.m.: 68.5-91.4 dB and 10 p.m.-6 a.m.: 69.3-76.4dB) than the permissible limit. Analysis of variance was also computed for heavy earth moving machineries in different operating conditions and also for different residential, commercial and industrial places to infer the level of significance. The difference of noise intensity produced by different wheel loaders at Lakhanpur and Lilari opencast projects, drilling machines at Lakhanpur opencast project, 50 tons capacity dumpers at various conditions of Ib river coalfield within the same operating condition was significant at both 5% and 1% levels of significance. Similarly, the variance of estimated noise level in residential places during day time and commercial and industrial places during day and night time was significant at both 5% and 1% levels of significance. Moreover, a preliminary survey adopting questionnaire method amongst the mine workers and local inhabitants was also carried out to evaluate their perception about the mining related noise.

Key words

Coal mining, Noise pollution, Community response

Introduction

Noise pollution is the second biggest occupational hazard in the Indian mining industries. The main sources of noise generation in coal mining areas are heavy earth moving machineries and crushing units, where concerned operator is exposed to noise (Pandya and Dharmadhikari, 2002). A cumulative effect of mining activities produces enormous noise and vibrations in the mining area, which constitute a source of disturbance. The availability of large diameter and high capacity pneumatic drills, blasting of hundreds of tonnes of explosive etc. are identified as noise prone activities (Spencer and Reeves, 2009; Spencer, 2010). Blasting is an integral part of mining. A part of energy released from the ignition of explosive results in ground vibration similar to the earthquake. When the intensity of ground vibration is very high, it damages the permanent structures and buildings in the surrounding areas (Bauer and Kohler, 2000). All the above mining activities are the major sources of noise and vibrations in and around the five opencast coal projects (viz., Samaleswari, Lilari, Lakhanpur, Lajkura and Belpahar) around Belpahar and Brajarajnagar of Ib river coalfield (Singh and Singh, 2004). The introduction of mechanized and large scale-machinery in mining has accentuated the problem of noise pollution in recent years (Kudesia and Tiwari, 2007). Though, the opencast mining has become most favourable due to its economic viability, better safety and conservation; the noise produced in such activities is the most prevalent environmental stress in the mining industry (Chakrabarti, 2000).

Prolonged exposure to noise over a period of years generally causes permanent damage to the auditory nerve and/or its sensory components (Diniz and Zannin, 2004; Banerjee and Chakraborty, 2006; Jakovljevic *et al.,* 2006; Krishna Murthy *et al.*, 2007). This irreversible damage, known as noise-induced hearing loss (NIHL), is the most common occupational disease of the mining belts throughout the world. Mine workers suffering from NIHL have difficulty understanding human speech and hearing other workplace cues (Sliwinska-Kwalska *et al.*, 1999; Prasher *et al.*, 2002). Hearing loss is the most prevalent disease among miners. Recent studies in USA revealed that around 90% of machine operators were overexposed to noise. These operators had daily noise doses that exceeded the Mine Safety and Health Administration's permissible exposure level of USA (Spencer and Reeves, 2009; Spencer, 2010). Workers are more prone to NIHL especially in the coal mining belts having multiple noise sources. It is important to characterize noise sources sufficiently well so that the sources most hazardous to hearing can be identified and those conditions of exposure that are most amenable to engineering controls can be pinpointed as well (Bauer and Kohler, 2000). Besides, the fauna in the forests and other areas surrounding the mines/industrial complexes is also affected by such noise. It has been believed that wild life is more sensitive to noise and vibrations than the human beings (Mathur, 2005). Despite regulations and efforts by government and industry to reduce noise-induced hearing loss (NIHL), it is still a problem in the Indian coal mining industry. A cross-sectional survey of noise sources and worker noise exposures has been conducted for heavy earth moving machinery and in population around Ib river coalfield.

Materials and Methods

The Ib river coalfield is located in the south-eastern part of NW-SE trending Mahanadi Master Basin belt between 21^0 30' and 22^0 06' N latitudes and 83^0 37' and 84^0 10' E longitudes. The areas

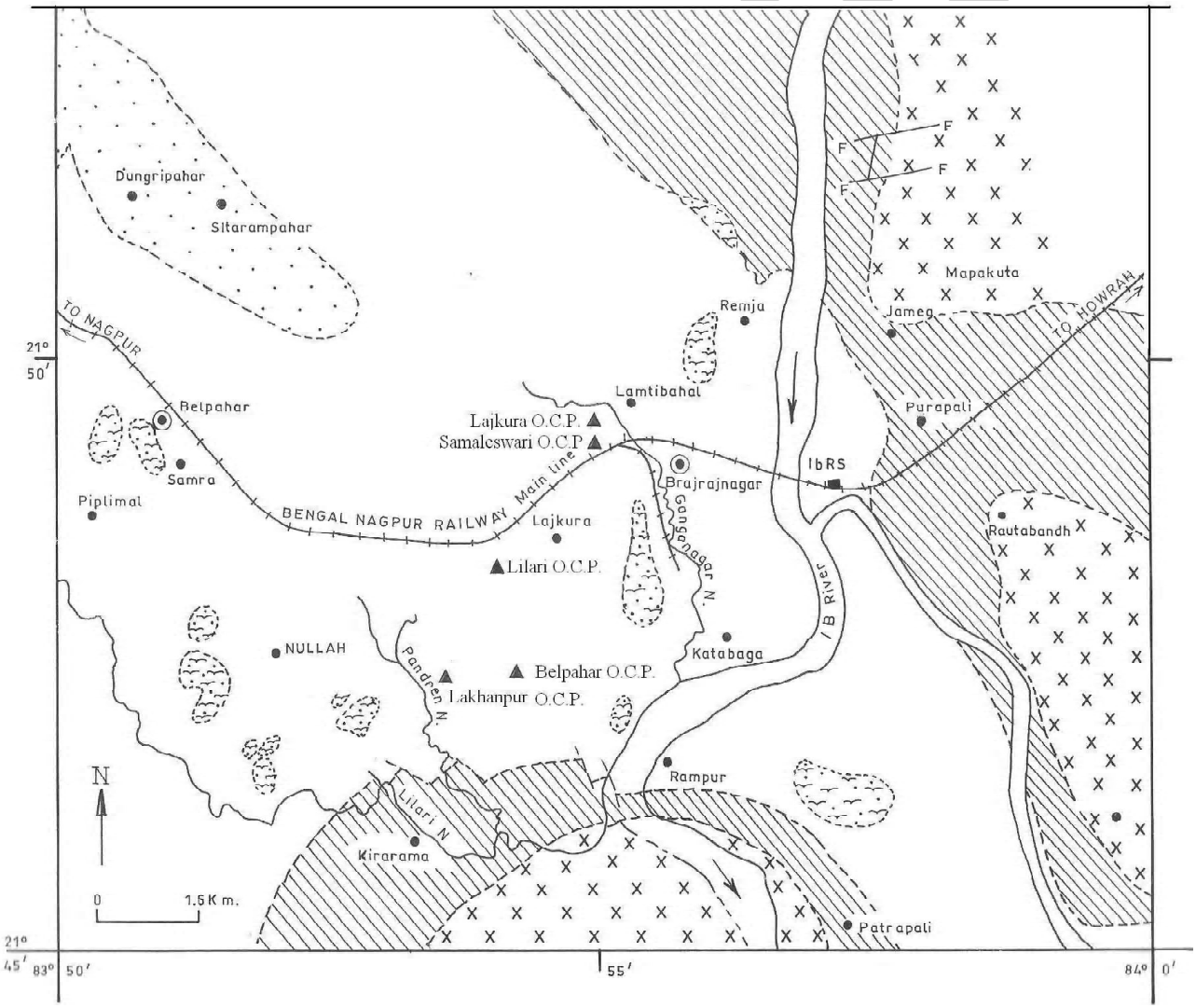

Fig. 1: Map of Ib river coalfield showing locations of five investigated opencast coal projects (OCP) around Ib river coalfield in Orissa, India.

embrace the Himgir sub-basin in the north and the Rampur sub-basin in the south. The major parts of Ib river coalfield comprises five opencast projects (viz., Samaleswari, Lilari, Lakhanpur, Lajkura and Belpahar) around Belpahar and Brajarajnagar townships of Jharsuguda district, Orissa. Noise levels of residential, commercial and industrial places of Belpahar and Brajarajnagar (a major part of Ib river coalfield) areas around these opencast coal projects have been assessed during December, 2008 (Fig. 1). Moreover, the noise produced from different heavy earth moving machineries was also assessed during February, 2008. The noise levels were measured following standard procedure using calibrated sound pressure dB meter (Model LUTREN, SL-4010) in and around the aforesaid five opencast projects in various operating conditions (Morillas *et al.,* 2002; Bluhm *et al.*, 2004).

Altogether 30 measurements were carried out within 1hr duration of different heavy machineries. Sixty observations were made for 2 hrs duration in different residential, commercial and industrial places in and around Belpahar and Brajarajnagar. Assessment of noise levels was carried out by holding sound pressure dB meter in hand at arms length at the chest level in order to reduce errors due to reflection of sound from the body of the investigator.

L_{eq} represents the equivalent energy sound level of a steady state and invariable sound. It includes both intensity and length of all sounds occurring during a given period. The noise levels in different time intervals were predicted along with their equivalent noise levels (L_{eq}). The value of L_{eq} in dB (A) unit was calculated by using the formula given by Robinson (1971). In order to determine the existence and statistical significance of these variations and trends, a cross classification analysis along with F-test was assessed on the data.

To delineate the perception about the noise and its significance on health of mine-workers, a reprehensive sample of public of nearby villages were interviewed on a very extensive scale using a questionnaire in the month of December, 2008. The questionnaire used for this interview consists of closed-ended and open-ended questions, which are divided into two main sections. The first section comprises the identifying data of the interviewee and the second involves aspects of his perception of the soundscape of the said investigated area (Szeremeta and Zannin, 2009). Moreover, an attempt was also made to investigate major sources of noise.

Results and Discussion

The analysis of noise level for different heavy earth moving machineries demonstrates that the noise intensities of some equipments were beyond the permissible limit i.e. 90 dB (Table 1) (DGMS, 1975). The noise levels of different wheel loaders in most of the cases at Lakhanpur and Lilari opencast projects were within the permissible limit in different operating conditions (Table 2), while its value was more than the permissible limit within the distance of 2.5 m (L_{eq}, 93.13dB). The L_{eq} values of different shovels at Samaleswari and Lajkura opencast projects also remained below the permissible limit (L_{eq}, 82.6-89.4dB) (Table 2). However, the L_{eq} values of different drilling machines (except idle condition: 81.33 dB) at Lakhanpur opencast project were more than the permissible limit (81.33-96.2 dB) (Table 2). During unloading, the crusher house produced noise (L_{eq}: 91.5dB), which was more than the permissible limit (Table 2). The dumpers of various capacities (50 and 30 tons) produced heavy noise during unloading (L_{eq}: 91.37 and 93.6dB, respectively). Generally, 30 tons capacities of dumpers produced more noise than 50 tons capacities (Table 3).

The L_{eq} values of various residential places during day time (6 a.m.-10 p.m.) ranged from 50.9 to 67dB and during night time (10 p.m.-6 a.m.) ranged from 40.8 to 53.3dB (Table 4). In most of the cases, the noise levels of the said area were more than the standard noise level (55dB during day and 45dB during night) (Table 1; CPCB, 2000). The noise levels of different commercial and industrial places were also beyond the permissible limit during the day time (L_{eq}: 61.6-88.3 dB), while during night time noise intensities were somewhat within the permissible limit (L_{eq}: 55.4-64.8dB) (Table 4).

The difference of noise intensity produced by different wheel loaders at Lakhanpur and Lilari opencast projects (Sl. No. 1), drilling machines at Lakhanpur opencast project (Sl. No. 3), 50 tons capacity dumpers at various conditions of Ib river coalfield (Sl. No. 5) within the same operating condition was significant at both 5% and 1% levels of significance. However, the difference in generation of noise by different shovels at Samaleswari and Lajkura opencast projects (Sl. No. 2), crusher house near Lajkura opencast project (Sl. No. 4) and 30 tons capacity dumpers at various conditions of Ib river coalfield (Sl. No. 6) within the same operating condition were significant at 5% level, but not at 1% level of significance. The difference of noise intensity produced by wheel loaders at Lakhanpur and Lilari opencast projects (Sl.No.1), shovels at Samaleswari opencast project (Sl. No. 2), drilling machines at Lakhanpur opencast project (Sl. No. 3), crusher house near Lajkura opencast project (Sl. No. 4), 50 and 30 tons capacity dumpers at various conditions of Ib river coalfield (Sl. No. 5 and 6) among the different operating conditions was significant at both 5% and 1% levels of significance (Table 5).

The variance of estimated noise level in residential places during day time and commercial and industrial places during day and night time was significant at both 5% and 1% levels of significance. But, the difference of noise level in different residential places during night time was not significant at both 5% and 1% levels of significance. The difference of noise level estimated at different monitoring locations in residential places during day time was significant at 5% level of significance. However, the difference of estimated noise level at residential places during night and commercial and industrial places during day and night was not significant at both 5% and 1% level of significance (Table 5).

The noise perception survey was carried out by a questionnaire, which was administered to 365 individuals in and around the present study area during December, 2008 on a very extensive scale. Among 365 interviewees, 129 were mine workers of five investigated opencast coal projects (Samaleswari, Lilari, Lakhanpur, Lajkura and Belpahar) and rest 236 respondents were local inhabitants of nearby villages. It was observed that most of the mine-workers were aware of noise pollution, but their health significance was not fully realized.

Table 1: Permissible noise limits (DGMS, 1975) and ambient noise standards (CPCB, 2000)

DGMS Permissible noise exposure limits *		CPCB ambient noise quality standards		
Duration of exposure in hours	Noise intensity dB(A)	Category of area	Limits in dB (A) day time	Limits in dB (A) night time
8	90		6 a.m. - 10 p.m.	10 p.m. - 6 a.m.
4	95	Industrial area	75	70
2	100	Commercial area	65	55
1	105	Residential area	55	45
½	110	Silence zone	50	40

* Sound level should not exceeded 115 dB (A) at any instance

Table 2 : Noise levels of different wheel loaders, shovels, drilling machines and crusher units at different opencast projects of Ib river coalfield (February 2008)

Operating conditions	Min	Max	Mean	L_{10}	L_{50}	L_{90}	Leq
Wheel loaders at Lakhanpur and Lilari opencast projects							
Idle Condition	85.4	89.2	87.075±1.66	88.7	86.3	85.8	86.45
Cabin door opened	82.2	88.4	85.525±2.875	87.5	84.1	82.6	84.5
Cabin door closed	78.4	80.2	79.375±0.767	80	79.3	78.7	79.33
Cabin door opened	86.4	89.8	88.05±1.502	89.3	87.7	86.9	87.8
Cabin door closed	79.2	82.7	80.95±1.524	82.4	81.6	79.6	81.7
Cabin door opened	89.2	91.5	90.55±1.034	91.2	90.3	89.6	90.34
Cabin door closed	80.2	85.4	83.35±2.288	85.2	83.4	80.5	83.7
With dumper at a distance of 2.5 m	92.0	94.2	93.325±0.956	93.7	93.1	92.4	93.13
Shovels at Samaleswari and Lajkura opencast projects							
Idle condition	79.4	85.2	82.45±2.538	84.6	82.3	80.4	82.6
Cabin door opened	85.8	89.7	87.92±1.732	89.2	87.3	86.1	87.47
Cabin door closed	84.4	86.2	85.55±0.806	85.7	85	84.6	85.02
Cabin door opened	87.2	91.2	89.72±1.78	90.6	89.3	88.1	89.4
Cabin door closed	86.2	88.3	87.42±0.97	88	87.4	86.6	87.43
Dumper at a distance of 2.5m	81.4	88.2	84.85±0.341	87.1	84.7	82.6	85
Drilling machines at Lakhanpur opencast project							
Idle condition	80.5	82.2	81.45±0.759	82	81.3	80.7	81.33
Cabin door opened	90.2	94.2	92.55±1.75	93.7	92.4	90.7	92.5
Cabin door closed	89.8	93.5	91.47±1.6	93.1	91.6	90.5	91.7
Cabin door opened	94.2	98.6	96.65±1.88	98.3	96.1	95.4	96.2
Cabin door closed	90.4	93.6	92±1.46	93.1	92.2	90.7	92.3
Out side at a distance 1.5 m	89.2	91.6	90.7±1.051	91.4	90.4	89.6	90.45
Crusher units at crusher house near Lajkura opencast project							
Unloading operation	88.9	93.6	91.45±2.053	92.7	91.3	89.2	91.5
Normal crushing	87.7	89.3	88.52±0.713	88.4	85.5	83.5	85.9
Crusher house motor	85.8	87.5	86.7±0.787	86.2	85.1	84.3	85.16
Apron feeder (coal discharge)	83.4	85.2	84.47±0.771	84.6	83.5	81.8	83.64
Drive house (near belt)	80.7	82.7	81.67±0.895	82.1	80.3	79.4	80.43

Table 3 : Noise levels of 50T and 30T capacity dumpers at various conditions around the investigated part of Ib river coalfield (December 2008)

Operating conditions	Min	Max	Mean	L_{10}	L_{50}	L_{90}	Leq	Min	Max	Mean	L_{10}	L_{50}	L_{90}	Leq
	50T capacity dumpers							30T capacity dumpers						
Idle condition	82.4	84.3	83.475±0.853	84.1	83.6	82.8	83.63	83.7	86.5	84.974±1.187	85.6	84.5	83.9	84.5
Moving with load	86.5	88.6	87.55±0.903	88.1	87.6	86.9	87.62	90.6	92.2	91.4±0.73	91.4	91	90.8	91
Moving on haulage road	87.9	90.4	89±1.128	90.2	89.3	88.4	89.35	89.8	94.3	92.425±1.95	93.2	91.8	90.3	91.9
Un loading	90.5	93.4	91.92±41.281	92.7	91.3	90.7	91.37	91.6	94.7	93.05±1.377	94.1	93.6	92.1	93.6

Table 4 : Noise levels of various residential, commercial and industrial places during day time (6 AM-10 PM) and night time (10 PM-6 AM) around Ib river coalfield (December, 2008)

Locations	Min	Max	Mean	L_{10}	L_{50}	L_{90}	Leq	Min	Max	Mean	L_{10}	L_{50}	L_{90}	Leq
Residential places	Day time (6 a.m.-10 p.m.)							Night time (10 p.m.-6 a.m.)						
Village Orangbasti near Samaleswari OCP	44.2	63.7	53.67±8.35	60.4	52.6	47.1	55.7	37.5	60.2	49.60±9.456	58.5	47.6	40.5	53.3
Village Kudapali near Samaleswari OCP	40.6	61.3	53.12±9.17	58.5	51.1	42.7	55.5	34.2	59.4	48.57±10.74	57.1	45.1	38.8	51.0
Khairikuni village near Lakhanpur OCP	42.7	72.4	60.87±13.04	64.2	61.6	46.8	67	40.7	55.3	48.87±6.08	52.6	46.1	43.7	47.5
Bandhbahal Colony near Lakhanpur OCP	48.5	65.7	57.92±7.65	61.8	58.5	51.6	60.3	36.5	58.6	49.80±9.463	56.0	47.3	39.6	52.1
Adarsh nagar Colony near Lajkura OCP	40.4	69.2	58.57±12.78	61.3	53.8	44.2	59	32.4	57.4	43.50±12.73	52.4	44.3	36.6	48.7
Jurabaga Village near Lilari OCP	49.2	62.4	56.17±5.41	59.7	56.3	51.1	57.6	38.7	53.4	47.27±6.20	51.7	46.8	40.2	49.1
Darlipali village near Lilari OCP	44.7	67.2	57.97±9.54	63.4	56.2	46.6	61.2	33.6	52.7	42.92±8.15	49.3	41.7	36.6	44.5
Banjipali village near Belpahar OCP	45.2	57.8	51.60±5.37	54.3	50.7	47.1	50.9	34.7	49.5	42.60±6.43	46.2	39.1	36.3	40.8
Commercial and Industrial places	Day time (6 a.m.-10 p.m.)							Night time (10 p.m.-6 a.m.)						
Brajarajnagar market	52.1	80.2	61.85±9.982	75.4	66.3	57.7	71.8	31	76.4	57.25±19.92	67.2	52.2	40.6	64.8
On the Haul road of Samaleswari OCP	47.3	86.3	68.5±17.29	82.2	68.7	51.3	85.7	34.6	71.2	54.825±16.37	64.3	50.6	42.3	59.2
Near Lajkura store	45	91.4	74.57±20.42	82.3	70.4	50.6	88.3	41.8	73.2	60.475±14.49	62.6	48.3	42.2	55.7
Near coal crusher house near Lajkura OCP	51	88.2	70.97±15.45	82.3	64.3	55.8	76.8	42.1	69.3	55.775±11.73	61.7	50.3	44.7	55.4
Near Lilari pump house	42.3	68.5	57.72±11.18	65.3	55.4	46.6	61.6	43.4	72.4	59.55±12.308	68.5	52.7	51.6	57.8

Table 5 : Analysis of variance of noise intensity of different heavy earth moving machineries and residential, industrial and commercial places around Ib river coalfield

Parameters	Source of variations	S.S.	D.F.	M.S.	Calculated value of F	Tabulated value of F	
• Wheel loaders at Lakhanpur and Lilari opencast projects (Feb.-2008)	Among the Noise intensities	57.94	3	19.31	F=32.78	$F_{0.05}$=8.65,	$F_{0.01}$=26.68
	Among the Operating conditions	625.42	7	89.34	F=151.68	$F_{0.05}$=3.44,	$F_{0.01}$=6.15
	Within the samples for both the variables	12.37	21	0.589			
• Shovels at Samaleswari and Lajkura opencast project (Feb.-2008).	Among the Noise intensities	32.74	3	10.91	F=16.28	$F_{0.05}$=8.70,	$F_{0.01}$=26.87
	Among the Operating conditions	127.24	5	25.448	F=37.98	$F_{0.05}$=4.61,	$F_{0.01}$=9.72
	Within the samples for both the variables	10.16	15	0.67			
• Drilling machines at Lakhanpur opencast Projects (Feb.- 2008)	Among the Noise intensities	35.09	3	11.63	F=44.73	$F_{0.05}$=8.70,	$F_{0.01}$=26.87
	Among the Operating conditions	506.49	5	101.29	F=389.57	$F_{0.05}$=4.61,	$F_{0.01}$=9.72
	Within the samples for both the variables	3.91	15	0.26			
• Crusher house near Lajkura opencast project (Dec. -2008).	Among the Noise intensities	16.3	3	5.37	F=15.79	$F_{0.05}$=8.74,	$F_{0.05}$=27.05
	Among the Operating conditions	224.02	4	56.005	F=164.72	$F_{0.05}$=5.91,	$F_{0.01}$=14.37
	Within the samples for both the variables	4.08	12	0.34			
• 50T capacity dumpers at various conditions of Ib River Coalfield (Dec. - 2008).	Among the Noise intensities	12.9	3	4.3	F=43.0	$F_{0.05}$=8.81,	$F_{0.05}$=27.34
	Among the Operating conditions	148.3	3	49.43	F=494.3	$F_{0.05}$=8.81,	$F_{0.05}$=27.34
	Within the samples for both the variables	0.9	9	0.1			
• 30T capacity dumpers at various conditions of Ib River Coalfield (Dec. - 2008).	Among the Noise intensities	19.99	3	6.66	F=20.61	$F_{0.05}$=8.81,	$F_{0.05}$=27.34
	Among the Operating conditions	166.19	3	55.39	F=171.48	$F_{0.05}$=8.81,	$F_{0.05}$=27.34
	Within the samples for both the variables	2.91	9	0.323			
• Residential places during day time (6 am-10 pm) around Ib River Coalfield (Dec. - 2008).	Among the Noise intensities	1860.45	3	620.15	F=57.36	$F_{0.05}$=8.65,	$F_{0.01}$=26.68
	Among the monitoring locations	282.45	7	40.35	F=3.73	$F_{0.05}$=3.44,	$F_{0.01}$=6.15
	Within the samples for both the variables	227.06	21	10.81			
• Residential places during night time (10pm-6 am) around Ib River Coalfield (Dec. - 2008).	Among the Noise intensities	1589.413	3	529.80	F=2.702	$F_{0.05}$=8.65,	$F_{0.01}$=26.68
	Among the monitoring locations	958.923	7	136.98	F=1.43	$F_{0.05}$=3.44,	$F_{0.01}$=6.15
	Within the samples for both the variables	4117.077	21	196.05			
• Commercial and industrial places during day time (6 am-10 pm) around IbRiver Coalfield (Dec. - 2008).	Among the Noise intensities	3160.56	3	1053.52	F=29.87	$F_{0.05}$=8.74,	$F_{0.05}$=27.05
	Among the monitoring locations	705.41	4	176.35	F=5.0	$F_{0.05}$=5.91,	$F_{0.01}$=14.37
	Within the samples for both the variables	423.19	12	35.265			
• Commercial and industrial places during Night time (10pm-6 am) around Ib River Coalfield (Dec. - 2008).	Among the Noise intensities	3327.69	3	1109.23	F=80.26	$F_{0.05}$=8.74,	$F_{0.05}$=27.05
	Among the monitoring locations	92.8	4	23.22	F=1.68	$F_{0.05}$=5.91,	$F_{0.01}$=14.37
	Within the samples for both the variables	165.87	12	13.82			

S.S.-Sum of squares, D.F.-Degree of Freedom, M.S.-Mean squares

The studies revealed that more than 40% of the mine workers monitored was subject to noise exposures above 90 dBA. In total, 53% respondents were not satisfied about the noise level in this mining belt. The study also revealed that 31% of interviewees were not satisfied with the noise produced by heavy earth moving machineries. None of the respondents (mining workers) was using appropriate ear protection (ear plugs or ear muffs). 9% of respondents told that they had at least one experience of being temporarily "deafened" by a loud noise especially during blasting. Headache, bad temper, hearing problem, loss of concentration and cardiovascular stress were some of the significant effects manifested by noise pollution (Ouis, 2001; Zannin *et al.,* 2001; Thakur, 2006). 38% respondents identified headache as the main health effect of noise pollution. 21% interviewers were feeling mental stress, 9% were suffering from insomnia and 0.1% respondents were suffering from hearing loss. 81% of students reported that their study was disrupted by frequent air horns of vehicles. 26% of local inhabitants of near by villages shared their sleep disturbance due to road traffic noise produced by coal loaded heavy dumpers and trucks during night-time. It warrants a systematic survey of sleep quality, number of awakenings or number of changes in sleep state to estimate the extent of sleep disturbance (Muzet, 2007; Goswami, 2009; Goswami *et al.,* 2011).

Noise pollution is an interfering air-pollutant, which possesses both auditory, and a host of non-auditory effects on the exposed mine workers and local inhabitants (Ziaudin *et al.,* 2007; Jakovljevic *et al.,* 2009; Lam *et al.,* 2009; Al-Ghonamy, 2010).

Prolonged exposure to high sound levels leads to hearing damage (Zannin *et al.,* 2003; 2006; Yang and Kang, 2005). Miners are not usually exposed to the strong noise level continuously. It is important to note that sound level above 130dB causes hearing impairment (Bauer and Babich, 2005). Continuous exposure to a noise level of 115dB is not permitted. Danger noise limit is above 90dB in which hearing impairment is likely to be occurred. Appropriate ear protection (ear muffs or plugs) should be used, if the noise level is more than 115dB. Nobody is permitted to enter an area, if noise level exceeds 140dB (Chakrabarti, 2000).

The present study explicitly reveals that the noise levels were more than the permissible limit in most of the investigated sites including residential, commercial and industrial zones during both day and night time, while in some cases noise levels were below the limiting values. Noise level assessed with different heavy equipments/machineries (shovels, dumpers, wheel loaders, drilling machines) revealed that in some of the operating conditions (viz., shovel with hard digging operation, unloading operation etc.), the noise levels were more than the permissible limit (90 dB), which contributes to limited duration over entire shift of work. However, in some cases the noise levels were in proximity of permissible limit. Hence, by increasing general awareness among the mine workers, adopting better technologies, strictly promulgating laws; the noise pollution can be controlled.

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