

**Intervention Study in Coal, Bauxite & Zinc Mines
(S&T Project sponsored by Ministry of Mines, Govt. of India)**

PHASE – I (COAL)

**Report of study undertaken at Kamptee Open Cast
Mines of Western Coal Fields Limited**



**राष्ट्रीय खनिक स्वास्थ्य संस्थान,
National Institute of Miners' Health,**

Ministry of Mines
JNARDDC Campus, Amravati Road,
Nagpur—440 023
Maharashtra, India
Tel: 071204—224494
Telefax: 07104—224268

Progress report on Intervention Study in Coal, Bauxite & Zinc Mines

1.	Title of the Project	Intervention Study in Coal, Bauxite & Zinc Mines (Sponsored by the Ministry of Mines, Government of India)
2.	Name & Address of implementing Institution	National Institute of Miners' Health JNARDDC Campus Amravati Road, Wadi Nagpur – 440 023
3.	Principal Investigator	Dr. A K Srivastava Ex-Director, National Institute of Miners' Health Nagpur
4.	Project team	1. Mr. B B Mandal, Sr. Research Officer 2. Dr. S V Dhatrik, Research Officer 3. Dr. S S Nandi, Research Officer 4. Dr. A S Kamavisdar, Research Officer 5. Dr. Shubhangi Pingle, Research Officer
5.	Project Staff	1. Mr. N P Kulkarni, Sr. Scientific Asst. 2. Mr. P D Zade, Sr. Scientific Asst. 3. Mr. Umesh Dhumne, Sr. Scientific Asst. 4. Mrs. Shilpa Ingole, Sr. Scientific Asst. 5. Mrs. Aruna Jawade, Sr. Scientific Asst. 6. Dr. Atul Vanerkar, Scientific Asst. 7. Mr. Sachin Narwadiya, Scientific Asst. 8. Ms Rajani Tumane, Scientific Asst.
6.	Date of approval	18 th March 2003
7.	Project initiated from	January 2006
8.	Approved cost	Rs.66.00 Lakh in three installments of Rs.21.Lakhs, 23 Lakhs and Rs.22 Lakh respectively.
9.	Fund received	Rs.21.00 Lakh
10.	Date of meeting of Project Monitoring Committee	6 th November 2008

Contents

INTRODUCTION	1
---------------------	----------

CHAPTER I - ENVIRONMENTAL STUDIES

Executive Summary	8
--------------------------	----------

1 **DUST SURVEY**

Methodology	11
Methodology for analysis	14
Free Silica Analysis	16
Observations	16
Results & Discussions	16
Conclusion	17

2 **NOISE SURVEY**

Methodology	18
Results & Discussions	19
Conclusion	46

3. **VIBRATION SURVEY**

Introduction	48
Material & Method	49
Vibration data	52
Risk Assessment Model	54
Conclusion	56

CHAPTER II - EPIDEMIOLOGICAL STUDIES

Introduction	57
Results & Discussions	57
Conclusion	64

CHAPTER III - MEDICAL STUDIES

Introduction	66
Material & Method	66
Result	68
Conclusion	74
Biochemical parameters	75
Observations & Results	76

REFERENCES	77
-------------------	-----------



1. INTRODUCTION:

Coal is a fossil fuel extracted from the ground by underground mining or open pit mining (surface mining). Coal is a ready combustible black or brownish black sedimentary rock. It is composed primarily of carbon along with associated other elements including sulfur. In India, there are two types of coal mining, surface mining and underground mining. Underground mining is more difficult and requires more miners, but much of our best coal is underground. Coal has been recognized as the most important source of energy for electricity generation in India. About 70 % coal output in the country is consumed in power sector. In addition, other industries like steel, cement, fertilizer, chemical, paper and thousands of medium and small scale industries are also dependent on coal for their process and energy requirements.

There are 8 coal producing companies in the public sector. Some companies are joint the Govt. of India and Govt. of Andhra Pradesh.

Name of companies and number of mines as shown in Table I and Table II state wise distribution.

Table I – Major coal mining companies in India

Company	No. of Collieries			
	OC	UG	Mixed	Total
ECL	18	92	2	112
BCCL	15	49	16	80
CCL	35	22	6	63
NCL	8	0	0	8
WCL	33	42	5	80
SECL	19	76	2	97
MCL	14	9	0	23
NEC	2	5	0	7
SCCL	12	55	0	67
BSMDCL	1	0	0	1



DVC	1	0	0	1
IISCO	0	1	2	3
JKML	1	3	0	4
BECML	1	0	0	1
ICML	1	0	0	1
JSPL	1	0	0	1
TISCO	2	5	0	7
TOTAL	164	359	33	556

Table II: State-wise distribution of coal mines

STATES	NO. OF COLLIERIES			
	OC	UG	MIXED	TOTAL
ANDHRA	12	55	--	67
ASSAM	2	4	--	6
CHHATTISGARH	12	44	2	58
J & K	1	3	--	4
JHARKHAND	60	85	24	169
MADHYA PRADESH	18	53	4	75
MAHARASHTRA	28	21	1	50
MEGHALAYA		1	--	1
ORISSA	14	9	--	23
WEST BENGAL	14	84	2	100
UP	3		--	3
TOTAL	164	359	33	556

Jharkhand continued to be the largest coal producing state, followed by Chhatisgarh having contribution of about 22 % and 17 % respectively to the national out put. Next in order of share in the total production were Orissa accounting for 165.6 %, Madhya Pradesh 13.8 %, Andhra Pradesh 9.4 %, Maharashtra 9 %, West Bengal 6.0 % and Uttar Pradesh 4.4 %, the remaining 1.7 % coal production occurred from Meghalaya, Assam and Jammu & Kashmir. Out of the total production of coal, 8.8 % was of cooking coal and the remaining 91.2 % was of non-cooking coal.

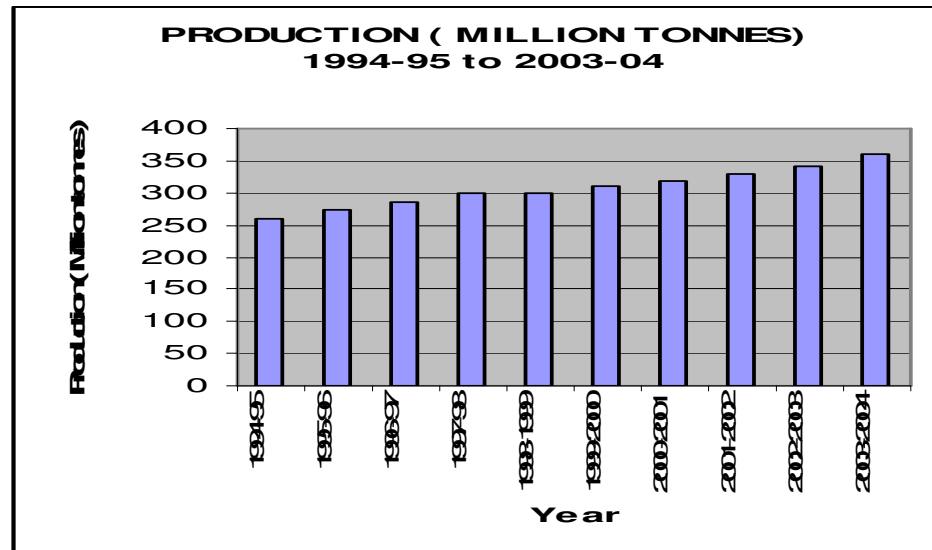
Out of 556 coal mines, there were 64 large mines, each producing more than 10 lakh tones coal during the year and these mines



accounted for bulk production; i.e., 67.5 percent. The contribution of 135 mines, having annual output ranging between 3 and 10 lakh tones each, was 19.5 percent. 207 mines, the individual production of which varied between 1 and 3 lakh tones, shared about 10.9 % coal production. 150 small mines contributed only 2.1 % production, each producing up to one-lakh tones.

Year-wise production of coal as shown below

Figure I: Year-wise production of coal



Health Hazards in coal mines:

Coal is an important energy source for many human and industrial activities. There is vast coal resources in India (2,00,000 million tones) and more than 50% of total miners (7,50,000) are working in coal mines. The commonest occupational health problem studied in India and abroad are coal workers' pneumoconiosis (CWP), disease caused by inhalation of coal dust.



Review of literature on CWP

Current knowledge of the epidemiology and clinical aspects of CWP comes mainly from studies of large populations of coal miners in Britain and United States. The reported prevalence of CWP (category 1 or greater) in eight studies done in the United states between 1961 and 1970 ranged from 4 to 46%. The variation in the prevalence of CWP was influenced by the rank of coal mine (a higher prevalence of CWP occurred among miners who mined medium- to high-rank coal and a lower prevalence was seen among miners who mined low-rank coal), although differences in radiographic standards as well as chest radiograph reader variability could also be contributory.

In 1969, the National study of Coal workers' Pneumoconiosis (NSCWP) was initiated by the National Institute of Occupational Safety and Health (NIOSH) to study the respiratory health of coal miners in the United States. The first round of the NSCWP was performed from 1969 to 1971 and include over 9000 coal miners in 31 mines, with a participation rate of over 90%. The reported prevalence of simple and complicated CWP was approximately 30%. Regional variations in the prevalence of CWP, attributed to hardness or rank of mined coal, were again observed. For example, CWP was much more prevalent among workers in the anthracite mines around Pennsylvania (46% simple CWP and 14% progressive massive fibrosis) where coal was of higher rank, and it was much less prevalent among miners in Utah (4.6% simple CWP and no complicated CWP),where lower rank of coal was mined. The radiographic category of simple CWP increases with length of service of UG coal miners.



NATIONAL STATUS:

Coal Workers' Pneumoconiosis (CWP): In India, Roy in 1956 reported five cases of CWP. Damoderan (1960) came across 30 cases of pneumoconiosis during 8 years of his service at Central Hospital, Dhanbad. One case of pneumoconiosis he observed had just 3 years of exposure. He also found some association between pneumoconiosis and rheumatoid arthritis. Chakraborty (1961) from industrial hygiene study in underground mines found the mean concentration between 32-39 and 12.6 mppcf during process of pick mining by hand, manual loading, machine cutting and machine drilling. Higher concentrations of dust (40.1 – 44.64 mppcf) were found during blasting. The mean free silica contents of the moisture free coal dust in two mines were 3.36 and 4.3% respectively. Later on, in a survey of nine underground coal mines (Chakraborty 1967) found the dust levels ranging from 7.3 to 174 mppcf. Chief advisor of factories (1961) in a survey of 950 coal mines from 12 bituminous mines found 18.8% prevalence of simple pneumoconiosis and 3 cases of progressive massive fibrosis (PMF). Dust surveys revealed very high values in machine drilling (44-129 mppcf) and machine cutting (34-110 mppcf), moderate values in coal cutting, dressing and loading (11-56 mppcf) and lower values (2-23 mppcf) during other operations. Kapur (1965) studied radiographs of 246 coal miners taken during 1962 at Central Hospital, Dhanbad. He found radiological signs of pneumoconiosis in 1.3% of the radiographs. The scientists of Central Mining Research Station (CMRS) Dhanbad (1972) in a survey of 850 coal miners found 19 (2.23%) explicit case of pneumoconiosis and 54 (6.35%) suspected cases of pneumoconiosis. Viswanathan et al (1972) carried out a comprehensive survey of coal mine workers in Jharia area of Bihar. Out of 8824 miners radio logically examined, they found pneumoconiosis in 10.8%. The prevalence rate in 9 mines varied from 6.3% to 16.8%. The prevalence rate in



underground and surface workers was 12.7% and 5.1% respectively. No correlation was observed between dust levels and prevalence of pneumoconiosis. Patnaik and Parihar (1990) during periodical medical examination reported 144 cases of pneumoconiosis in South Eastern Coal Fields (SECL) it was further reported 137 (95%) cases with small opacities and 7 (5%) cases with large opacities with duration of exposure of less than 10 years.


The commonest occupational illness problems studied so far in Indian coal Mines is CWP or Silicosis. However, data on occupational illness due to exposure noise, heat, repetitive strain injuries (RSI), occupational dermatitis, and occupational eye illnesses are not available.

The present study was conducted in the coal industry with following objectives

- Environmental evaluation for total and respirable dust, free silica analysis, noise dosimetry, occupational vibration exposure and risk analysis, etc.
- Health status evaluation for occupational and non occupational illness
- Identifying suitable Intervention measures and strategies

The Study report is divided into three parts. These are

- 1) Environmental Studies in coal mines.
- 2) Epidemiological Studies of coal mine workers.
- 3) Medical studies of coal mine workers.



CHAPTER - I

Environmental Studies



1 Executive Summary

Dust survey: Respirable dust is a major environmental hazard in mines. The survey conducted by the Institute started with a mechanized coal mine to investigate into the respirable dust concentration in the mine air with a view to ascertain their hazard potential. A total of 10 area dust samples were collected from different workplaces of Kamptee opencast mines of Western Coalfields Limited (WCL).

The TWA for dust was calculated for an eight hours shift (as per Coal Mines Regulations, 1957 under The Mines Act, 1952) for the workplace activity. Dust levels in the mines were within the permissible limit (as recommended by DGMS i.e. 3 mg/m^3). The free silica content in the analyzed samples was too low to be determined by Standard Analytical Procedure.

As per CMR 123, the equation to calculate TWA permissible limit i.e. $15/(\% \text{ respirable quartz or Free silica})$ is applicable where the silica content in airborne respirable dust is $\geq 5\%$. But in all the samples collected during the study and analyzed for free silica (SiO_2) content were having free silica too low to be determined by Standard Analytical Procedures and sophisticated equipment like FTIR. Hence the TLV for the studied mines remains to be 3 mg/m^3 .

Noise Dozimetry was carried out in the mine for 26 persons engaged in major mining activities. Category wise distribution is shown below:

Table 1.1: Category-wise distribution for noise Dozimetry

Sr No.	Category	Number
1.	Dumper operator	8
2.	Shovel operator	8
3.	Dozer operator	3
4.	Motor grader operator	1
5.	Drill operator	2
6.	Crane operator	1
7.	Crusher operator	3
	TOTAL	26



Eight hours time weighted average (TWA) of noise exposure in dB(A) for different categories was considered for health risk assessment. DGMS has prescribed noise limits that are not to be exceeded to avert adverse health effects. The warning limit is set at 85 dB(A) while 90 dB(A) is called the danger limit.

Out of 26 samples collected and studied, it was observed that 11 (42.3%) cases showed noise level below 85 dB(A). Noise level exceeded 85 dB(A) in 8 (30.76 %) cases whereas 7 (26.92%) samples exceeded DGMS danger limit of 90 dB(A). The dumper operators are exposed to highest level of noise while the crane operator recorded lowest level of exposure.

Equipment Induced Human Vibration : Whole Body Vibration (WBV) was measured in all three orthogonal axes to determine the maximum magnitude along any axis. This was analysed using ISO 2631-1:1997 guidelines. The following was observed:

- A total no. of 18 equipment was studied. It was found that except 3 (16.67%) dozers, all other 15 (83.33%) machines had Z axis as their dominant axis of vibration. These dozers had maximum vibration along X axis.
- All equipment had crest factors above 9 indicating significant shock (Peak) values compared to r.m.s values.
- Shovels were found to be safest as far as WBV was concerned. None of them showed health risk either by r.m.s or by VDV method.
- All dozers (100%) studied under this project indicated health risk either by r.m.s or by VDV method. It means that caution should be taken to reduce the vibration magnitude to no risk level.



- One dumper (10%) out of total ten showed no health risk to their operators when analysed by both the methods. Six dumpers (60%) indicated risk when analysed by r.m.s. method whereas seven (70%) dumpers indicated health risk when all of them were studied using VDV method. Three (30%) dumpers had shown risk with maximum probability termed as “likely” when r.m.s method was used. But only two (20%) posed health risk with maximum probability when VDV method was used.

1. DUST SURVEY



1.1 Methodology

1.1.1 Selection of Sites:

A preliminary walk through survey was undertaken before carrying out the study. The scientists had gone through the entire mine during active production phase and observed the different locations in the mine.

Qualitative assessment was done at the workplace by interviewing employees and extracting technical and other relevant information with special reference to dust. Respirable dust samples were collected from the locations after consultation with the Mine Manager.

1.1.2 Sampling Schedule:

A team of scientists from NIMH visited Kamptee opencast coal mine located in Nagpur district of Maharashtra State and collected 10 (ten) area samples between 13/10/2006 – 16/10/2006.

1.1.3 Environmental Monitoring:

As a part of environmental monitoring, the following equipment and accessories were used for collection of respirable dust for area monitoring at the work place.

1.1.4 Equipment:

- Personal Dust Sampler Pump with charger and other accessories.



- For dust collection 37 -mm cassette filter holder holding Polyvinyl Chloride filter of 37-mm diameter with pore size of 5.0- μ m supported with backup pad in a two and three-piece cassette was used.
- Pre and post calibration of personal samplers was carried out by flow meter calibrator.
- Aluminum cyclones were used for respirable dust collection.
- The sampling head holders were used to keep the cassette, cyclone, and coupler together as well as to facilitate the air to enter only from the cyclone inlet.
- Digital single pan analytical balance (of Shimadzu having range of 0.001 mg to 5200 mg) was used for pre and post weighing of the filters.
- Fourier Transform Infrared Spectrophotometer (of BOMEM make) with die was used for finding out the percentage of free silica.
- Laboratory press (hydraulic) was used for preparation of KBr pellets of the digested samples.
- Muffle furnace was used for digestion of various samples.
- Porcelain crucibles were used for digestion of various samples.
- Mortar and pestle, 50 mm agate was used for mixing.
- Metal spatula was used for transferring KBr while making pellets.
- Non-serrate, non-magnetic forceps were used to handle the filter papers to keep them free from human touch as well as any source of error.



-
- Pellets were stored in desiccators to protect them from moisture.
- Prior to preparing each pallet, to protect the mixture from contamination, laboratory grade alcohol was used.
- To prepare the pellets, KBr was weighed by using tissue paper.

1.1.5 Methodology of Sampling:

- Before initiating field study each filter was weighed on a digital single pan balance model Shimadzu AW 220 and labeled in Occupational Hygiene laboratory of NIMH, Nagpur.
- The filter cassette with holder was used to hold the filter tightly in place during sampling. The cassette consists of an inlet and an outlet with all three sections. A cellulose support pad was placed in the outlet of the cassette with the PVC filter. The Aluminum cyclone was attached with cassette.
- The filter cassette was attached to the pump and the pump was turned on to run for several minutes.
- Before sampling each personal sampling pump was calibrated
- The source monitoring (area) was carried out by keeping the sampler at a distance of 5 to 15 m from the area of dust generation.
- After sampling, the pump was calibrated again and the actual flow rate was noted in the data sheet.
- The collected sample was carefully preserved and taken to the institute for analysis.



1.2 Methodology for Analysis:

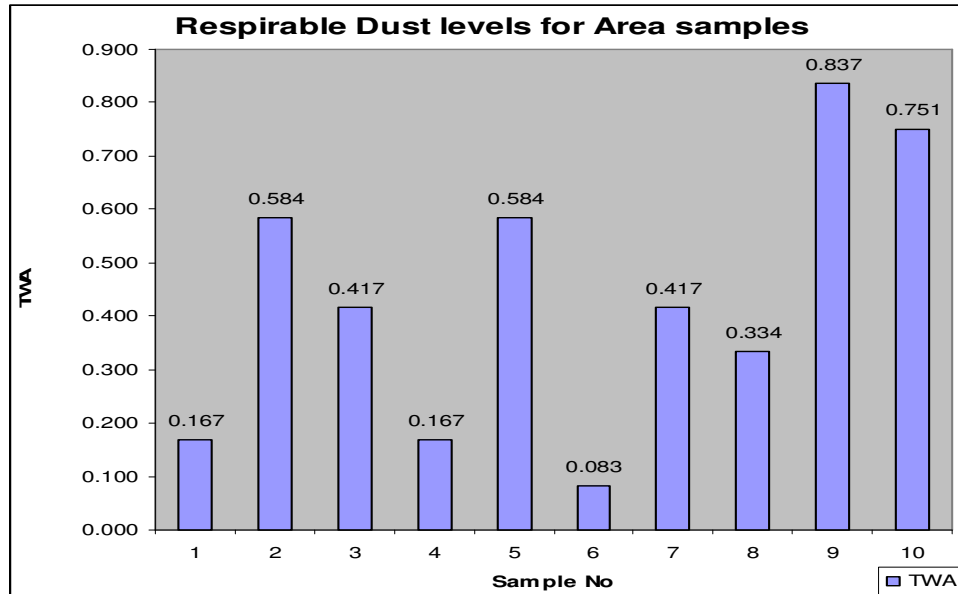
- Fourier Transform Infra-Red Spectroscopy was used for free silica analysis of dust samples collected from mine and brought to the laboratory.
- The filter samples and blank were placed in porcelain crucibles, loosely covered with porcelain dish and were ashed in muffle furnace for 3 hours at 600 °C.
- Each time, each accessory was washed with ethanol for removing the contamination.
- The bottle of KBr was dried overnight at 110 °C in an oven. KBr (0.2 mg) was weighed and added directly to each sample. The sample ash and KBr were mixed thoroughly. The material was transferred to mortar for complete mixing.
- The mixture was transferred to a 13 mm evacuable pellet die using butter paper and camel's hair brush. A pellet was pressed using standard technique.
- The pellet was analyzed qualitatively by using FTIR technique.
- The percentage of free silica was quantitatively analyzed and the concentration of free silica was calculated.

A total of 10 area samples were collected from the Kamptee mines. These samples were analyzed at Central Laboratory NIMH, Nagpur. The results of the area samples are depicted in Table 1.2.



Table 1.2: Result of area respirable dust monitoring studies

Sr. No.	Area/Location	Operation	TWA for Respirable dust mg/m ³
1.	Loading Plant near shovel operation	Shovelling	0.167
2.	Coal face during loading operation	Loading	0.584
3.	Coal Stockyard	Loading	0.417
4.	Loading Point near shovel operation	Loading and shovelling	0.167
5.	Coal Handling Plant	Coal Handling	0.584
6.	Haul Road Junction	Coal transportation	0.083
7.	Drill operation (between 2 drills)	Drilling	0.417
8.	On haul road of Loading point (interior)	Coal transportation	0.334
9.	Beginning of haul road of loading point	Coal transportation	0.837
10.	Loading Point during shovelling	Loading and shovelling	0.751



Graph – 1.1



1.3 Free Silica Analysis

All the dust samples were qualitatively analyzed for free silica (quartz) at 798 cm^{-1} wave number. But no doublet peak characteristic of silica was observed in any of the samples. Thus it can be safely concluded that free silica concentration was below the detection limit (BDL).

1.4 Observations

All dust samples were analyzed for free silica content. The free silica content in the samples was too low to be determined by using Standard Analytical Procedures (SAP) and equipment.

The TWA levels of all the collected samples were within the Permissible Exposure Limits as suggested by DGMS.

1.5 Results and Discussions

Table 1 and Graph 1 show the TWA of dust samples collected at OCM Kamptee. The TWA for dust was calculated for an eight hours shift (as per The Mines Act, 1952) for the workplace activity. Dust levels in the mines were within the permissible limit (as recommended by DGMS i.e. 3 mg/m^3). The free silica content in the analyzed samples was too low to be determined by Standard Analytical Procedure.

As per MMR 124, the equation to calculate TWA permissible limit i.e. $15/(\% \text{ respirable quartz or Free silica})$ is applicable where the silica content in airborne respirable dust is $\geq 5\%$. But in all the samples collected during the study and analyzed for free silica (SiO_2) content were having free silica too low to be determined by Standard Analytical Procedures and sophisticated equipment like FTIR. Hence the TLV for the studied mines remains to be 3 mg/m^3 .



1.6 Conclusion

- A total of 10 area samples were collected from different locations of OCM Kamptee.
- It was observed that the Time Weighted Average permissible limit for respirable dust in all the sampled locations was within the limits prescribed by DGMS, i.e. 3 mg/m^3 (As per CMR 123).
- It was observed that the free silica content in all the analyzed samples on FTIR was too low to be determined by using Standard Analytical Procedures (SAPs) and equipment like FTIR.

2. NOISE SURVEY



2.1 Sampling Schedule:

The scientific team of NIMH visited Kamptee opencast coal mine located in Nagpur district of Maharashtra State and collected 26 (twenty six) personal noise samples between 13/10/2006 – 14/12/2006

2.2 Equipment:

- To measure the noise levels to which the miners at Kamptee opencast coal mine were exposed, systematic personal noise Dozimetry studies were carried out for the specified operators.
- Noise Dosimeter (Quest Technologies-Q 500- Type 1) was used for personal noise Dozimetry sampling.

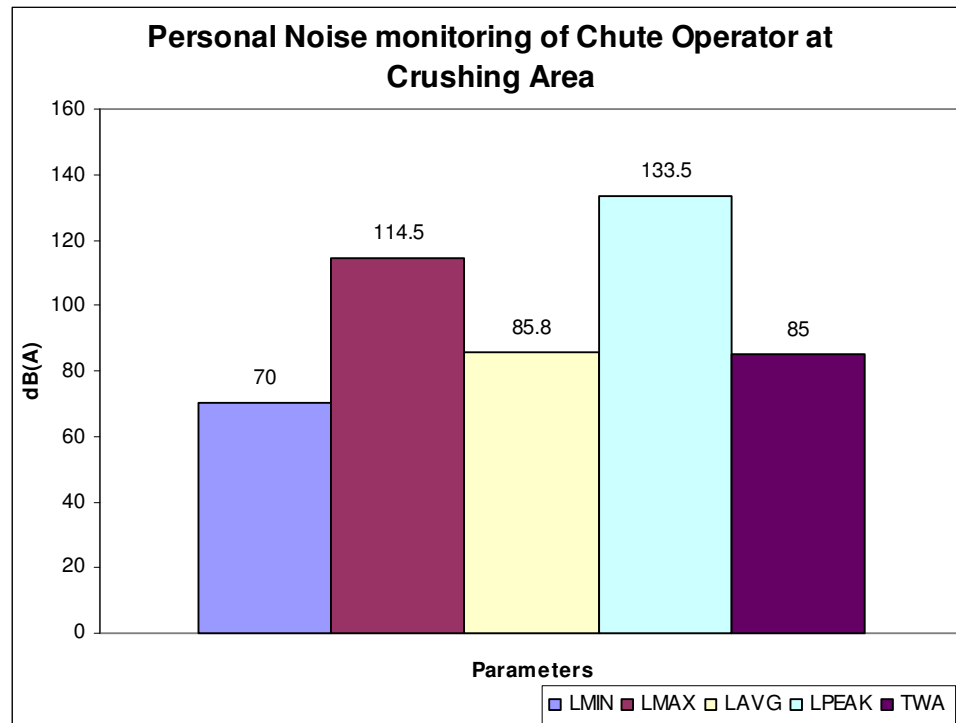
2.3 Methodology for Personal Noise Dozimetry:

- For conducting the personal noise dosimetry survey, Noise dosimeters (Q 500 - Type 1) were used.
- The Noise Dosimeter was attached to the worker in such a manner that it neither interfered with his safety nor with his work while performing his normal duties. The sensor of the instrument was clipped at the collar of the worker so that it didn't hinder either with his movement or his safety.
- The survey was carried out by attaching the Noise Dosimeter to the worker for an entire working shift.
- The logging interval of the Noise Dosimeter was set at 1 minute with an Exchange rate of 5 dB and with the "Slow" response in "A" weighting.
- The Noise levels were measured on slow setting (500 msec^{-1}), which in precision grade instruments conforms to ISO standards (1979).
- All these settings were in compliance with the OSHA standards.



- In India DGMS Circular No. 18 Tech. 75 has prescribed the permissible noise level of 90 dB (A) in a shift of 8 hours for unprotected ear.
- The “warning limit” as per DGMS has been fixed at 85 dB(A).
- Graphs 1 - 10 represent the findings of the Noise Dosimetry Survey graphically.

2.4 Results and Discussions:

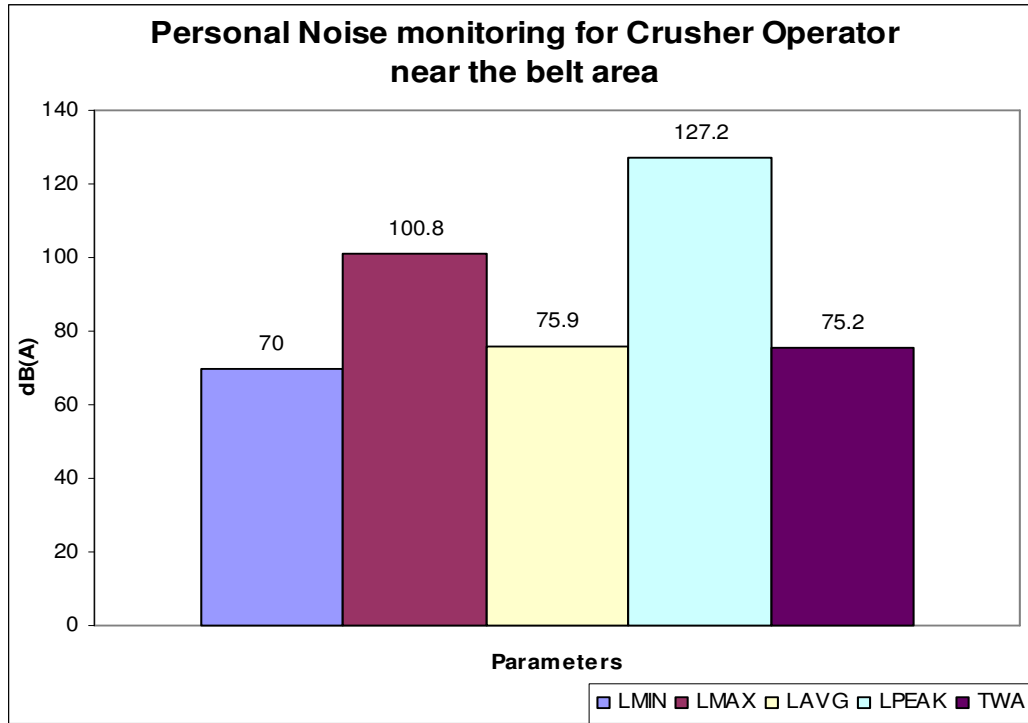


Graph – 2.1



S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
1.	Chute Operator in Crushing Area Mr. Ramdev Dayal (Emp. No. 11)	13/10/06	1 st shift	70.0	114.5	85.8	133.5	85.0

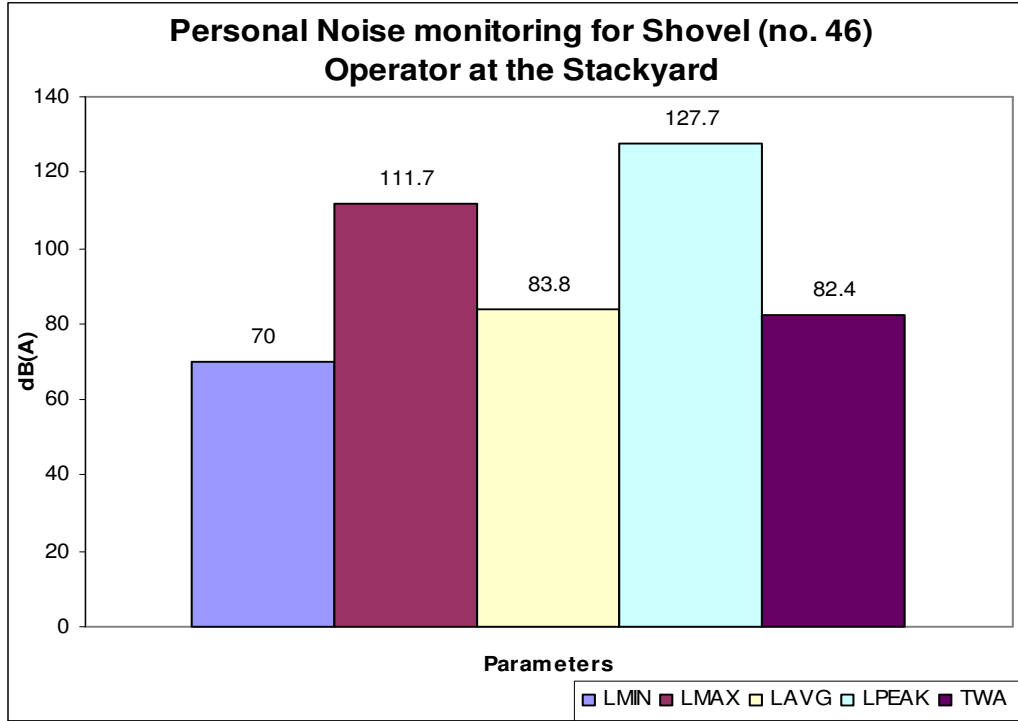
The noise levels were observed to be in the range of 70.0 dB(A) – 114.5 dB(A) for the Chute Operator in Crushing Area. The L_{AVG} was observed to be 85.8 dB(A) and the L_{PEAK} was observed to be 133.5 dB(A). The Time Weighted Average for the entire shift was observed to be 85.0 dB(A), which is equal to the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.2

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
2.	Crusher operator near the belt area Mr. P. P. Skariah (Emp. No.180529 85)	13/10/06	1 st shift	70.0	100.8	75.9	127.2	75.2

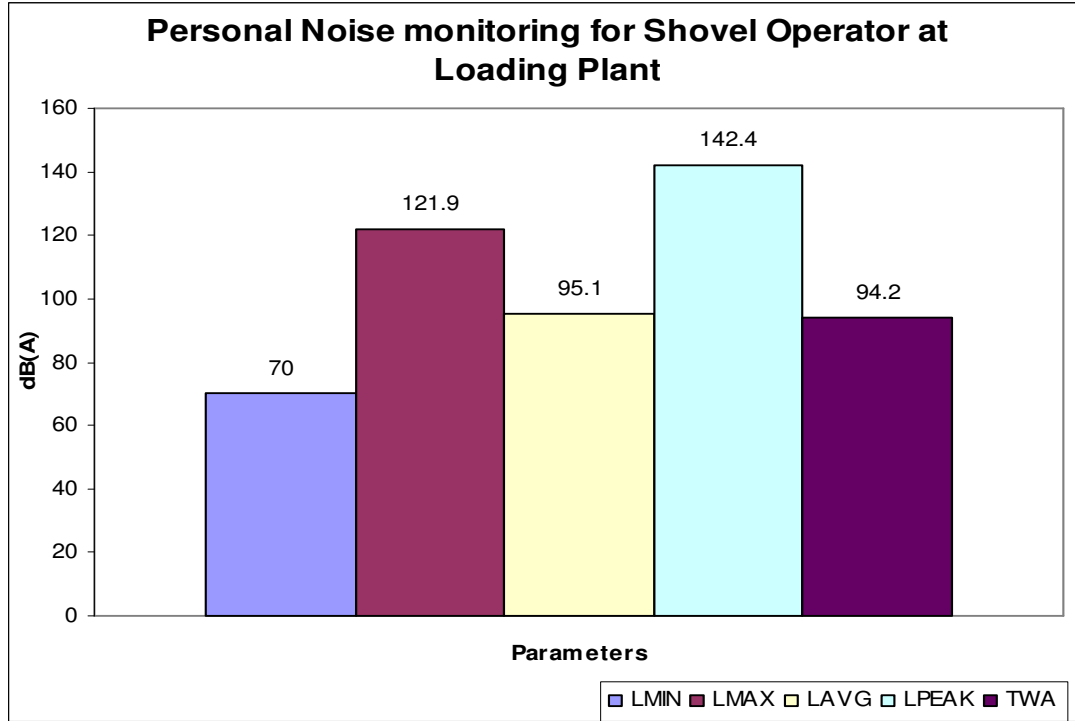
The noise levels were observed to be in the range of 70.0 dB(A) – 100.8 dB(A) for the Crusher Operator near the belt area. The L_{AVG} was observed to be 75.9 dB(A) and the L_{PEAK} was observed to be 127.2 dB(A). The Time Weighted Average for the entire shift was observed to be 75.2 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.3

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
3.	Shovel (no. 46) Operator Mr. Shankar	13/10/06	1 st shift	70.0	111.7	83.8	127.7	82.4

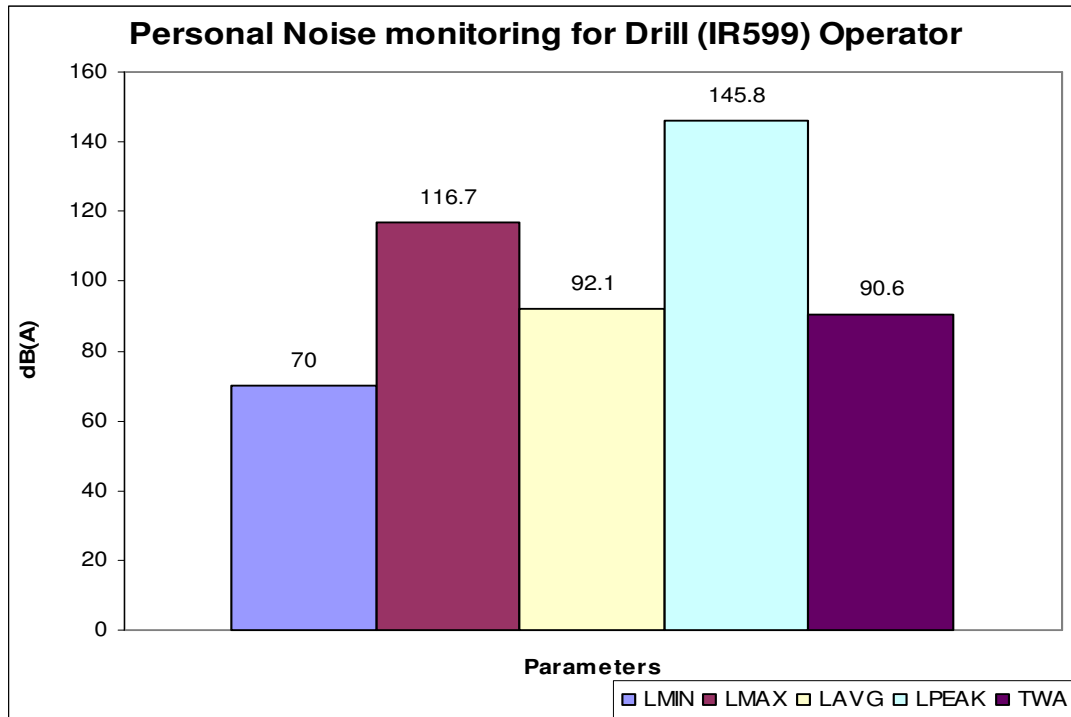
The noise levels were observed to be in the range of 70.0 dB(A) – 111.7 dB(A) for the Shovel (no. 46) Operator. The L_{AVG} was observed to be 83.8 dB(A) and the L_{PEAK} was observed to be 127.7 dB(A). The Time Weighted Average for the entire shift was observed to be 82.4 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.4

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
4.	Shovel Operator at Loading Plant Mr. Suresh Chowdhary	13/10/06	1 st shift	70.0	121.9	95.1	142.4	94.2

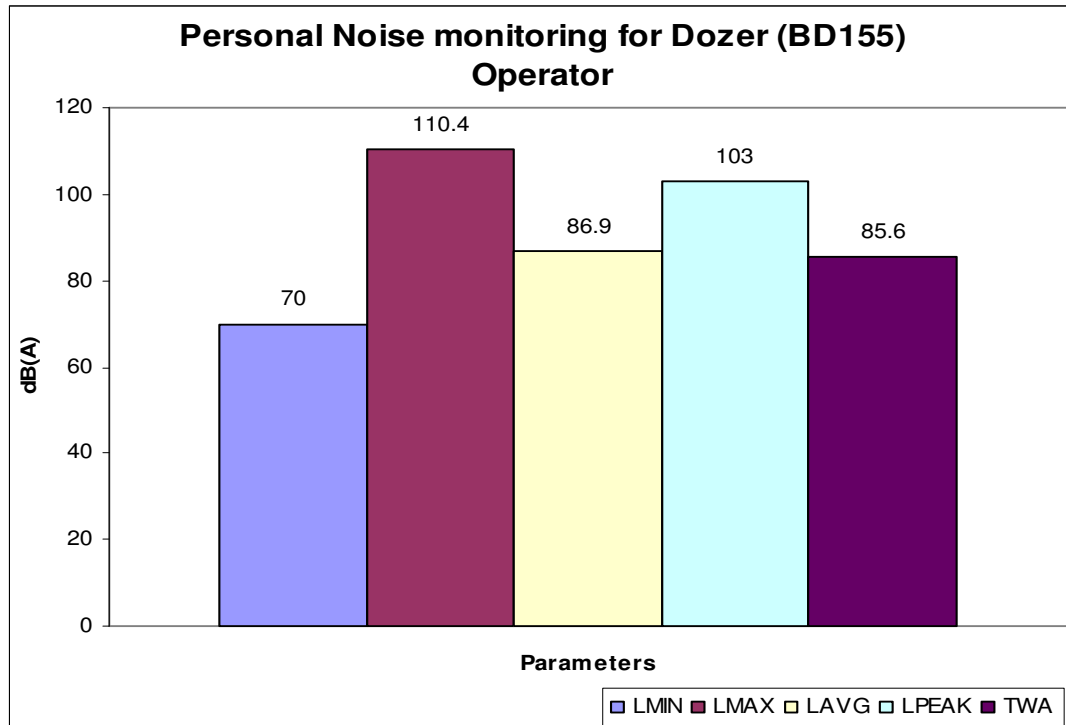
The noise levels were observed to be in the range of 70.0 dB(A) – 121.9 dB(A) for the Shovel Operator at the Loading Plant. The L_{AVG} was observed to be 95.1 dB(A) and the L_{PEAK} was observed to be 142.4 dB(A). The Time Weighted Average for the entire shift was observed to be 94.2 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.5

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
5.	Drill (IR599) Operator Mr. Ashok Yeshwant	16/10/06	1 st shift	70.0	116.7	92.1	145.8	90.6

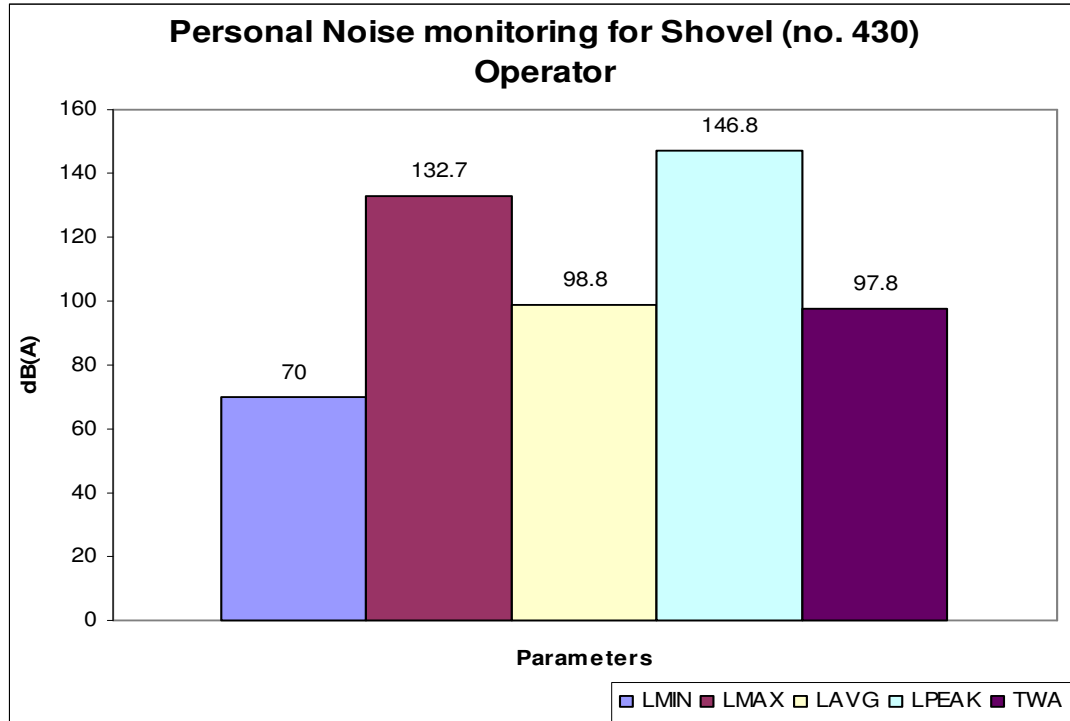
The noise levels were observed to be in the range of 70.0 dB(A) – 116.7 dB(A) for the Drill (IR599) Operator. The L_{AVG} was observed to be 92.1 dB(A) and the L_{PEAK} was observed to be 145.8 dB(A). The Time Weighted Average for the entire shift was observed to be 90.6 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.6

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
6.	Dozer (BD155) Operator Mr. Maharaj Din	16/10/06	1 st shift	70.0	110.4	86.9	103.0	85.6

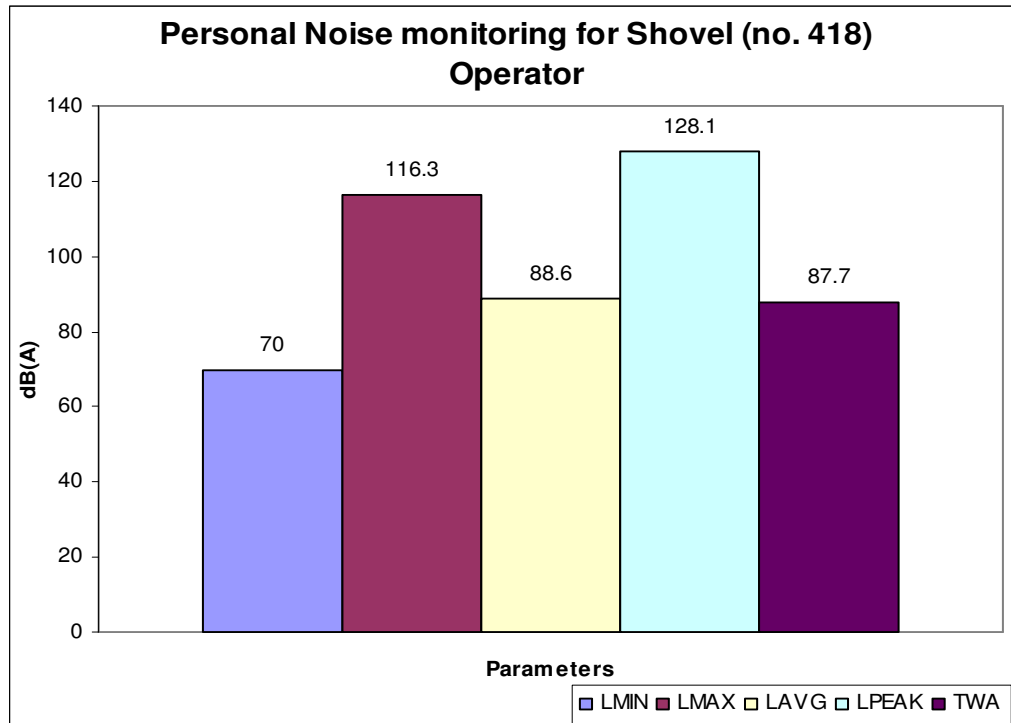
The noise levels were observed to be in the range of 70.0 dB(A) – 110.4 dB(A) for the Dozer (BD155) Operator. The L_{AVG} was observed to be 86.9 dB(A) and the L_{PEAK} was observed to be 103.0 dB(A). The Time Weighted Average for the entire shift was observed to be 85.6 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.7

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
7.	Shovel (no. 430) Operator	16/10/06	1 st shift	70.0	132.7	98.8	146.8	97.8

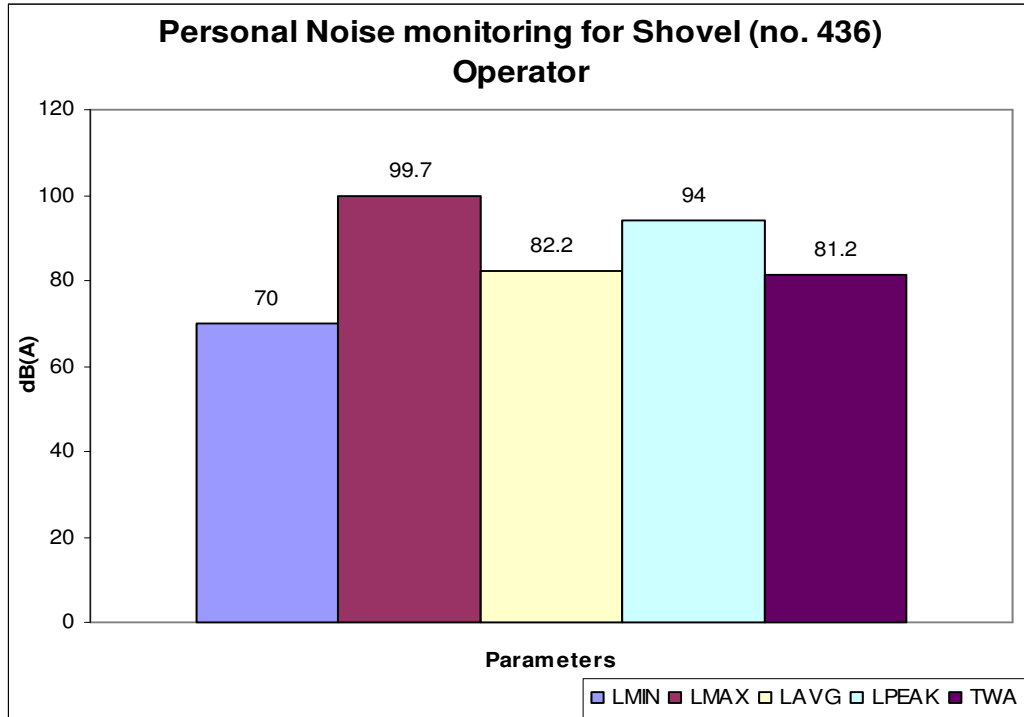
The noise levels were observed to be in the range of 70.0 dB(A) – 132.7 dB(A) for the Shovel (no. 430) Operator. The L_{AVG} was observed to be 98.8 dB(A) and the L_{PEAK} was observed to be 146.8 dB(A). The Time Weighted Average for the entire shift was observed to be 97.8 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.8

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
8.	Shovel (no. 418) Operator Mr. Ram Dayal	16/10/06	1 st shift	70.0	116.3	88.6	128.1	87.7

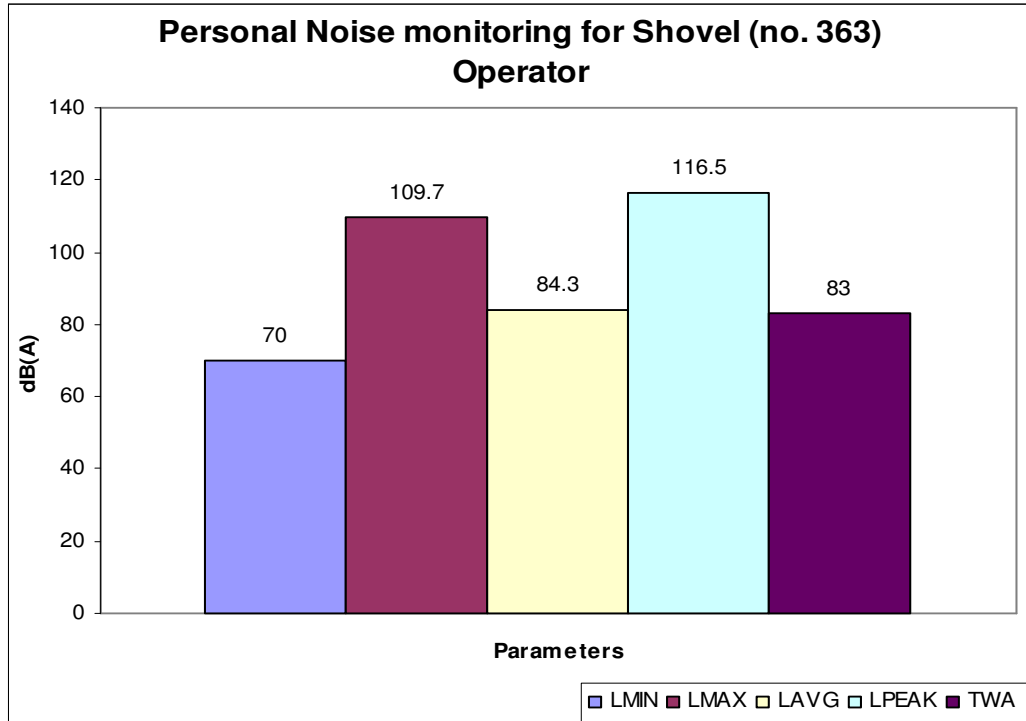
The noise levels were observed to be in the range of 70.0 dB(A) – 116.3 dB(A) for the Shovel (no. 418) Operator. The L_{AVG} was observed to be 88.6 dB(A) and the L_{PEAK} was observed to be 128.1 dB(A). The Time Weighted Average for the entire shift was observed to be 87.7 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.9

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
9.	Shovel (no. 436) Operator	16/10/06	1 st shift	70.0	99.7	82.2	94.0	81.2

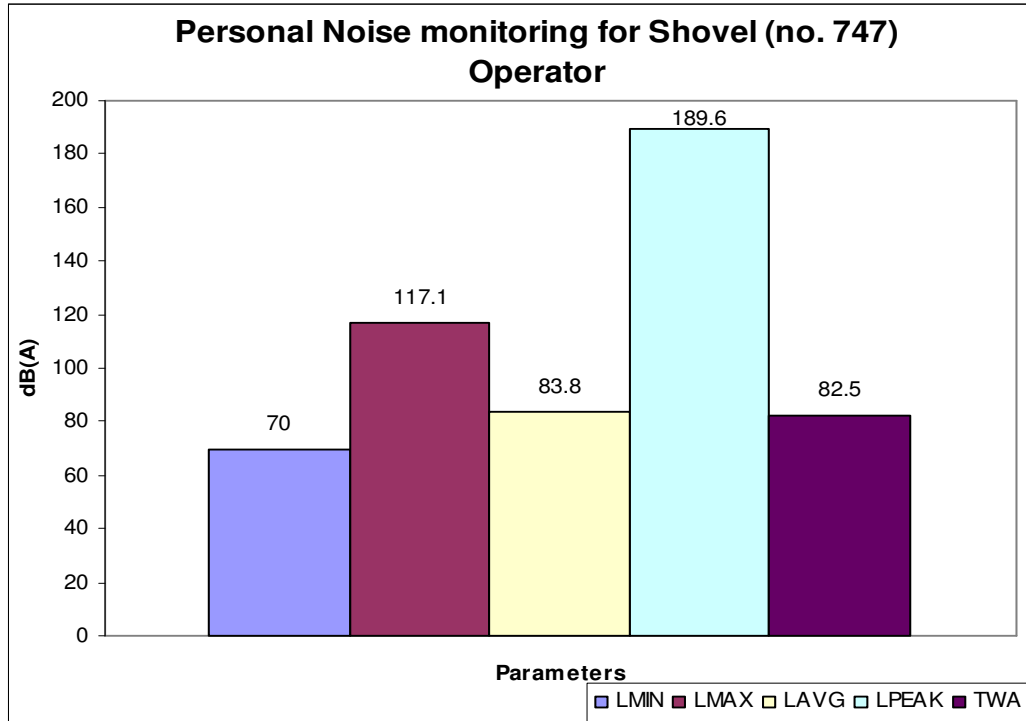
The noise levels were observed to be in the range of 70.0 dB(A) – 99.7 dB(A) for the Shovel (no. 436) Operator. The L_{AVG} was observed to be 82.2 dB(A) and the L_{PEAK} was observed to be 94.0 dB(A). The Time Weighted Average for the entire shift was observed to be 81.2 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.10

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
10.	Shovel (no. 363) Operator Mr. Shyam Kumar	16/10/06	1 st shift	70.0	109.7	84.3	116.5	83.0

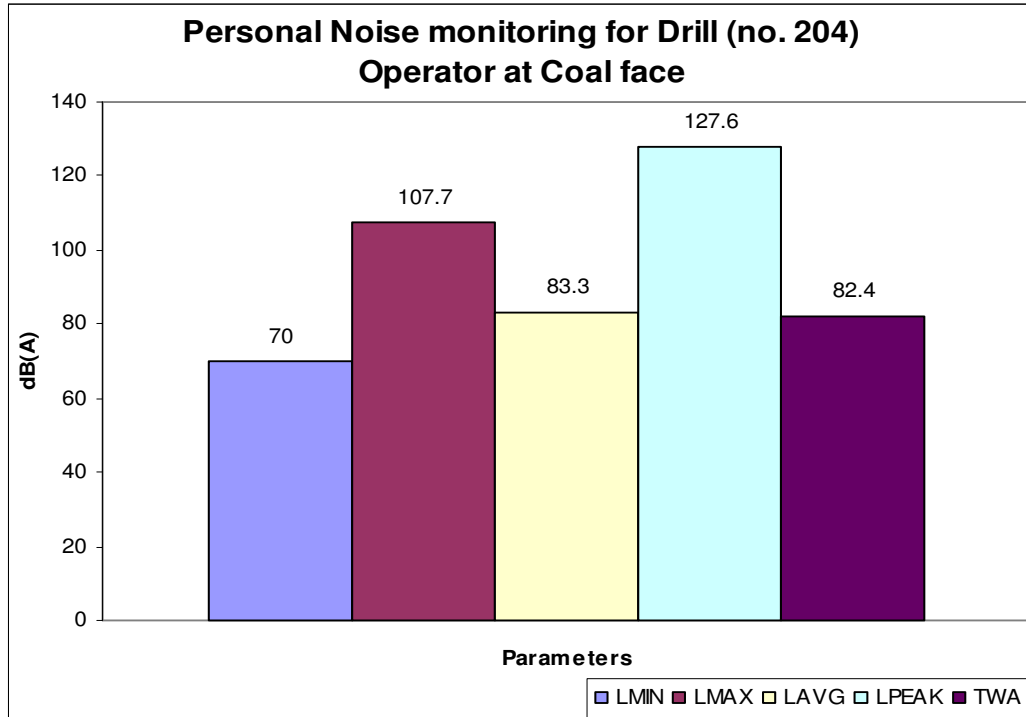
The noise levels were observed to be in the range of 70.0 dB(A) – 109.7 dB(A) for the Shovel (no. 363) Operator. The L_{AVG} was observed to be 84.3 dB(A) and the L_{PEAK} was observed to be 116.5 dB(A). The Time Weighted Average for the entire shift was observed to be 83.0 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.11

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
11.	Shovel (no. 747) Operator Mr. Tusshar	16/10/06	1 st shift	70.0	117.1	83.8	189.6	82.5

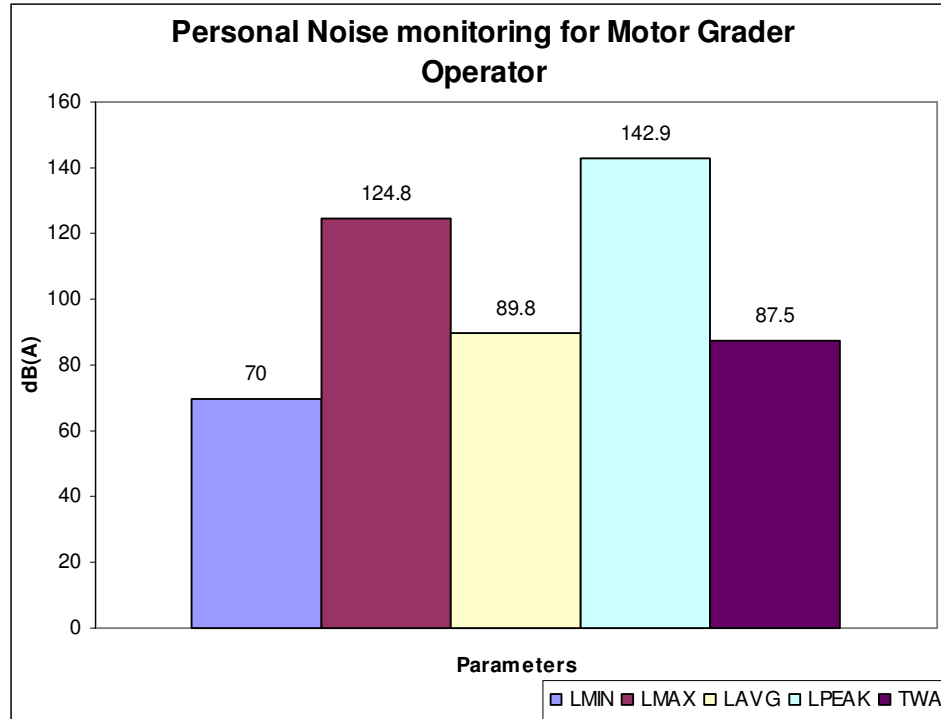
The noise levels were observed to be in the range of 70.0 dB(A) – 117.1 dB(A) for the Shovel (no. 747) Operator. The L_{AVG} was observed to be 83.8 dB(A) and the L_{PEAK} was observed to be 189.6 dB(A). The Time Weighted Average for the entire shift was observed to be 82.5 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.12

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
12.	Drill (no. 204) Operator at Coal face Mr. Krishna	1/12/06	1 st shift	70.0	107.7	83.3	127.6	82.4

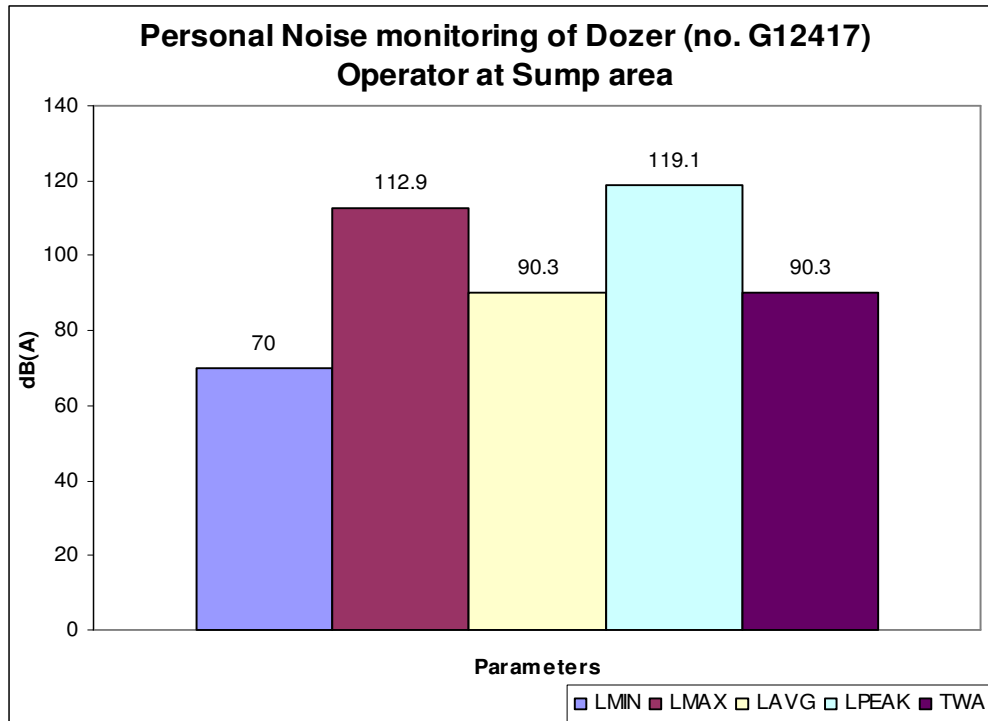
The noise levels were observed to be in the range of 70.0 dB(A) – 107.7 dB(A) for the Drill (no. 204) Operator at the coal face. The L_{AVG} was observed to be 83.3 dB(A) and the L_{PEAK} was observed to be 127.6 dB(A). The Time Weighted Average for the entire shift was observed to be 82.4 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.13

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
13.	Motor Grader Operator Mr. Kishorilal Arora (Emp. No. 18050559)	1/12/06	1 st shift	70.0	124.8	89.8	142.9	87.5

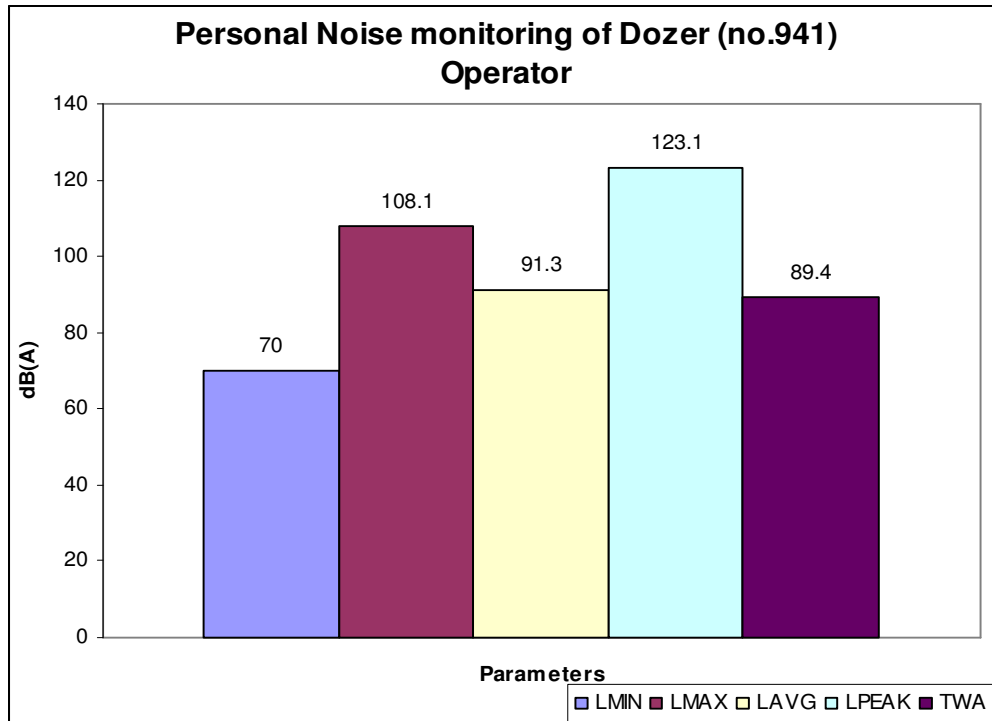
The noise levels were observed to be in the range of 70.0 dB(A) – 124.8 dB(A) for the Motor Grader Operator. The L_{AVG} was observed to be 89.8 dB(A) and the L_{PEAK} was observed to be 142.9 dB(A). The Time Weighted Average for the entire shift was observed to be 87.5 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.14

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
14.	Dozer (no. G12417) Operator at Sump area Mr. Shival Pararkar (Emp. No. 18050690)	1/12/06	1 st shift	70.0	112.9	90.3	119.1	90.3

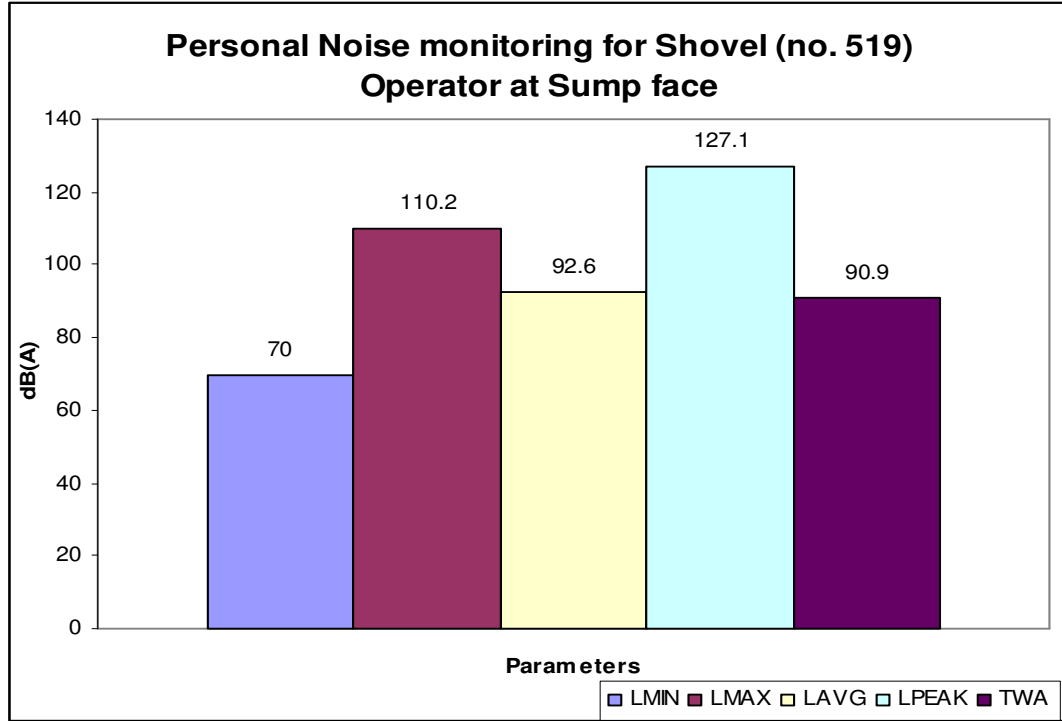
The noise levels were observed to be in the range of 70.0 dB(A) – 112.9 dB(A) for the Dozer (no. G12417) Operator at the Sump area. The L_{AVG} was observed to be 90.3 dB(A) and the L_{PEAK} was observed to be 119.1 dB(A). The Time Weighted Average for the entire shift was observed to be 90.3 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.15

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
15.	Dozer (no. 941) Operator Mr. Dev Sharan (Emp. No. 18202127)	1/12/06	1 st shift	70.0	108.1	91.3	123.1	89.4

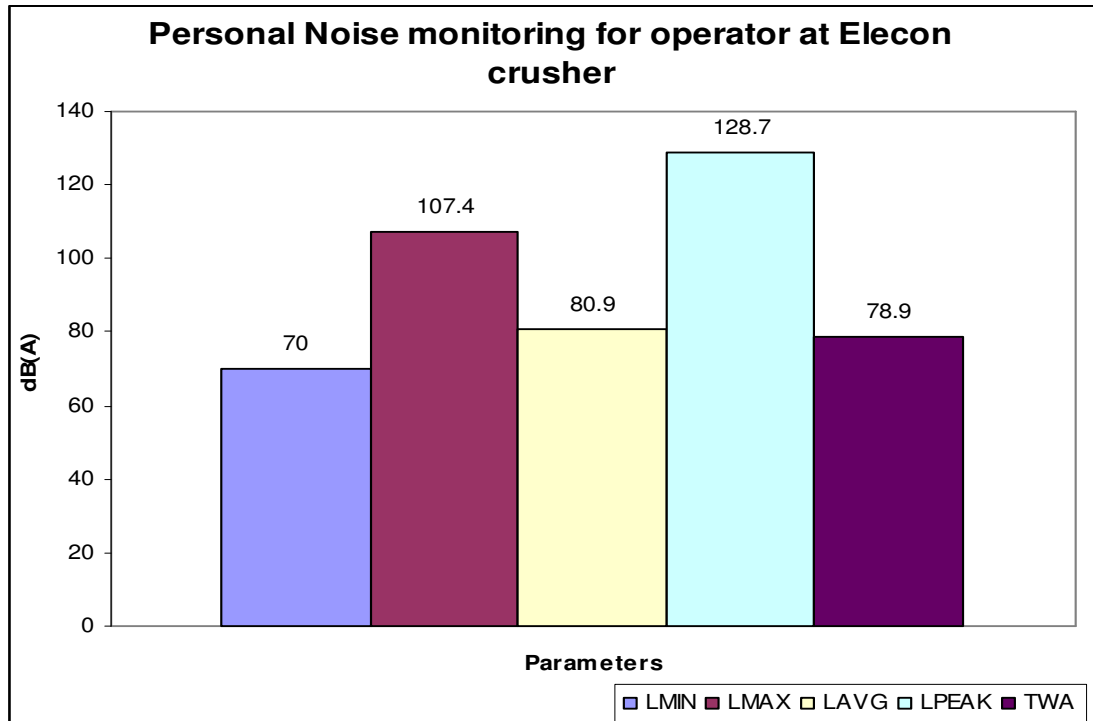
The noise levels were observed to be in the range of 70.0 dB(A) – 108.1 dB(A) for the Dozer (no. 941) Operator. The L_{AVG} was observed to be 91.3 dB(A) and the L_{PEAK} was observed to be 123.1 dB(A). The Time Weighted Average for the entire shift was observed to be 89.4 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.16

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
16.	Shovel (no. 519) Operator at Sump face Mr. Sambhu Prasad (Emp. No. 18106450)	1/12/06	1 st shift	70.0	110.2	92.6	127.1	90.9

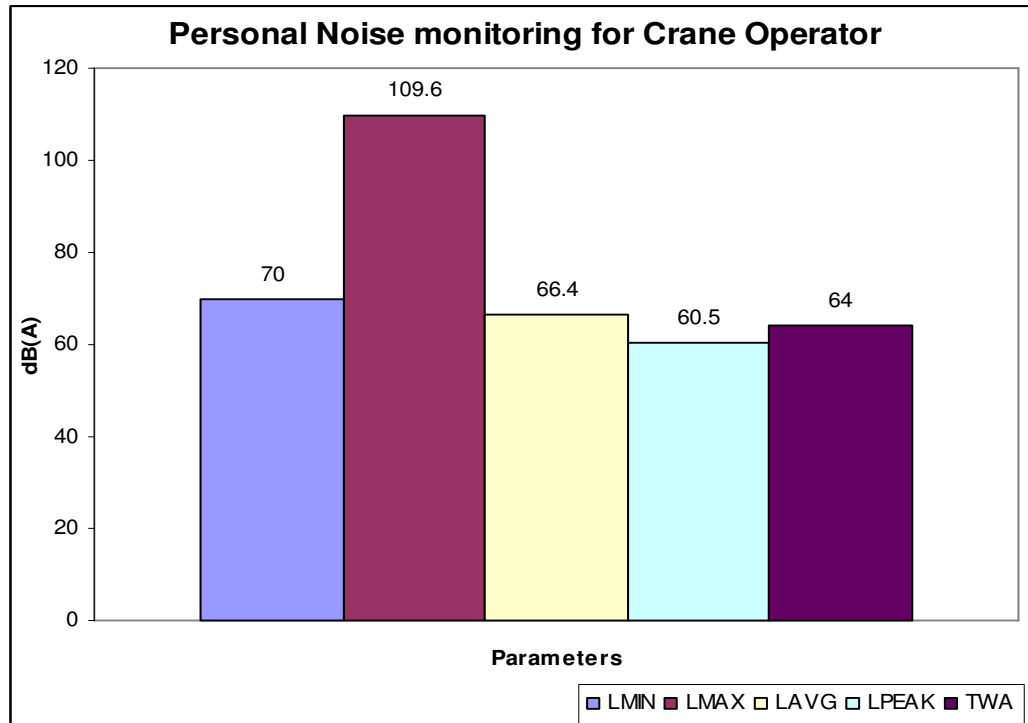
The noise levels were observed to be in the range of 70.0 dB(A) – 110.2 dB(A) for the Shovel (no. 519) Operator at the Sump face. The L_{AVG} was observed to be 92.6 dB(A) and the L_{PEAK} was observed to be 127.1 dB(A). The Time Weighted Average for the entire shift was observed to be 90.9 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.17

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
17.	Operator at ELECON Crusher Mr. Dharandas Shahdev Emp. No. 18070953)	1/12/06	1 st shift	70.0	107.4	80.9	128.7	78.9

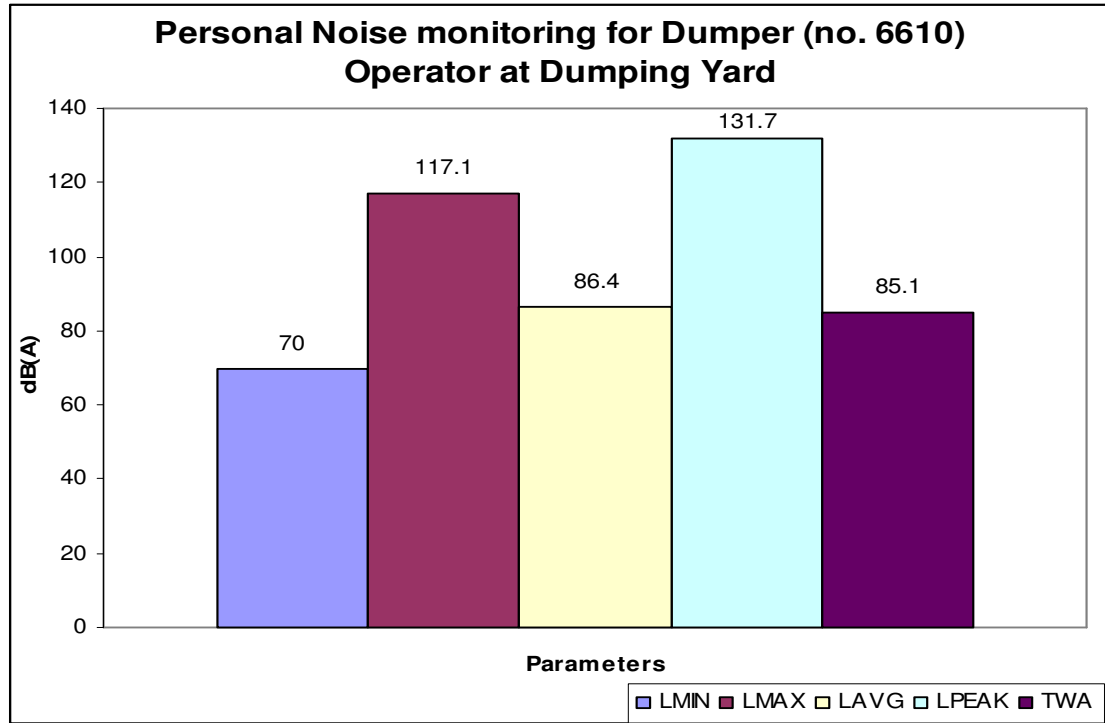
The noise levels were observed to be in the range of 70.0 dB(A) – 107.4 dB(A) for the Operator at the ELECON Crusher. The L_{AVG} was observed to be 80.9 dB(A) and the L_{PEAK} was observed to be 128.7 dB(A). The Time Weighted Average for the entire shift was observed to be 78.9 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.18

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
18.	Crane Operator Mr. Ram Shringare (Emp. No. 49)	1/12/06	1 st shift	70.0	109.6	66.4	60.5	64.0

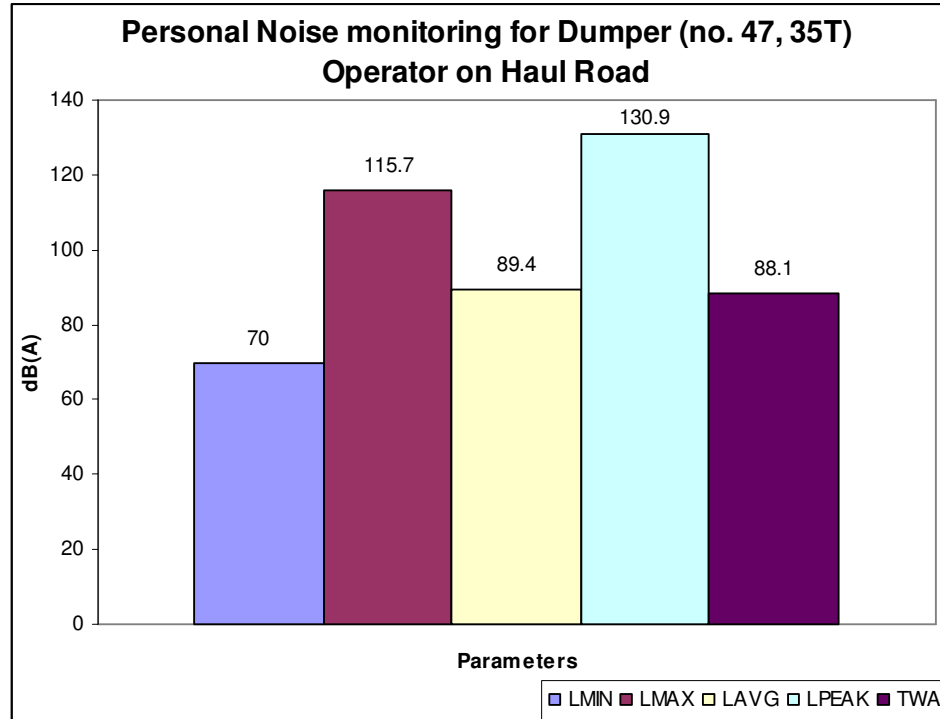
The noise levels were observed to be in the range of 70.0 dB(A) – 109.6 dB(A) for the Crane Operator. The L_{AVG} was observed to be 66.4 dB(A) and the L_{PEAK} was observed to be 60.5 dB(A). The Time Weighted Average for the entire shift was observed to be 64.0 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.19

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
19.	Dumper (no. 6610) Operator Mr. S. L. Dwivedi (Emp. No. 877)	14/12/06	1 st shift	70.0	117.1	86.4	131.7	85.1

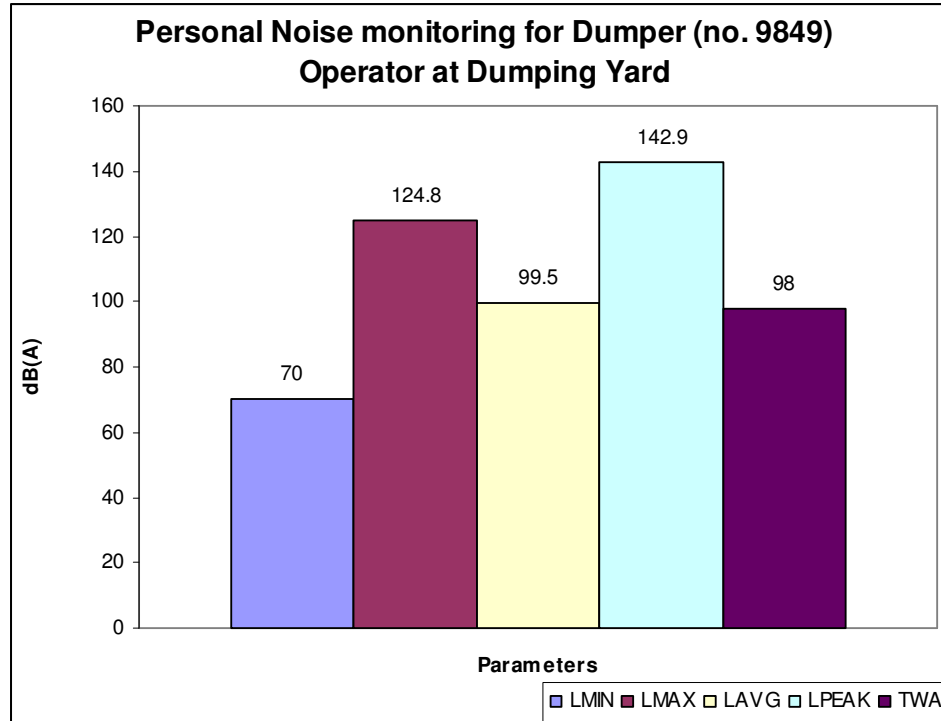
The noise levels were observed to be in the range of 70.0 dB(A) – 117.1 dB(A) for the Dumper (no. 6610) Operator. The L_{AVG} was observed to be 86.4 dB(A) and the L_{PEAK} was observed to be 131.7 dB(A). The Time Weighted Average for the entire shift was observed to be 85.1 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.20

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
20.	Dumper (no. 47) Operator Mr. Ashok	14/12/06	1 st shift	70.0	115.7	89.4	130.9	88.1

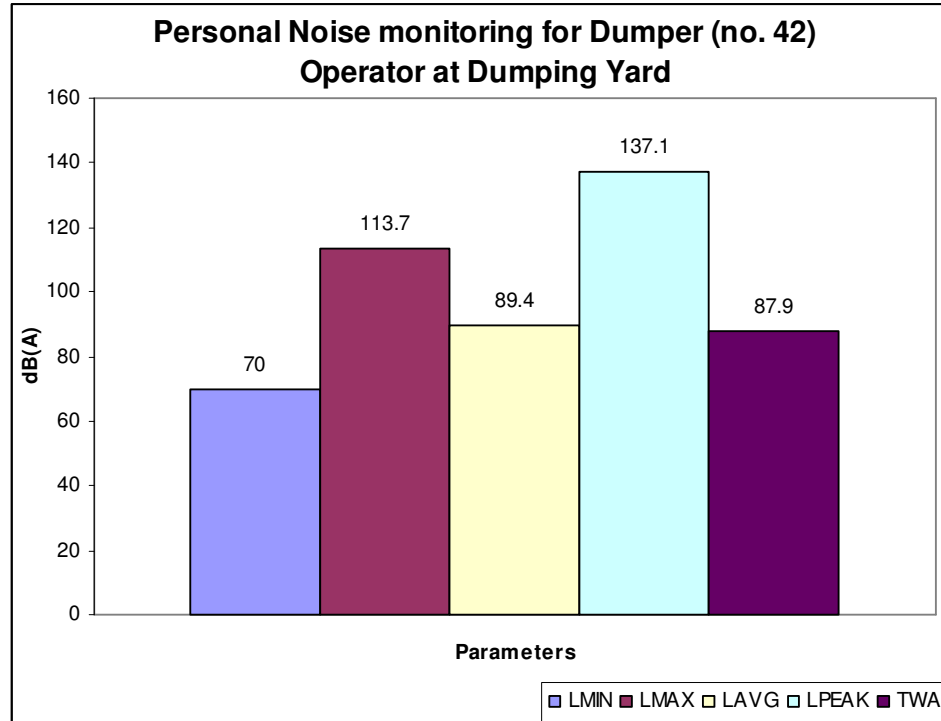
The noise levels were observed to be in the range of 70.0 dB(A) – 115.7 dB(A) for the Dumper (no. 47) Operator. The L_{AVG} was observed to be 89.4 dB(A) and the L_{PEAK} was observed to be 130.9 dB(A). The Time Weighted Average for the entire shift was observed to be 88.1 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.21

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
21.	Dumper (no. 9849) Operator Mr. Billan Shah (Emp. No. 1210)	14/12/06	1 st shift	70.0	124.8	99.5	142.9	98.0

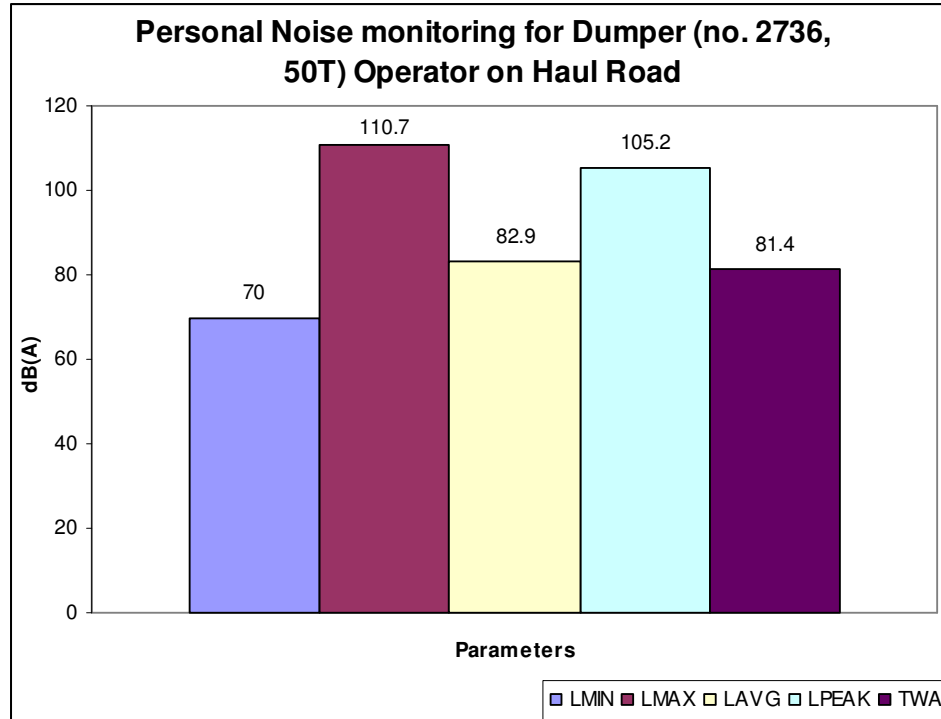
The noise levels were observed to be in the range of 70.0 dB(A) – 124.8 dB(A) for the Dumper (no. 9849) Operator. The L_{AVG} was observed to be 99.5 dB(A) and the L_{PEAK} was observed to be 142.9 dB(A). The Time Weighted Average for the entire shift was observed to be 98.0 dB(A), which exceeds the Danger Limit of 90 dB(A) prescribed by DGMS.



Graph 2.22

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
22.	Dumper (no. 42) Operator Mr. Ravichand Gajanan (Emp. No. 815)	14/12/06	1 st shift	70.0	113.7	89.4	137.1	87.9

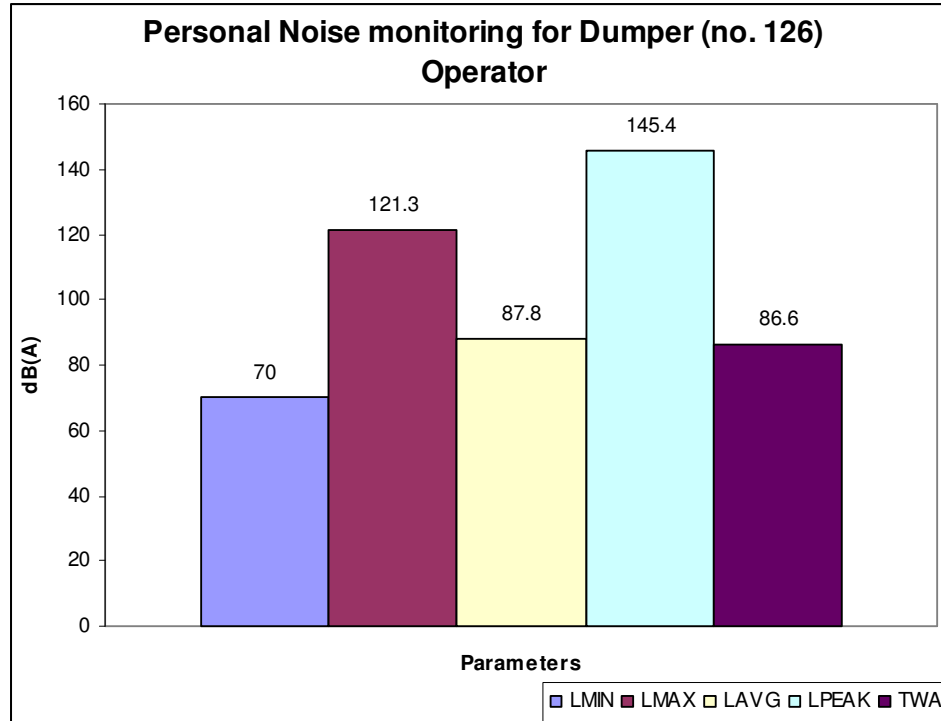
The noise levels were observed to be in the range of 70.0 dB(A) – 113.7 dB(A) for the Dumper (no. 42) Operator. The L_{AVG} was observed to be 89.4 dB(A) and the L_{PEAK} was observed to be 137.1 dB(A). The Time Weighted Average for the entire shift was observed to be 87.9 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.23

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
23.	Dumper (no. 2736) Operator Mr. Gopal Singh	14/12/06	1 st shift	70.0	110.7	82.9	105.2	81.4

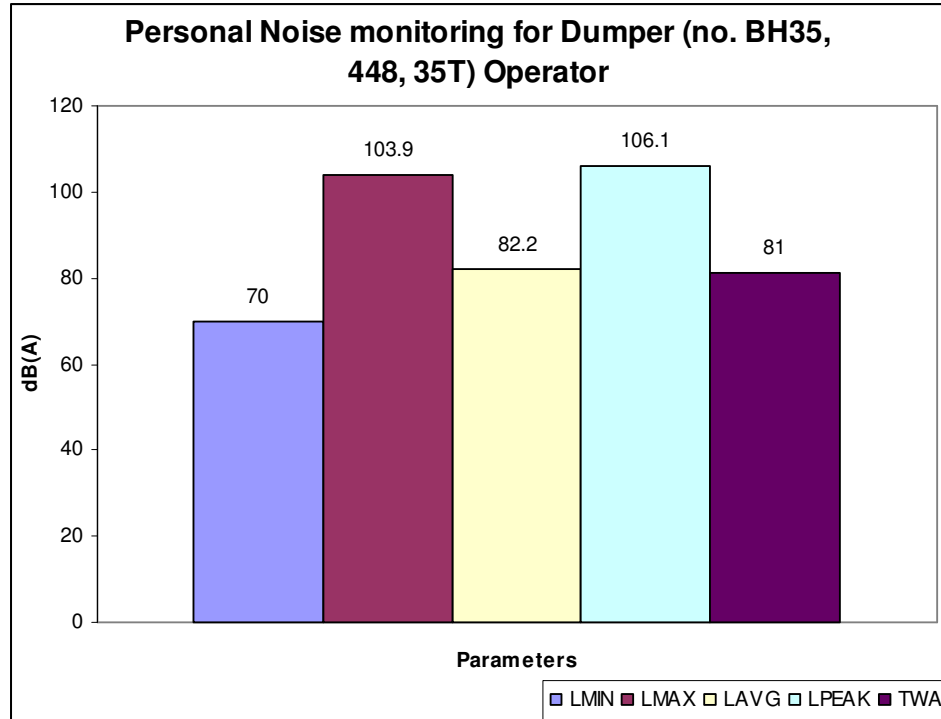
The noise levels were observed to be in the range of 70.0 dB(A) – 110.7 dB(A) for the Dumper (no. 2736) Operator. The L_{AVG} was observed to be 82.9 dB(A) and the L_{PEAK} was observed to be 105.2 dB(A). The Time Weighted Average for the entire shift was observed to be 81.4 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.24

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
24.	Dumper (no. 126) Operator Mr. Krishna Ramteke	14/12/06	1 st shift	70.0	121.3	87.8	145.4	86.6

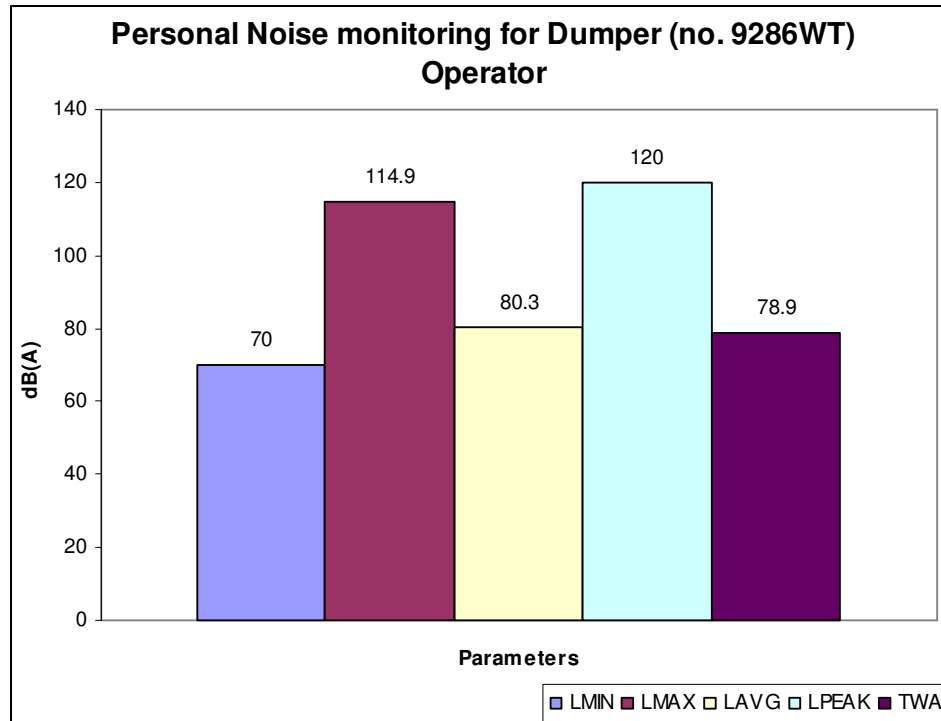
The noise levels were observed to be in the range of 70.0 dB(A) – 121.3 dB(A) for the Dumper (no. 126) Operator. The L_{AVG} was observed to be 87.8 dB(A) and the L_{PEAK} was observed to be 145.4 dB(A). The Time Weighted Average for the entire shift was observed to be 86.6 dB(A), which exceeds the Warning Limit of 85 dB(A) prescribed by DGMS.



Graph 2.25

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
25.	Dumper (no. BH35 448) Operator Mr. Kalika Bharadwaj	14/12/06	1 st shift	70.0	103.9	82.2	106.1	81.0

The noise levels were observed to be in the range of 70.0 dB(A) – 103.9 dB(A) for the Dumper (no. BH35 448) Operator. The L_{AVG} was observed to be 82.2 dB(A) and the L_{PEAK} was observed to be 106.1 dB(A). The Time Weighted Average for the entire shift was observed to be 81.0 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Graph 2.26

S. No.	Personnel sampled	Date	Shift	L _{MIN} dB(A)	L _{MAX} dB(A)	L _{AVG} dB(A)	L _{PEAK} dB(A)	TWA dB(A)
26.	Dumper (no. 9286WT) Operator Mr. VijayKumar Singh	14/12/06	1 st shift	70.0	114.9	80.3	120.0	78.9

The noise levels were observed to be in the range of 70.0 dB(A) – 114.9 dB(A) for the Dumper (no. 9286WT) Operator. The L_{AVG} was observed to be 80.3 dB(A) and the L_{PEAK} was observed to be 120.0 dB(A). The Time Weighted Average for the entire shift was observed to be 78.9 dB(A), which is within the Permissible Exposure Limits prescribed by DGMS.



Conclusions:

Noise dosimetry was carried out in the mine for persons engaged in major mining activities. Category wise distribution is shown in Table 2.1:

Table 2.1: Categories of sampled personnel

Serial No.	Category	Number
1.	Dumper operator	8
2.	Shovel operator	8
3.	Dozer operator	3
4.	Motor grader operator	1
4.	Drill operator	2
5.	Crane operator	1
6.	Crusher operator	3
	TOTAL	26

Eight hours time weighted average (TWA) of noise exposure in dB(A) for different categories is shown below in Table 2.2. The dumper operators are exposed to highest level of noise while crane operator recorded lowest level of exposure.

Table 2.2: TWA Noise range

Serial No.	Category	TWA Range dB(A)
1.	Dumper operator	78.9 - 98.0
2.	Shovel operator	81.2 – 97.8
3.	Dozer operator	85.6 – 90.3
4.	Motor grader operator	87.5 – 87.5
4.	Drill operator	82.4 – 90.6
5.	Crane operator	64.0 – 64.0
6.	Crusher operator	75.2 – 85.0

DGMS has prescribed noise limits that are not to be exceeded to avert adverse health effects. The warning limit is set at 85 dB(A) while 90 dB(A) is called the danger limit. Accordingly, the data can be further classified according to their health risk potential as shown in Table 2.3:



Table 2.3: Data classification as per DGMS noise limits

Serial No.	Category	No. of Samples below warning limit i.e. 85 dB(A)	No. of Samples above warning limit but below danger limit i.e. 90 dB(A)	No. of Samples above danger limit i.e. 90 dB(A)
1.	Dumper operator	3	4	1
2.	Shovel operator	4	1	3
3.	Dozer operator	0	1	2
4.	Motor grader operator	0	1	0
4.	Drill operator	1	0	1
5.	Crane operator	1	0	0
6.	Crusher operator	2	1	0
7.	TOTAL	11 (42.3%)	8(30.76 %)	7 (26.92 %)

Out of 26 samples collected and studied, it was observed that 11 (42.3%) cases showed noise level below 85 dB(A). Noise level exceeded 85 dB(A) in 8 (30.76) cases whereas 7 (26.92%) samples exceeded DGMS danger limit 90 dB(A)

3. VIBRATION SURVEY



3.1 Introduction

Vibration transmitted to the body through the supporting surfaces such as feet, buttocks or back is known as Whole body vibration (WBV). There are various sources of WBV in opencast mines such as 1) seat transmitted vibration from dumper, dozer, shovel, backhoes, road graders etc. and 2) WBV transmitted through feet while standing on or moving near vibrating machines like various type of crushers or vibrating screen.

Current Literatures on the subject shows strong epidemiological evidence which associates occupational exposure to WBV with an increased risk of low back pain, sciatic pain, and degenerative changes in the spinal column, including lumbar inter-vertebral disc disorders. The parts of the body most likely to be injured during exposure to whole-body vibration depend on the magnitude of vibration, distribution of the motion within the body, body postures, and the vibration frequency, direction and duration.

Prediction of health risks of exposure to whole body vibration is not supported by a strict dose effect relationship. But the risk of exposure can be characterized following ISO 2631-1:1997 guidelines. The guidelines graphically represent certain combination of magnitude and exposure periods which can distinguish no risk, low risk and high risk dose of vibration exposure.

3.2 Objective

The primary purpose of the study was to measure the vibration magnitude of the HEMMs and persons moving around or standing near vibrating machines in terms of acceleration (m/s^2). A time motion study was to be carried out for determining the period of exposure. The final objective was to combine the magnitude and duration of exposure in accordance with ISO 2631-1:1997 to predict the health risk.



3.3 Field study schedule

Studies at Kamptee opencast mines, WCL were conducted in January and February, 2007. Eighteen samples from the mines were collected. The locations and equipment were selected after discussion with the mine management. The study was planned to complete within a period of 30 days to exclude any major variation in conditions of vehicle and road.

3.4 Materials and methods:

- Whole Body Vibration study was conducted using a Human Vibration Meter of Larson Davis, USA (Model HVM 100). The instrument complies with the requirements of ISO 5349-1:2001, ISO 2631-1:1997 & ISO 8041:1990.
- Operators of various HEMMs like dozers, dumpers, and shovel were covered under this study.
- A tri-axial seat-pad accelerometer was placed under the seat of the operator of the HEMM during active period and the readings in all three axes (orthogonal x,y,z) of vibration were recorded in the vibration meter.
- Measurements periods varied between 5 to 20 minutes at working sites during normal course of operation. The duration typically represented a cycle of operation of the equipment under study. The operator and the supervisor were later interviewed to find the average number of cycles or Trips he performed or completed in a day. In case where the job does not comprise any specific cycle of operation with corresponding duration, the exposure was quantified by collecting information from mine officials as well as the concerned worker.



- Vibration levels were evaluated as per procedures laid down in ISO 2631 (Part 1):1997 to find whether the vibration levels were below, inside or above the Health Guidance caution Zone (HGCZ) described in the standard. Parameters such as A_{eq} (frequency weighted r.m.s. acceleration value), V.D.V (Vibration Dose Value) and CF_{mp} were noted and used for analysis.

3.5 Frequency of vibration:

The frequency of vibration, which is expressed in cycles per second (Hz), affects the extent to which vibration is transmitted to the body (e.g., to the surface of a seat or the handle of a vibratory tool), the extent to which it is transmitted through the body (e.g., from the seat to the head), and the effect of vibration in the body.

The effects of whole body vibration are usually greatest at the lower end of the range; from 0.5 to 100 Hz. Frequencies below about 0.5 Hz can cause motion sickness.

Since human responses to vibration vary according to the vibration frequency, it is necessary to weight the measured vibration according to how much vibration occurs at each frequency. Frequency weightings reflect the extent to which vibration causes the undesired effect at each frequency. Weightings are required for each axis of vibration. The whole body vibration standard ISO 2631-1:1997 directs the user to select the filter so as to implement W_d frequency weighting for X and Y axis of measurement and W_k weightings for Z axis. W_f is used for evaluating frequencies considered for motion sickness. The weightings are fully described in ISO 8041:1990. These three are called principal weightings and shown in Figure 3.1.

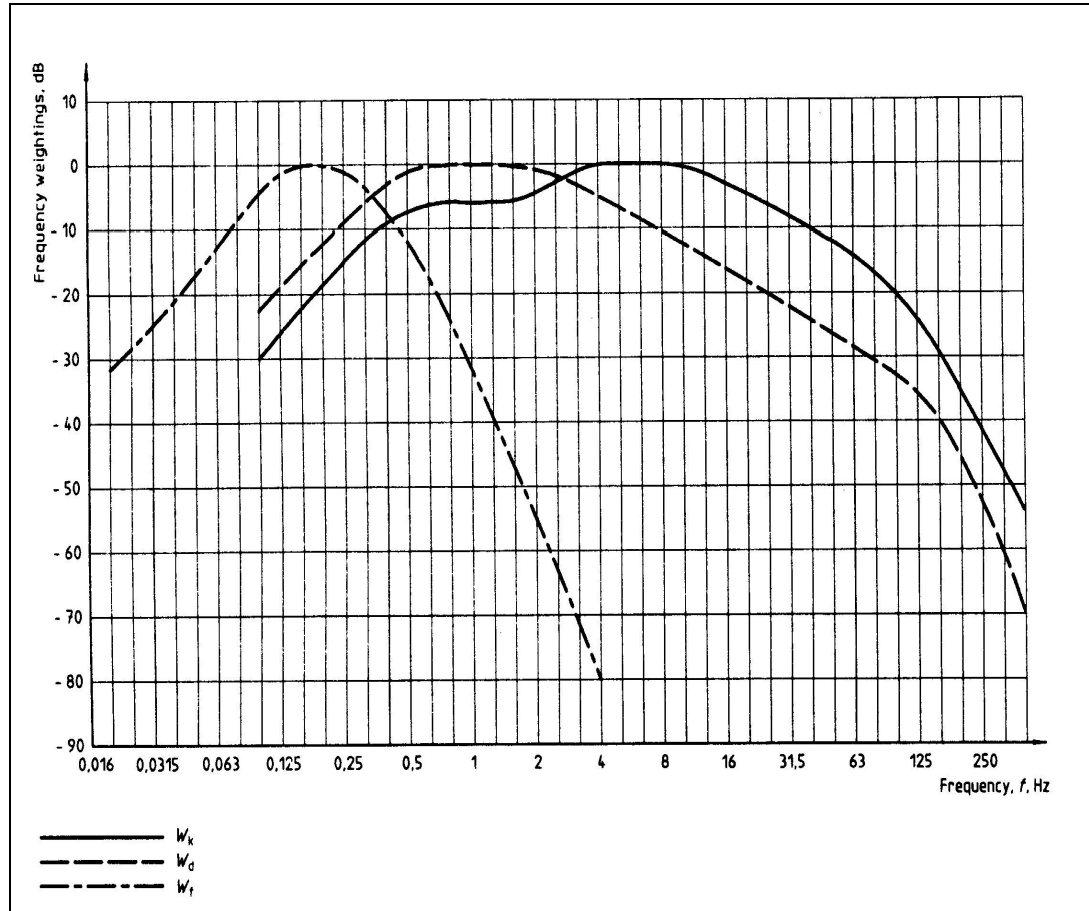


Fig 3.1- Principal frequency weightings W_a , W_k and W_f as described in ISO 8041:1990



3.6 Vibration Data

Table 3.1: Acceleration magnitude (m/s^2) along dominant axis (Z) and VDV
Dumpers)

Equipment	A_{eq} (m/s^2)	CF_{mp} (dB)	VDV_n (measured)	Av. No. of trips/day	VDV_T (VDV total)
Dumper 1	0.596	13.6	3.88	20	8.18
Dumper 2	1.071	19.7	8.41	20	17.74
Dumper3	1.210	14.9	5.12	20	10.80
Dumper 4	1.110	13.6	5.66	20	11.94
Dumper 5	0.793	13.6	4.54	20	9.58
Dumper 6	0.613	16.3	5.68	20	11.98
Dumper 7	1.230	13.8	6.16	20	12.99
Dumper 8	1.270	16.2	12.13	20	25.59
Dumper 9	0.985	19.3	7.81	20	16.48
Dumper 10	1.140	20.6	9.46	20	19.96

Table 3.2: Acceleration magnitude (m/s^2) along dominant axis and VDV
(Dozer)

Equipment	A_{eq} (dominant axis)	CF_{mp}	VDV_n	Duration of exposure (Hours)	Duration of measurement (sec)	VDV_T
Dozer 1	0.862 (X)	14.7	4.61	3.0	62	16.74
Dozer 2	0.878 (X)	17.6	4.62	3.0	91	15.24
Dozer 3	0.956 (Z)	17.5	3.77	3.0	116	11.71
Dozer 4	0.882 (X)	18.2	4.35	3.0	133	13.06



Table 3.3: Acceleration magnitude (m/s^2) along dominant axis (Z) and VDV
(Shovel)

Equipment	A_{eq} (m/s^2)	CF_{mp} (dB)	VDV_n (measured)	Duration of Exposure (Hours)	Duration of measurement (sec)	VDV_T (VDV total)
Shovel 1	0.226	20.0	1.66	5.1	258	4.82
Shovel 2	0.235	20.2	1.62	5.1	216	4.91
Shovel 3	0.237	21.2	1.70	5.1	252	4.96
Shovel 4	0.239	24.2	2.05	5.1	264	5.92

Table 3.4: Duration of exposure

Equipment	No. of trips or cycles/ day	Time taken per cycle/ trip	Total Duration (hours)	Remarks
Dumper	20	15 minutes	$300/60 = 5.0$	Empty and loaded run time total
Dozer	NA	NA	3.0	from mine records
Shovel	$20 \times 4 = 80$	3.85 minutes	$80 \times 3.85 / 60 = 5.1$	4 dumpers per shovel

3.7 Risk assessment model:

The magnitude of the acceleration is continually changing; hence a single overall value is used for determining the severity. In most cases, when vibration does not contain shocks, the acceleration magnitude is expressed by using the **root-mean-square (r.m.s) value** considering continually changing acceleration and corresponding time periods.

According to basic evaluation method described in ISO 2631-1:1997, the magnitude of acceleration (Y axis) along with duration of exposure (X axis) is to be taken for comparison in a mathematical model (Fig 3.2) called the Health Guidance Caution Zone (HGCZ) that indicates the health risk for the exposed people.

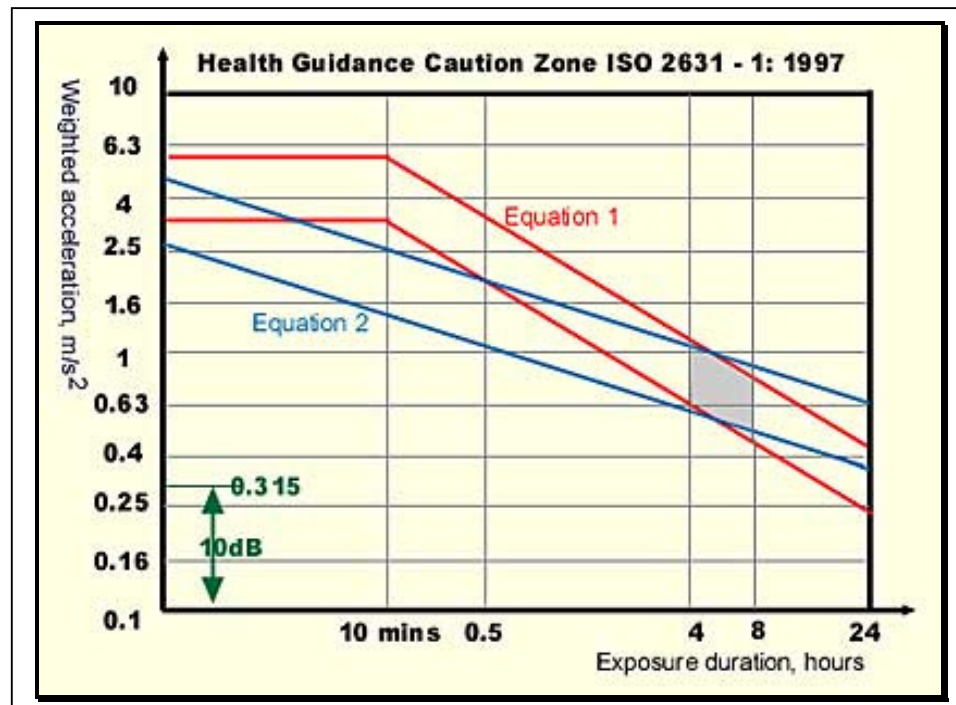


Fig 3.2 - Health guidance caution zone (Annex B, ISO 2631-1:1997)



To determine the effects of exposure to whole body vibration on health, the weighted r.m.s acceleration (A_{eq}) in the frequency range 0.5 to 80 Hz, from vibration that is transmitted through a seat pan to the seated body, has been measured for each axis x, y and z and the highest frequency-weighted acceleration in any axis after multiplying by appropriate scaling factor has been taken into account for assessment. Horizontal vibration is multiplied by a scaling factor (k) of 1.4 before assessment [k=1.4 for x & y axes, k=1 for z axis].

3.8 Crest Factors (CF_{mp}) and total VDV: All the CF_{mp} values were above nine. As per technical guidance shown in ISO standard a crest factor above nine represents presence of significant shocks during the exposure. Hence the VDV method was also used in addition to the basic evaluation method as per clause 6.2.2 of ISO 2631-1 for determination of severity. VDV_T i.e total VDV was determined before assessment of risk. The lower and upper limits of risk zones have been taken as 8.5 and 17 $ms^{-1.75}$ respectively.

3.9 Summary of risk assessment: Table 3.5 shows risk assessment of the operators exposed to whole body vibration in their workplace.

Table 3.5 – Summary of risk assessment

Equipment	Health Risk assessment by r.m.s method	Health Risk assessment by VDV method
Dumper 1	Not Indicated	Not Indicated
Dumper 2	Indicated	Likely
Dumper 3	Likely	Indicated




Dumper 4	Indicated	Indicated
Dumper 5	Indicated	Indicated
Dumper 6	Indicated	Indicated
Dumper 7	Likely	Indicated
Dumper 8	Likely	Likely
Dumper 9	Indicated	Indicated
Dumper 10	Indicated	Indicated
Dozer 1	Indicated	Indicated
Dozer 2	Indicated	Indicated
Dozer 3	Indicated	Indicated
Dozer 4	Indicated	Indicated
Shovel 1	Not Indicated	Not Indicated
Shovel 2	Not Indicated	Not Indicated
Shovel 3	Not Indicated	Not Indicated
Shovel 4	Not Indicated	Not Indicated

3.10 Conclusions:

- A total no. of 18 equipment was studied. It was found that except 3 (16.67%) dozers, all other 15 (83.33%) machines had Z axis as their dominant axis of vibration. These dozers had maximum vibration along X axis.
- All equipment had crest factors above 9 indicating significant shock (Peak) values compared to r.m.s values.
- Shovels were found to be safest as far as WBV was concerned. None of them showed health risk either by r.m.s or by VDV method.
- All dozers (100%) studied under this project indicated health risk either by r.m.s or by VDV method. It means that caution should be taken to reduce the vibration magnitude to no risk level.



- One dumper (10%) out of total ten showed no health risk to their operators when analysed by both the methods. Six dumpers (60%) indicated risk when analysed by r.m.s. method whereas seven (70%) dumpers indicated health risk when all of them were studied using VDV method. Three (30%) dumpers had shown risk with maximum probability termed as “likely” when r.m.s method was used. But only two (20%) posed health risk with maximum probability when VDV method was used.



CHAPTER - II

Epidemiological Studies



EPIDEMIOLOGICAL STUDIES

1 Introduction

PME records from January to November 2006 were taken from Western Coalfields Limited (WCL), which were in a special FoxPro package developed by WCL for their usage. The data was converted in Excel sheet with the help of software engineer. Detailed study of 1552 subjects from PME records of Kamptee Mines in Nagpur area was done.

2 Categorization of job type

The multiplicity of designations used in the mines is a deterrent in understanding and classifying the nature of exposure. Based on the nature of duties, place of work and exposure, all the study subjects were classified in to five job categories. Out of total 1552 subjects studied, 414 subjects were working at the Face, 255 subjects in Transport, 327 subjects in Maintenance, 113 subjects in Supervisor capacity and 443 subjects in other situations. Appendix-1 shows their designation and job category.

3 Statistical Methods:

All the data was compiled on MS Excel and analyzed using Epi-Info 6 software.

4 Results & Discussion:

A total of 1552 subjects, 1476 male and 76 female were studied. 49.5% subjects belonged to 41-50 years age group, while percentage of younger subjects in this study was very low. Majority 857 (55.2 %) of the subjects were employed for the last 20-30 years. The average height of the male miners 163 cm and that of female was 150 cm, while the average weight of male and female miner was 64.3 and 53.1 Kg respectively. More then



half of the subjects were either under weight or over weight as per their BMI – indicating a high prevalence of malnutrition. The details are shown in Table 1.

Table – 1: Distribution of Study Subjects According To Personal Characteristic

	MALE		FEMALE		Total
STUDY SUB	1476	95.1	76	4.89	1552 (100)
AGE in YRS.					
< 25	001	0.06	00	00	01 (0.06)
26 – 40	130	8.80	10	13.1	140 (9.0)
41 – 50	719	48.7	50	65.7	769 (49.5)
> 50	626	42.4	16	21.0	642 (41.3)
Mean ± SD	49.0 ± 6.40		46.7 ± 5.20		--
NO. of YRS. WORKED					
< 10	61	4.13	09	11.8	70 (4.5)
11 - 20	166	11.2	51	67.1	217 (13.9)
21 - 30	842	57.0	15	19.7	857 (55.2)
> 30	407	27.5	01	1.3	408 (26.2)
Mean ± SD	25.0 ± 6.43		16.5 ± 5.14		--
Height	1455	98.5	74	97.3	1529 (98.5)
Mean ± SD	163.0 ± 10.8	--	150.0 ± 5.8	---	---
Weight	1452	98.3	74	97.3	1526 (98.3)
Mean ± SD	64.3 ± 8.0	--	53.1 ± 9.64	--	--
BMI	1455	98.5	74	97.3	1529 (98.5)
NORMAL	709	48.7	34	45.9	743 (48.5)
UNDER WT.	228	15.6	14	18.9	242 (15.8)
OVER WT.	518	35.6	26	35.1	544 (35.5)
Mean ± SD	24.1 ± 8.63		23.7 ± 4.06		--
Total	1476 (95.1)	95.1	76	4.89	1552 (100)



Age and general characteristics of study subjects in different job categories are shown in Table 3. Subjects engaged in transport and maintenance was comparatively younger while the average age of face worker was more than 50 years. Face and supervisory staff had a work history of more than 25 years. Over weight and obesity was common among supervisors.

Table–2a: General Characteristics of Male Workers in Different Job Categories.

CHARECT-ERISTICS	FACE N=414 (26.6%)	TRANS- PORT N=255 (16.4%)	MAINTEN- ANCE N=325 (20.9%)	SUPER- VISOR N=113 (7.28%)	OTHERS N=369 (23.7%)
Age Mean ± SD	50.7 ± 5.14	46.3 ± 6.21	47.8 ± 6.45	49.8 ± 7.93	49.8 ± 6.4
Work History Mean ± SD	26.5 ± 4.60	22.4 ± 6.13	23.8 ± 6.46	27.0 ± 8.16	25.3 ± 7.04
Height Mean ± SD	162.5 ± 8.30	163.4 ± 16.03	163.0 ± 10.0	163.0 ± 13.7	163.2 ± 8.51
Weight Mean ± SD	60.8 ± 10.75	66.8 ± 11.06	64.4 ± 11.6	71.2 ± 50.8	64.3 ± 11.5
BMI Mean ± SD	22.8 ± 5.53	24.6 ± 6.35	24.5 ± 8.55	27.4 ± 20.6	24.0 ± 5.47

Table–2b: General Characteristics of Female Workers in Different Job Categories

CHARECT-ERISTICS	FACE N=0	TRANS- PORT N=0	MAINTEN- ANCE N=2 (2.63%)	SUPER- VISOR N=0	OTHERS N=74 (97.3%)
Age Mean ± SD	--	--	46.0 ± 7.07	--	46.7 ± 5.2
Work History Mean ± SD	--	--	19.5 ± 4.9	--	16.5 ± 5.1
Height Mean ± SD	--	--	146.5 ± 2.1	--	150.0 ± 5.8
Weight Mean ± SD	--	--	55.0 ± 0.0	--	53.3 ± 9.7
BMI Mean ± SD	--	--	25.6 ± 0.74	--	24.0 ± 5.47



Tobacco chewing was common in more than half of the subjects, while a little less than on fourth of subjects were found to use alcohol and or cigarettes. Such high percentage of users denotes the lack of health awareness among these subjects. This would also reflect on the morbidity pattern of these miners. These habits were more frequent among face workers. Only 7 out of 76 women were found to be using chewing tobacco.

Table – 3: Distributions of Male Subjects According to Addiction and Job

CHARECTE- RISTICS	FACE N=414		TRANS- PORT N=255		MAINTEN ANCE N=325		SUPER- VISOR N=113		OTHERS N=369		Total
	N	%	N	%	N	%	N	%	N	%	
Alcohol Consumption	92	22.2	53	20.7	47	14.3	20	17.6	65	14.6	277 (18.7)
Smoker	104	25.1	59	23.1	39	11.9	21	18.5	53	11.9	276 (18.6)
Tobacco Chewer	214	51.6	122	47.8	137	41.8	47	41.5	141	38.2	661 (44.7)
Total	410	98.5	234	91.7	223	68.1	88	77.8	259	70.1	1214 (82.2)

The physiological variables like Pulse etc of different categories of workers is shown in Table 5. Average chest expansion was found to be less than 5 cms among workers classified as others.



Table-4a: Distributions of Male Subjects According to Physiological findings and job

CHARECT-ERISTICS	FACE N=414	TRANS-PORT N=265	MAINTE-NANCE N=325	SUPER-VISOR N=113	OTHERS N=369
Pulse Mean \pm SD	80.2 \pm 35.1	81.5 \pm 45.5	78.4 \pm 3.51	78.5 \pm 3.0	78.6 \pm 2.75
Systolic Blood Pressure Mean \pm SD	122.9 \pm 9.53	123.4 \pm 8.7	123.4 \pm 9.89	124.0 \pm 14.9	124.7 \pm 11.7
Diastolic Blood Pressure Mean \pm SD	79.7 \pm 4.51	79.6 \pm 6.0	82.7 \pm 45.5	80.8 \pm 4.49	79.9 \pm 13.0
Hemoglobin % Mean \pm SD	13.3 \pm 0.57	13.5 \pm 0.55	13.4 \pm 1.17	13.6 \pm 0.55	13.4 \pm 0.71
Chest Expansion Mean \pm SD	5.1 \pm 1.20	5.1 \pm 0.85	5.21 \pm 1.50	5.0 \pm 0.70	4.97 \pm 0.93

Table-4b: Distributions of Female Subjects According to Physiological findings

CHARECT-ERISTICS	FACE N=0	TRANS-PORT N=0	MAINTE-NANCE N=2	SUPER-VISOR N=0	OTHERS N=74
Pulse Mean \pm SD	--	--	76.0 \pm 2.8	--	77.9 \pm 2.8
Systolic Blood Pressure Mean \pm SD	--	--	115.0 \pm 7.07	--	117.9 \pm 9.7
Diastolic Blood Pressure Mean \pm SD	--	--	79.0 \pm 1.41	--	78.4 \pm 4.2
Hemoglobin % Mean \pm SD	--	--	10.0 \pm 0.00	--	14.1 \pm 12.2
Chest Expansion Mean \pm SD	--	--	4.0 \pm 1.41	--	3.2 \pm 2.6



Table – 5: Pre-existing Morbidity among and Male Subjects According to Sickness History

CHARACTERISTICS	FACE N=414		TRANSPORT N=255		MAINTENANCE N=325		SUPERVISOR N=113		OTHER N=369		Total 1476
	N	%	N	%	N	%	N	%	N	%	
Past Sickness History	55	13.2	40	15.6	52	16.0	29	25.6	61	16.5	292 (19.7)
Present Complaint	10	2.4	8	3.1	6	1.8	3	2.6	8	2.1	35 (2.3)

Table IV shows Occupational characteristics of study subjects according to category wise. Highest percentage of face worker having were been alcohol, smoking and tobacco chewing habit. Subjects self reported past history and present sickness history. Highest 21.6 % & 5.5 % past history and present history found in other category and face category respectively. Out of total 1552 subjects only 0.6 % vision problem found in other category. Each category found abnormal X-ray findings but not only single subjects found in supervisor category. Mean value of chest expansion was more found in maintenance category as compare to other category. Remaining other parameter was under range of normal limit.

Morbidity recorded in study subjects is shown in table 5. Hypertension and Diabetes were common preexisting sicknesses in all job categories. Highest percentage of subjects with diabetes mellitus was detected in subjects employed in transport related jobs. Hypertension was equally common in face workers and those employed in other jobs. Subjects suffering from diabetes and having hypertension together were maximally found in transport category.



Eye disease, Bronchial asthma, Fractures, Hernia and Hydrocoele were commonly reported. Clinically detectable Musculo-skeletal disorders were reported by less than one percent of subjects. Other diseases included Hypothyroidism, Hemiplegia, Amputation, Renal calculus, extra Pulmonary tuberculosis, Appendicitis, Hansen's and Malignancy.

Table – 6 : Morbidity Record of Study Subjects.

PAST Sickness	FACE		TRANS- PORT		MAINTENANCE		SUPERVISOR		OTHER	
	N	%	N	%	N	%	N	%	N	%
DIABETES MELLITUS	5	1.2	11	4.3	7	2.1	5	4.4	13	2.9
HYPERTENSION	24	5.7	10	3.9	19	5.8	7	6.1	26	5.8
DIABETES MELLITUS & HYPERTENSION	3	0.7	11	4.3	2	0.6	2	1.7	--	--
BRONCHIAL ASTHMA	6	1.4	4	1.5	4	1.2	6	5.3	5	1.1
EYE DISEASES (CATARACT CONJUNCTIVITIS, DIMINISHED VISION)	4	0.9	--	--	4	1.2	2	1.7	6	1.3
Bone fracture	3	0.7	1	0.3	3	0.9	2	1.7	3	0.6
MSD	3	0.7	--	--	1	0.3	--	--	2	0.4
CVD	--	--	1	0.3	2	0.6	--	--	3	0.6
HERNIA	1	0.2	1	0.3	1	0.3	3	2.6	2	0.4
HYDROCOELE	--	--	--	--	1	0.3	1	0.8	2	0.4
EPILEPSY	1	0.2	--	--	1	0.3	--	--	1	0.2



ACID PEPTIC DISEASE	4	0.9	--	--	6	1.8	--	--	--	--
CA HEAD OF PANCREAS	--	--	--	--	--	--	--	--	1	0.2
HYPOTHYROIDISM	--	--	--	--	--	--	--	--	2	0.4
HEMI- PLEGIA	1	0.2	--	--	--	--	--	--	--	--
MALIG- NANCY OF E.N.T.	--	--	--	--	--	--	--	--	1	0.2
AMPU- TATION	--	--	--	--	--	--	1	0.8	--	--
CALCU- LUS IN KIDNEY/ URINARY TRACT	--	--	--	--	1	--	--	--	--	--
TUBER- CULOSIS OTHER THAN PULM.T.B.	--	--	1	0.3	--	--	--	--	1	0.2
APPEND- ICITIS	--	--	--	--	--	--	--	--	1	0.2
LEPROSY	--	--	--	--	--	--	--	--	1	0.2


5. Conclusion

The study shows that age of most of the workers was within 41-50 years. 35 % employees were overweight which shows requirement of intense health education for this workforce involved in the study. Similarly there were 2.6 % employees having Diabetes mellitus and 5.5% employees having hypertension whereas 1.1% was having both. Comparative study shows that Face workers had more sickness history. Muscular Skeletal Disorders were observed only in Face, Maintenance and other workers but not in Transport and Supervisory



राष्ट्रीय खनिक स्वास्थ्य संस्थान, नागपुर
NATIONAL INSTITUTE OF MINERS' HEALTH, NAGPUR

workers. Similarly Eye diseases were found in each category of employees but not found in Transport employees.



CHAPTER - III

Medical Studies



1 Introduction

The scientific staff of National Institute of Miners' Health (NIMH) carried out interventional medical studies among 276 WCL employees (all men) of which 54 were face workers, 100 were transport workers, 54 were maintenance workers, 36 were other category and 32 were supervision workers. WCL employees were evaluated by well defined medical Questionnaire, Pulmonary Function Test (PFT), Chest X-ray, Audiometry and Vision Screening Test.

2 Material and Methods

Medical Examination: Each WCL worker was given NIMH I.D. code no. A brief family & personal history, present and past medical status, symptoms and signs related each body system etc. were noted in medical questionnaire form. Along with this questionnaire a general medical check up was done for blood pressure, pulse-rate and Height in cm and body weight in kg.

Chest X-rays (CXR): A Postero Anterior (PA) CXR of 163 WCL employees was carried out on 300 mA x-ray machine with 125 Kv. All CXRs were interpreted as per ILO guidelines for classification of Chest Radiograph for Pneumoconiosis. The CXRs were evaluated by a panel comprising Dr. S. Nandi(NIMH), Dr.A. Sinha & Dr. D. Sengupta (WCL).

Pulmonary Function Test (Spirometry): FVC, FEV₁, FEV₁ %, PEFR, etc was carried out in 236 workers by Cosmed Pony Graphic 4.0 by following standard procedure. All results were expressed at BTPS. The results were interpreted as normal Spirometry as well as obstructive,



restrictive or combined impairment on the basis of the performance of the subject. Predictive FVC was calculated by predictive equation of Kamat et al (1982).

Audiometry Test: Evaluation of subjects for hearing capability was measured for air conduction by audiometric test with the help of Elkon eda 3N3 multi diagnostic audiometer MH 2K2 189 among 204 workers. The test was conducted in a closed room having minimal background noise. Electro acoustic generator producing pure tones at predetermined frequencies and intensities were used to do this test. The sound frequencies range from 0.5 KHz to 4 KHz and the minimum intensity for measurement was from 15 dB(A). The subject was made to sit comfortably on a chair and thoroughly briefed about audiometric test. Earphones were put on his ears and a hand switch was given to him to note his response to various sound intensity and frequency. He was instructed to press the switch as soon as he hears a faint sound. The responses of the subject were noted in the Elkon audiogram data sheet. The results were calculated by formula recommended in Guides to the Evaluation of Permanent Impairment by American Medical Association.

Vision Screening Test: 163 workers were examined for Refractive error and Colour Blindness. The test was done with the help of Vision Screener Testing Machine, "Titmus Optimum Vision Screener Model No. 2a." The subject was told to look through the Vision Screener and identify the numbers, symbols and colour in sequential manner etc. The response of the subject to the above test was noted on the standard Titmus TNO Record form.



Random Blood Sugar (RBS): Blood sample was collected by pricking the ring finger of the subject's left hand and transferred to the Quicktek Blood Glucose strip. RBS was noted from the display of Glucometer Quicktek Hyproguard Product.

Statistical Methods: All the data was compiled on MS Excel and analyzed using Epi-Info 6 software.

3. Results:

A total of 276 subjects were studied of which 54.34% subjects belonged to 41-50 years age group, while percentage of younger subjects in this study was very low. Majority 64.49 % of the subjects were employed for the last 20-30 years. The average height of the miner was 163.48 cms, while the average weight of the miner was 68.85 Kgms. More than half of the subjects were over weight as per their BMI. The details are shown in Table 1.

Table – 1: Distribution of Study Subjects According to Personal Characteristic

STUDY SUB	276	
AGE (yrs)		%
< 25	0	0
25 – 40	28	10.14
41 – 50	150	54.34
> 50	98	35.5
Mean ± SD	48.38 ± 6.08	
NO. of YRS. WORKED		
≤10	13	4.71
11 - 20	31	11.23
21 - 30	178	64.49
> 30	54	19.56
Mean ± SD	25.18 ± 6.41	



HEIGHT		
Mean ± SD	163.48 ± 6.32	
WEIGHT		
Mean ± SD	68.85 ± 12.17	
BMI		
Normal	113	40.94
Under Wt.	8	2.89
Over Wt.	155	56.15
Mean ± SD	25.74 ± 4.26	
Total	276	100

Age and general characteristics of study subjects in different job categories are shown in Table 2. Subjects engaged in transport were comparatively younger while the average age of supervision worker was more than 50 years. Supervision, face, other and maintenance workers had a work history of more than 25 years. Over weight and obesity was common among supervision workers.

Table-2: General Characteristics of Workers in Different Job Categories

CHARACTERISTICS	FACE N=54	TRANSPORT N=100	MAINTENANCE N=54	SUPERVISION N= 32	OTHERS N=36
Age Mean ± SD	49.46 ± 5.25	46.42 ± 5.93	48.0 ± 6.67	52.02 ± 5.38	49.75 ± 5.56
Work History Mean ± SD	26.33 ± 6.28	23.01 ± 6.37	25.69 ± 6.47	28.06 ± 6.21	26.11 ± 5.13
Height Mean ± SD	162.25 ± 5.07	164.65 ± 6.05	162.37 ± 7.13	163.30 ± 6.0	164.22 ± 7.19
Weight Mean ± SD	67.79 ± 12.45	69.39 ± 12.06	67.83 ± 11.68	71.26 ± 12.69	67.97 ± 13.29
BMI Mean ± SD	25.66 ± 3.96	25.60 ± 4.22	25.77 ± 4.8	26.66 ± 6.09	25.14 ± 4.32



Distribution of the study subjects according to addiction and job category are shown in table 3. Tobacco chewing was common in about half of the subjects, while fourth of subjects were found to use alcohol and or cigarettes. Such high percentage of users denotes the lack of health awareness among these subjects. .

Table – 3: Distributions of Subjects According to Addiction and Job

CHARACTERISTIC	FACE N=54		TRANS- PORT N=100		MAINTENANCE N=54		SUPER- VISION N=32		OTHERS N=36	
	N	%	N	%	N	%	N	%	N	%
Alcohol Consumption	15	27.77	39	39	14	25.92	10	31.25	8	22.22
Smoker	17	31.48	27	27	13	24.07	4	12.5	11	30.55
Tobacco Chewer	33	61.11	60	60	26	48.14	14	43.75	18	50

The physiological variable of different categories of workers is shown in Table 4.

Table-4: Distributions of Subjects According to Physiological findings and Job

CHARACTERISTICS	FACE N=54	TRANS- PORT N=100	MAINTENANCE N=54	SUPER- VISION N=32	OTHERS N=36
Pulse Mean \pm SD	77.62 \pm 11.73	75.46 14.18	73.95 \pm 17.96	76.92 \pm 3.61	78.66 \pm 3.91
Systolic Blood Pressure Mean \pm SD	130.0 \pm 14.34	128.11 \pm 14.19	126.65 \pm 12.8294	129.08 \pm 11.06	128.38 \pm 15.6
Diastolic Blood Pressure Mean \pm SD	85.40 \pm 8.94	83.38 \pm 8.81	83.62 \pm 9.24	82.88 \pm 8.02	83.66 \pm 7.06



Table 5 shows subjects self reported past history and present sickness history. Past sickness history was more common in supervision workers (28.12%) and least common in other category workers (7.69%). Present complaints was common in face workers (29.62%)

Table – 5: Pre-existing Morbidity among Subjects According to Sickness History

CHARACTERISTICS	FACE N=54		TRANSPORT N=100		MAINTENANCE N=54		SUPERVISION N=32		OTHERS N=36	
	N	%	N	%	N	%	N	%	N	%
Past Sickness History	13	24.07	14	14	8	14.81	9	28.12	2	7.69
Present Complaint	16	29.62	28	28	15	27.77	7	21.87	5	13.88

Morbidity pattern in study subjects is shown in table 6. Combined hypertension and diabetes was common in face and maintenance workers (7.4% each). Hypertension alone was common (18.7%) supervision and least in others category (8.33%). Musculoskeletal symptoms (MSD) were prevalent in all the workers. About 35.16% of transport workers followed by 33.33% in others, 31.25% in supervision, 26% in transport and 22.22% in maintenance workers had MSD. .



Table – 6 : Morbidity pattern of Study Subjects.

Morbidity Pattern	FACE N=54		TRANS- -PORT N=100		MAINTENANCE N=54		SUPERVISOR N=32		OTHERS N=36	
	N	%	N	%	N	%	N	%	N	%
Diabetes Mellitus	1	1.85	6	6	1	1.85	2	6.25	1	2.77
Hypertension	9	16.66	12	12	7	12.96	6	18.75	3	8.33
Diabetes Mellitus & Hypertension	4	7.40	5	5	4	7.40	4	12.5	2	5.55
IHD	3	5.55	2	2	1	1.85	2	6.25	0	0
MSD	18	33.3	36	36	11	20.37	05	15.62	9	25

Pulmonary Function Test (Spirometry)

Pulmonary function test was done in 236 workers out of which 178 (75.42%) have normal spirometry. Table 7 shows prevalence of pulmonary impairment in study subjects. The study revealed restrictive impairment among 26.04% in transport workers followed by 20.83% in supervision worker.

Table 7 showing pulmonary function in study subjects

PULMONARY IMPAIRMENT	FACE N=47		MAINTENANCE N=49		TRANSPORT N=96		SUPERVISION N=24		OTHERS N=20	
	N	%	N	%	N	%	N	%	N	%
Normal	39	82.97	41	83.67	66	68.75	18	75	14	70
Restrictive	5	10.63	5	10.2	25	26.04	5	20.83	4	20
Obstructive	2	4.25	2	4.08	3	3.12			2	10
Combined	1	2.12	1	2.04	3	3.12	1	4.16	0	0



Audiometry

Audiometry was done in total 204 subjects of which 95(46.56%) have normal and 100 (49.01%) have mild hearing impairment. The study reveals that mild hearing impairment was highest in face workers (65.30%) followed by supervision (52.38%), others (50%) , maintenance (42.22%)and transport (40.29%) workers. Moderate impairment was seen in 2 workers in maintenance, transport and other category, whereas 1 worker each in supervision and face workers.

Table 8 Showing hearing impairment in study subjects

HEARING IMPAIRE-MENT	FACE N=49		MAINTENANCE N=45		TRANSPORT N=67		SUPERVISION N=21		OTHERS N=22	
	N	%	N	%	N	%	N	%	N	%
Normal	16	32.65	24	53.33	37	55.22	9	42.85	9	40.90
Mild	32	65.30	19	42.22	27	40.29	11	52.38	11	50
Moderate	1	2.04	2	4.44	2	2.98	1	4.76	2	9.09
Severe	0	0	0	0	1	1.49	0	0	0	0

Vision Screening Test

Refractive error(R.E.) in both eyes was high in face (28.88%)as well as supervision workers (27.77%) followed by maintenance (19.44%)and was least among transport workers (9.37%). 7 workers were suspected as partial colour blind.

Table 9 Showing vision screening results in study subjects

	FACE N=45		MAINTANANCE N=36		TRANSPORT N=64		SUPERVISION N=18	
	N	%	N	%	N	%	N	%
Normal	22	48.88	25	69.44	48	75	11	61.11
R.E. Rt. Eye	4	8.88	1	2.77	7	10.93	2	11.11
R.E. Lt. Eye	1	2.22	1	2.77	0	0	0	0
R.E. Both Eyes	13	28.88	7	19.44	6	9.37	5	27.77



Evaluation of CXR

CXR were done in 163 workers; it was observed that 93.86 % of CXRs were normal. Pulmonary Tb. was found in 11.11% of supervisor, 4.44% of face, 2.77% of maintenance and 1.56% of transport worker. Malignancy was suspected in one supervision worker. Coal workers pneumoconiosis was not found in any worker.

Table 10 Showing X-ray findings in study subjects

	FACE N=45		MAINTANANCE N=36		TRANSPORT N=64		SUPERVISION N=18	
	N	%	N	%	N	%	N	%
Pul Tb	2	4.44	1	2.77	1	1.56	2	11.11
Chr. Bronchitis	1	2.22	0	0	0	0	0	0
COPD / COAD	1	2.22	0	0	0	0	1	5.55

4. Conclusion:

To conclude the observation, the study shows that most of the workers in 41-50 age of years. About 56 % overweight employees were found, this percentage shows necessary intense health education is required for this workforce involved in this study. Coal workers pneumoconiosis was not found in the workers, suggestive of appropriate dust control in the environment. Muscular Skeletal Disorder (MSD) was prevalent to the extent of 28.62% in all category workers with maximum of 36% in transport workers. MSD might be attributed to the vibrations to which workers are exposed during their job. Hearing impairment was present in more than 50% of workers indicating noise pollution in the mining environment.



The medical services of coal industry should be more health oriented and strive to improve the health of workers. Specifically it should organize camps for improving the life style of workers through health awareness campaigns. Importance of the use of personal protective equipment like ear muff should be enlightened. Engineering measures to control exposure levels of noise, vibration and dust should be implemented.

BIOCHEMICAL PARAMETERS

Detection of dust induced diseases is based on radiological abnormalities, which is a late (10 to 15 years of exposure) and irreversible manifestation of disease. It is of great interest to investigate using antioxidants as prospective markers which may be useful for early detection for onset of coal workers pneumoconiosis (CWP) as CWP is a non curable disease.

Objectives

- To study the involvement of oxidative stress in coal dust exposed miners.
- To study serum antioxidants in coal miners.
- To understand the role of important mediators of injury in the progression of CWP

Study design:

- Blood samples were collected for the assessment of the antioxidant enzymes in 30 miners as well as control group. The study subjects were selected on the basis of clinical and occupational history.
- All the potential confounder factors such as age, height, weight, blood pressure, literacy, alcohol, coffee consumption, smoking habit, working years and socioeconomic status were taken into account.



Oxidative damage markers

- Glutathione (GSH) concentrations
- Glutathione-S-transferase (GST)
- Catalase (CAT)
- Lipid peroxidase

Methods

Following methods were used

- Protein - Lowery's method
- GST - Haebig method
- Catalase - Sigma protocols
- GSH - Sigma protocols
- LPO - Sigma protocols

Observations and Results:

	Protein (g/liter)	GST (IU/mg) of protein T3	Catalase (IU/mg) of protein	Extracellular of GSH ($\mu\text{g/ml}$)	Lipid Peroxidase ($\mu\text{mol/ml}$)
Study subjects	70.89 \pm 0.58	2.98 \pm 0.47	21190.6 \pm 0.46	5.9 \pm 0.44	8.12 \pm 0.49
Control subjects	71.34 \pm 0.47	3.5 \pm 0.46	48762.57 \pm 0.56	7.01 \pm 0.77	5.68 \pm 0.55

- The study showed that the CAT, GSH and GST declined while LPO elevated in the exposed miners. GSH which is required to scavenge free radicals and is a substrate for hydrogen peroxide-removing enzyme. Declined levels of the GST may not be able to conjugate GSH with other substrate help in their detoxification.
- From this study we conclude that, the changes in the concentration of the antioxidants and antioxidant enzymes in the blood reflect exposure to dust in the miners.
- This result is in agreement with the hypothesis that reactive oxygen species are involved in cell injury induced by coal mine dust and may be predictive of the degree of inflammation and pneumoconiosis induced by coal mine dust



References:

1. Injuries, Illness and Hazardous Exposure in the Mining Industry 1986-1995: A surveillance Report U.S. Department of Health and Human Services, Public Health Services, Centers for Diseases Control and Prevention National Institute for Occupational Safety & Health
2. Attfield M.: British Data on coal workers' Pneumoconiosis and relevance to US condition Am.J. Public Health 82: 978-983, 1992
3. Attfield M, Castellan R: Epidemiological data on US coal miners pneumoconiosis, 1960 to 1988 Am. J. of Public Health 82: 964-970
4. Morgan W, Burgess D., Jacobsen G.: The prevalence of Coal workers' pneumoconiosis in U.S. Coal Miners. Arch Environ Health 27: 221-226, 1973
5. Marshall W: Cases of spurosis melanosis in the lungs or of phthisis melanotica Lancet ii 271-274, 1834
6. Roy, B.K., 1956, Pneumoconiosis in Central Indian Coal-Mines. Brit. J. Indus. Med., 13: 184-186.
7. Damodaran, K., 1960, Pneumoconiosis in Coal Miners. Ind. J. Indust. Med., 6:49.
8. Chakraborty, M.K., 1961, A preliminary work on assessment of dust hazard in Indian Mines, Central Mining Research station, Dhanbad, Report NO.h/2.
9. Chakraborty, M.K., 1967, some import.Int problems of health associated with miners' work. Ind, J. Indus. Med., 13: 1-16.
10. Chief Advisor Factories, 1961, Pneumoconiosis in the Coalmines of Jharia and Ranigunj Coalfields, Government of India, Ministry of Labour and Employment, Report no.20.
11. Kapur, M.S., 1965, Coal miners' pneumoconiosis. J. Ind. Med. Ass., 45:538-539.
12. Central Mining Research Station, Dhanbad, 1971-1972, Annual Report -Study of Dust Problem in a Coal Mine, 199-120
13. Viswanathan, R., Prasad Madan, Singh H.K. et al.: Report of morbidity survey in Dhanbad-Jharia Coal Fields, with speci.ll reference to pneumoconiosis, Rajendra Memorial Research Memorial Institute of Medical Science, Patana, 1972



14. Patnaik, J.P and Parihar, Y.S., 1990, Analysis of 144 cases of coal workers pneumoconiosis detected in SECL. Ind.J. Indus. Med., 36: 157-161.
15. Caplan, A, and Burden, D.J., 1947, Proc. Conf. On Silicosis, Pneumoconiosis and Dust Suppression. 16-17 April 1947, held at Inst. Min.Eng. and Inst. Mineral Metallurgy, London. Paper No.5, 1-37
16. Effrench, G.E.: 1953, The epidemiology of lobar pneumonia in Kolar Gold -" Fields. Proc. Soc. Study Indust. Med., 5 19.
17. Watson HH The dust problem in Kolar Gold Mines Bull. Inst. Mining and Metal, London No.453, Pg. No. 185, 1952.
18. Gowada,A.M.S. Pnemoconiosis in Kolar Gold Fields VI lit Int.Pnemoconiosis Conference, Bochum, pp 219-1225,1983
19. Rangacharyulu, S., 1987, A study of lung function in underground workmen of Champion Reef Mine, Kolar Gold Fields. Ind. J.Indus.Med., 33:93-99.
20. Report of poisoning Enquiry Committee, Ministry of Labour and Employment. Govt. of India 1960
21. Chief Advisor Factories, 1961a, Silicosis hazard in lead and Zinc mines in Rajasthan.
22. Sikand, B.K. and Pamara, S.P., 1949, Preliminary report on the occurrence of silicosis amongst stone masons. In" The transactions of the VII Tuberculosis Workers Conference.
23. Dhar B. B. : Mining and Environment published by A.P.H. Publishing Corporation I , New Delhi 110002 pages 4-5
24. British Occupational Hygiene Society Committee on Hygiene Standards. A basis for flax dusts. Ann. Occ. Hyg. 23: 1-26 (1980)
25. A TS statement -Snowbird Workshop un Standardization of Spirometry, Am. Review Re~pir. Di~ 119: 831-M38,1971J
26. International Labour Office: ILO/UC International Classification of Radiographs for pneumoconiosis (1979) Occupational Safety and Health Series XX; International Labour Office, Geneva, Switzerland