*wjert*, 2020, Vol. 6, Issue 1, 27-46. *Review Article* ISSN 2454-695X

World Journal of Engineering Research and Technology
WJERT

www.wjert.org

SJIF Impact Factor: 5.924

# ASSESSMENT AND CONTROL OF DUST AND NOISE POLLUTION IN MINES AND QUARRIES: A REVIEW

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**Article Received on 06/11/2019** **Article Revised on 27/11/2019** **Article Accepted on 17/12/2019**

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## ABSTRACT

As much as we do acknowledge the economic benefits of mining activities, there is the need also to recognize the environmental hazards that come with it in order to find ways of dealing with them. Mining is essentially a destructive development activity where ecology suffers at the altar of economy. The health cost of mining operations sometimes outweighs the benefits gained. Dust pollution in terms of particulate matters is increasing tremendously mainly due to rise in open cast projects, transportation, coal stockyard overburden dumps as well as mineral mine fires and other domestic activities. Mine dust can result in a serious nuisance and loss of amenity for populations living in the vicinity of a mine. Health hazards of mines'/quarries' dust include asbestosis lung cancer, kidney damage, black lung cancer, bronchial cancer, gastro-irritation, cough, conjunctivitis, CNS deterioration, silicosis. Noise has been recognized as a health hazard with potent implications on occupational safety. The physiological and psychological effects of noise on humans are often subtle and insidious, appearing so gradually that it becomes difficult to associate cause with effect. This paper focuses on the adverse effects of dust and noise in mines and quarries and provides the control measures for protecting the workers against it.

**KEYWORDS:** Assessment, control, dust, noise, pollution, mines, quarries.

## 1.0 INTRODUCTION

A mine is an excavation made directly or through shafts and galleries on mineralized zones in the earth's crust to extract or mine the ore minerals (Okeke, 2017). Examples of mines include coal mine, gold mine, iron ore mine and quarry (where construction materials are extracted and processed).

Mining is the process of extracting minerals of economic value from the earth's crust for the benefit of mankind (Okeke, 2017). Mining has been identified to comprise various activities involving the removal of minerals (including quarrying) (Acheampong, 2004), producing several raw materials (Mbendi, 2004) which have lots of environmental and health impacts (Okeke, 2000; Nkpuma et al, 2015). These have emanated from the methods of operation by the various mining firms and their effects on the natural environment as well as the people in the surrounding communities (Scholtens and Van Wenveen, 2000; Shrock, 2002; Nyakeniga, 2009). The health cost of mining operations sometimes outweighs the benefits gained. The cost aspect of health hazards is caused by harmful dust and noise which is emitted during surface mining operations (Risk Assessment Workbook for Mines, 2009).

The gains from the sector in form of increased investment are being achieved at great environmental, health and social costs to the residence, recording series of public outcry against the mining companies. The private sector of an economy plays a major role in the development of most mining projects, these mining projects in turn create income and generated revenues for the economy which is used in its development and growth. Since the private sector's main goal is to maximize profit, the private sector is less concerned with the harm that it poses to the environment. But in spite of its economic benefits, mining activities mhave adverse and serious effects on land use and land cover.

A quarry is a place from which dimension stone, rock, construction aggregate, riprap, sand, gravel, or slate are excavated from the ground. A quarry is the same thing as an open-pit mine from which minerals are extracted (Wikipedia, 2016) while quarry operations involves not only extraction of material (rock) but also crushing and screening that makes the rock suitable for use as construction materials, industrial materials, agricultural materials etc. So many quarries exist in this very nation and thus, generating substantial income and revenue to the economy and reducing poverty but its environmental impacts are being neglected by the authorities responsible for the establishment of these quarries, and also by quarry owners and operators.

Quarrying is a form of land use and part of the local heritage where nonmetallic rocks and aggregates are extracted from land (Ukpong, 2012). Dimension and crushed-stones are the final output of such industry in which these products are used for different purposes in our life (Nartey et al., 2012). Quarrying is a process by which rock is extracted from the ground and crushed to produce aggregate, which is then screened into desired sizes. This screened aggregate is then used for the construction of roads, rail lines, bridges, hospitals, schools, airports, factories, and homes, all of which has crucial impact on economic development of any country.

Unfortunately, these activities cause significant impact on the surrounding environment (Okafor, 2006; Okeke, 1997). In fact, the extraction process normally depends on heavy machines and explosives, where both processes are normally associated with air pollution, noise pollution, damage to biodiversity and habitat destruction (Lameed and Ayodele, 2010); in addition to water (Osha, 2006) as well as soil (Haritash et al., 2007). From the agricultural view, released dust not only settles on land, plants and trees but also on surface waters, and thus causing various negative impacts on ecosystem as a whole.

Some active mines and quarries in Nigeria are listed in Table 1 below:

**Table 1: Some Active Mines and Quarries in Nigeria (Ukpong, 2012; Okeke, 1997 & 2017).**

| S/No. | Mines/Quarries | Location |
|---|---|---|
| 1. | Coal Mine | Enugu (South-East, Nigeria) |
| 2. | Coal Mine | Okaba (North Central, Nigeria) |
| 3. | Iron Ore Mine | Itakpe (North Central, Nigeria) |
| 4. | Lead-zinc Mine | Abakaliki (South-East, Nigeria) |
| 5. | Andesite Quarry | Uturu-Okigwe (South-East, Nigeria) |
| 6. | Diorite Quarry | Lakpaukwu-Okigwe (South-East, Nigeria) |
| 7. | Diorite Quarry | Ishiagu(South-East, Nigeria) |
| 8. | Dolerite Quarry | Afikpo (South-East, Nigeria) |
| 9. | Granite Quarry | Akamkpa (Oban massif, South-East, Nigeria) |
| 10. | Limestone Quarry | Nkalagu (South-East, Nigeria) |

## 2.0 Overview of Sources, Characteristics and Environmental Problems of Dust and Noise Pollution

### 2.1 Sources of Dust and Noise Pollution

Dust is a generic term used to describe dry particulate matter (PM) suspended in the atmosphere. Dust is formed when fine particles become entrained in the atmosphere by turbulent action of wind, by the mechanical disturbances of fine materials, through the release of particulate-rich gaseous emissions or other physical disturbances (Barik, et al., 2004).

Dust pollution are generated in mines and quarries through wind blowing on mine tailings, removal of vegetation and top soil, onsite blasting and drilling operations, use of crushing and screening equipment, construction activities and the driving of vehicles on access and haul roads. Dust levels are significantly influenced by climatic factors such as rainfall, temperature and wind. Hot and dry environmental conditions generally result in more dust.

Noise could be defined as a sound which is disagreeable for the individual and which disturbs the normal way of an individual or unwanted sound. In mining industry, the problem of noise has got attenuated due to increased level of mechanization for improving productivity. Prolonged exposure to high levels of noise is dangerous and may also bring about physiological disorders. (Tiwari, et al., 2000).

Noise pollution associated with mining may include noise from drilling, blasting, vehicle engines, loading and unloading of rock into steal dumpers, chutes, power generation, and other sources. Cumulative impacts of shoveling, ripping, drilling, blasting, transport, crushing, grinding, and stock-piling can significantly affect wildlife and nearby residents.

### 2.2 Characteristics of Dust and Noise Pollution

Dust pollution in terms of particulate matters is increasing tremendously mainly due to rise of open cast/quarrying projects, transportation, coal stockyard overburden dumps as well as mineral mine fires and other domestic activities. The particulate matters going to atmosphere are generally of size 1 to 100 µm, particle size from 1 to 10 µm remain suspended for long time depending on its weight, but particulate greater than 10 µm due to gravity settles on near vegetation surface, plant leaves, soils, water bodies etc. act as pollution sink (Barik, et al., 2005).

Fugitive dust particles can pose significant environmental problems at some mines. They are mainly minerals common to soil, including silicon oxides, aluminum, calcium and iron. About half of fugitive dust particles are larger than 10 µm in diameter and settle more quickly than the smaller particles. The inherent toxicity of the dust depends upon the proximity of environmental receptors and type of ore being mined. High levels of arsenic, lead, and radionuclides in windblown dust usually pose the greatest risk (Nkpuma et al, 2015).

Noise pollution could be continuous (produced constantly by machinery that keeps running without interruption) or intermittent (noise level that increases and decreases rapidly, e.g that from equipment that operates in cycles). It could also be impulsive (created by explosions or construction equipment) or low frequency (makes up part of the fabric of our daily soundscape). Low frequency noise is the hardest type of noise to reduce at source, so it easily spread for miles around.

### 2.3 Environmental Problems of Dust and Noise Pollution

#### 2.3.1 Dust Pollution

Dust consists of solid particles generally between 1 to 100 μm in diameter constituents of particulate components of air pollutants. Often it is soil or rock material (silica and silicates) and mineral compounds/metals that are also in the size range (< 100 μm) including non-metals (arsenic, coal, phosphorous and asbestos) and metals (lead, manganese, chromium, iron, nickel and vanadium), trace metals and metal-oxide. Other constituents of the particles include smoke (liquid, gas and solid), fly ash (solids from burning of coal).

According to Narayanan 2009, particulates in the atmosphere are complex mixtures of organic and inorganic substances. They can be liquids, solids or a mixture of both. Rough distribution of major sources of particulates in the atmosphere include road transport (25%), non-combustion industrial processes (drilling, blasting, mining processes) (40%), public power generation like burning of coal in the thermal power plants (15%) and others (20%). The particulates are generally resistant to domineers and when inhaled by human beings causes serious health hazards. The sources, health hazards and control of some of the dust particles/particulates are shown in Table 2 below

**Table 2: Environmental Pollutants (Dust/Particles) Associated with Mining and Quarrying and Their Effects (Health Hazards) and Control (Adapted from Narayanan, 2009).**

| S/No. | Pollutants | Source | Health Hazard | Control |
|---|---|---|---|---|
| 1. | Arsenic | Mining | Lung and Skin Cancer | Uses of bag filters, cyclones, scrubbers, precipitation, conversion |
| 2. | Asbestos | Mining | Asbestosis Lung Cancer Silicosis | |
| 3. | Cadmium | Mining (Zinc-Ore) | Kidney Damage | |
| 4. | Chromium | Mining | CNS Deterioration | |
| 5. | Coal/Fly Ash | Mining/Power Generation | Black Lung Cancer | |
| 6. | Iron | Mining | Nausea and Vomiting | |
| 7. | Lead | Mining | CNS Deterioration | |
| 8. | Nickel | Mining | Bronchial Cancer | |
| 9. | Phosphorous | Mining | Gastro-Irritation | |
| 10. | Vanadium | Mining (Coal-Ores) | Cough, Conjunctivitis | |

| | | | | |
|---|---|---|---|---|
| 11. | Manganese | Mining | CNS Deterioration | |
| 12. | Silica | Quarrying/Aggregates Production | Silicosis | |
| 13. | Zinc | Mining/Metallurgy | Toxic | |

Mine dust can result in a serious nuisance and loss of amenity for populations living in the vicinity of a mine. For certain industrial and mineral activities, dust constitutes a nuisance and creates poor working condition. The control of pollution arising out of this industrial and other dust seems to be continuous is ongoing and never-ending process. Exposure to dust may lead to several distinct types of diseases in the body. For example, coal worker's pneumoconiosis due to coal dust. The majority cases of pneumoconiosis develop after prolonged exposure to such dust. Black Lung diseases is caused by accumulation of fine coal dust within the respiratory system. Inhalation of coal dust over a long time may cause blockage of the airways and Lungs. The effect of dust pollution on plant life is no less harmful. Qualitative and quantitative changes in solar radiation on leaf surfaces and alternation in energy exchange process decrease in chlorophyll and chloroplast (Kamla-Raj, 2010; Iwuji et al, 2016).

### 2.3.2 Noise Pollution

To achieve higher productivity levels, the trend is to achieve higher levels of mechanization in all aspects of mining of the different mode of pollution; the one due to noise assumes prominence in the light of increased mechanization (Tiwari et al., 2000). Noise has been recognized as a health hazard with potent implications on occupational safety. The physiological and psychological effects of noise on us are often subtle and insidious, appearing so gradually that it becomes difficult to associate cause with effect.

Noise has been found to interfere with our activities at three levels:

a) Radiological level in referring with the satisfactory performance of the hearing mechanism
b) Biological level interfering with the biological functioning of the body: and
c) Behavioral level affecting the sociological behavior of the objects.

Effects of high intensity noise is given in Table 3 and impact of increased noise stress on human responses is given in Table 4.

**Table 3: Effect of High Intensity Noise on Human Being (adapted from Tiwari et al., 2000).**

| Noise (db) | Effects Observed |
|---|---|
| 0 | Threshold of audibility |
| 100 | Change in pulse rate |
| 110 | Stimulation of reception in skin |
| 120 | Pain threshold |
| 130-135 | Nausea, vomiting, dizziness, interference with touch and muscle |
| 140 | Extreme limit of human noise tolerance, pain in ear, prolonged exposure causing insanity |
| 150 | Prolonged effect causing burning of the skin |
| 160 | Minor permanent damage if prolonged |
| 190 | Major permanent damage in a short time |

**Table 4: Impact of Increased Noise Stress on Human Responses (adapted from Tiwari et al., 2000).**

<table>
<tr>
<td rowspan="2">A. Physiological impacts<br>1. Cardio-Vascular construction (High blood pressure, heart attack, heartbeat increase)<br>2. Gastro-intestinal modification (ulcers)<br>3. Endocrine stimulation<br>4. Respiratory modification<br>5. Skin resistance alteration<br>6. Headache<br>7. Muscular tension<br>8. Neurological disorder<br>9. Dilation of pupil, paling of skin<br>10. Blinking</td>
<td>B. Hearing impairment<br>Permanent/ Temporary hearing loss</td>
<td rowspan="2">D. Task interference<br>Reduced working efficiency<br>Increased error rate,<br>Proneness to accidents<br><br>xtended output</td>
<td rowspan="2">E. Sleep interference<br>Awakening<br>Medication<br>Electro-cephalographic modification<br>Sleep stage alteration</td>
<td rowspan="2">F. Physiological disorder<br>Annoyance<br>Fear<br>Anxiety,<br>Nervousness<br>Misfeasance<br>Fatigue<br>Startled response</td>
</tr>
<tr>
<td>C. Communication interference</td>
</tr>
</table>

### 2.4 Noise Exposure Index

The noise exposure index (NEI) is defined as the ratio of actual time at a certain noise level to the permitted exposure time as given in Table 5.

$$NEI = \frac{C}{T}$$

Where:

C = actual time (measured at mine)

T = permitted exposure time (as given in Table 5)

If the employee works in different noise levels, NEI is calculated for each noise level and the total NEI for the shift is the sum of all the individual NEIs. A worker's NEI is considered out of compliance if his daily NEI exceeds the desired value.

**Table 5: Permitted Noise Exposure (adapted from Tiwari et al., 2000).**

| Duration/day (h) | Noise level (db A) |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1 – 1/2 | 102 |
| 1 | 105 |
| 3/4 | 107 |
| 1/2 | 110 |
| 1/4 or less | 115 |

## 3.0 Assessment and Control of Dust Pollution in Mines and Quarries/Case Histories

### 3.1 Dust Emissions

Dust is generated in quarry operation during the breaking down process of rocks. Thus, the airborne concentration depends on the energy put into the process. Consequently, screened product is then transported using large amounts of heavy machinery creating movement of traffic, which causes erosion and dust bloom clouds which is severe dust pollution that is then carried through the surrounding by wind.

Therefore, it is not only the quarry process itself but the collection, loading, transporting and delivery of the material that also constitutes considerable dust emissions. Unless dust generation is prevented, dust moves with ambient air and can have far reaching consequences in locations far from the source. The consequences of this process can have an effect on vegetation, animals, and health of the workers and local communities.

### 3.2 How They Can Be Measured

Deposition rates for dusts are rarely measured, and exposure is judged by amounts retained on leaves. However, removal of dust from leaves by rain varies greatly among plant species, from those that are 'self-cleaning' (the lotus effect) to those that accumulate large quantities (Neinhuis & Barthlott, 1997).

Deposition of dusts to aerodynamically 'rough' vegetation is greater than to short vegetation, which has led to the planting of trees and hedges as screens to intercept dust and protect areas close to sources (Freer-Smith et al., 1997).

Dust can be measured as particulate matter in air. It is typically classified according to its particle size:

a) PM10: refers to particles 0.01 µm in size or less (coarse particles)
b) PM2.5: refers to particles 0.0025 µm in size or less (fine particles)

### 3.3 Effects

Quarry dusts, like dusts in general, affect vegetation by both physical and chemical processes. Physically, dust may cover the leaf surface and reduce the amount of light available for photosynthesis, or may occlude stomata. Occlusion may lead to increased resistance to gas exchange, or may prevent full stomata closure, leading to water stress. Increased transpiration is a common response to dust exposure.

Chemically, quarry dusts may be relatively inert (from operations involving hard acidic rocks or some sandstones) or may be strongly alkaline (limestone). Alkaline quarry dusts may have detrimental chemical effects on leaf surfaces. Infestation by pests and pathogens is likely to be enhanced.

Indirect effects may be caused through the soil, especially for the deposition of alkaline quarry dust on acid soils, which can increase the pH and available calcium, leading to changes in vegetation and invertebrate community composition. For unmanaged ecosystems which have been acidified by atmospheric deposition of sulphuric and nitric acids, there may be local beneficial effects if the quarry dust is alkaline, or can supply limiting minerals (e.g. calcium or magnesium).

### 3.4 Impact of Dust Pollution in Quarries

There is no doubt or argument that dust pollution in quarries poses various health risks to its workers as well as to the surrounding communities. Such risks include respiratory ailments, skin and eye problems, and safety issues due to poor visibility. The dust particle size, concentration, chemical composition and length of the exposure are factors considered in evaluating the health risks involved. Long-term severe exposure can pose the risk of developing silicosis, a fatal lung disease.

Occupational exposure to dust is a well-known phenomenon, that occurs everywhere not just in developing countries. Nevertheless, many quarry operations are located close to residential areas, which means that the impact of airborne dust is a problem that has to be dealt with not only because of occupational requirements but also in terms of broad environmental regulations. Local communities are now becoming more aware of the health impacts of dust inhalation and raising the issue.

### 3.5 Dust Mitigation Solutions for Quarries

Dust control needs to be a key priority on any quarry operation. Prevention and control measures should not be applied in an ad hoc manner but integrated into comprehensive, well-managed and sustainable programs. Dust Prevention and effective Dust Control Systems should be implemented to protect workers' health, surrounding communities, and the environment.

Bag filters (fabric filters) used for controlling particulate matter operate like a vacuum cleaner. Dirty gas is blown or sucked through a fabric filter bag, which collects dust. The dust is removed periodically when bag is shaken. Fabric filters can be very efficient collectors for even sub-micron sized particles and are widely used in industrial applications.

A lot of large particles of dust and pollen in the atmosphere can lead directly to greater precipitation in clouds. Particles from pollution are needed as catalysts to form ice in clouds, which can influence precipitation and cloud dynamics. These particles can serve as the center, or nuclei, for cloud droplets that combine to form raindrops.

Scrubbers are air pollution control devices that use liquid to remove particulate matter or gases from an industrial exhaust or flue gas stream. This automized liquid (typically water) entrains particles and pollutant gases in order to effectively wash them out of the gas flow.

Industrial scrubbers are of three major types which includes wet scrubbers, dry scrubbers and electrostatic precipitators.

Cyclones separators (or simply cyclones) are separation devices that use the principle of inertia to remove particle matter from flue gases. Cyclones is one of many air pollution control devices known as precleaners since they generally remove larger pieces of particulate matter. Cyclone separators work much like a centrifuge, but with a continuous feed of dirty air.

### 3.6 Case History (Mining, Development and Environment: Bijolia Mining Area in Rajasthan, India; Chauhan, 2010).

Mining and its associated activities of drilling, blasting and transportation increase the suspended particulate matter in the air which is harmful to the health of the workers exposed to the mine environment. A high-volume sampler was used for collecting air samples from different mines, which gave SPM values ranging from 411 to 467 µg/m $^{3}$ (Chauhan, 2010). One sample was collected far away from the mining area to obtain the background figure of fresh air which gave SPM value of 199 µg/m$^{3}$. Though the value of 411 to 467 µg/m$^{3}$ is well within Central Pollution Control Board (CPCB) standards for areas coming under industrial and mixed use (i.e. 500 µg/m$^{3}$), it is more than double of 199 µg/m$^{3}$ coming from fresh air which the villagers would be exposed to but for working in the mines. The maximum $SO_2$ and $NO_2$ values varied between 30 and 70 µg/m$^{3}$ while CO levels were below detectable limits. Results show that all the values for $SO_2$ and $NO_2$ and CO are well within the CPCB standards for areas coming under industrial and mixed use (i.e. 120 µg/m$^{3}$ for $SO_2$ and $NO_2$ and 5000 µg/m$^{3}$ for CO). Fine dust inhaled by workers leads to diseases related to lungs and liver such as “silicosis”, “bronchitis”, “asthma” and “tuberculosis”. Figure shows that nearly 75 (25%) of the 300 workers interrogated show dust related diseases as mentioned. Nearly 161 (25%) workers felt that the mining has caused air pollution affecting their health slowly. 173 (25%) mine workers felt that mining is the cause of increase in diseases and misery (Chauhan 2004).

Though the SPM in air measured at 411 to 467 µg/m$^{3}$ are below limits prescribed by Central Pollution Control Board (500 µg/m$^{3}$), it is more than twice that (199 µg/m$^{3}$) found in the fresh air which the villagers otherwise would inhale. The World Health Organization (WHO) considers only 55 µg/m$^{3}$ as acceptable and above 90 µg/m$^{3}$ as unacceptable. Hence, it is necessary to have control measures such as wet drilling and blasting by effective stemming and millisecond delay detonators. Plantation of wide-leaf trees around the mines, on waste dumps, in mine worker villages and on both sides of the mine as well as village roads should be undertaken. Wide leaf trees intercepts dust more rapidly. Sprinkling of water on the mine roads settles dust and reduce dust particles in the air. If such measures are adopted SPM in air which affects the health of mine worker, would be considerably reduced and have positive impact on the health of mine workers.

## 4.0 Assessment and Control of Noise Pollution in Mines and Quarries

### 4.1 Noise Pollution

Noise is undesirable sound measured in terms of pressure levels (decibel) by sound level meters. Noise is undesirable sound. Sound is mechanical transfer of energy without transfer of mass. Propagation of sound waves (pressure fluctuations) requires a medium. The velocity, C, of sound in a medium is given by:

$$C = 344\sqrt{\frac{T}{T_0}}\ \text{m/s}^1$$

Where, $T$ = temperature in absolute scale;

$T_0$ = 293 K

Noise pollution is increasingly becoming a nuisance and health hazard. Effects of noise pollution have physical, physiological and psychological dimensions. Noise above 80 decibels (tolerance level) is of concern to human health and prolonged exposure to such noise leads to mental imbalance (Kryter, 1970; Cuniff, 1977).

#### 4.1.1 Intensity of Sound

The intensity of sound (I) is measured in terms of pressure levels. The response on human ear to sound pressures is quite remarkable, extending over a wide range of pressure, 2 x $10^{-5}$ to 100 $N.m^{-2}$. That is, the response is in the 1: $10^7$ range. The intensity (I) response is logarithmic and is represented by decibels, dB.

$$L_P = 20\log_{10}\frac{P}{P_{ref}}\ .dB$$

$$dB = 10\ \log\left(\frac{A}{A0}\right)$$

Pressure level, $L_P$, is the logarithmic ratio of measured sound pressure, P, and a reference sound pressure, $P_{ref},$ ($P_{ref}$ = 2 x $10^{-5}$ $N.m^{-2}$ ($10^{-12}$ $W.m^{-2}$)), which is the lowest sound pressure some people can detect. Some of the sound pressure levels are given in Table 6 below:

**Table 6: Sound Pressure Levels.**

| Sound Pressure (N/m$^2$) | Sound Pressure Level (dB) | Source/Effect |
|---|---|---|
| 2 x 10$^{-5}$ | 0 | Threshold of hearing |
| - | 10 | Rustling of leaves |
| 2 x 10$^{-4}$ | 20 | Whisper at 1m distance |
| - | 30 | Solitary place |
| 2 x 10$^{-3}$ | 40 | Quite room |
| - | 50 | Business office |
| 2 x 10$^{-2}$ | 60 | Normal conversion |
| - | 70 | Regular noise |
| 2 x 10$^{-1}$ | 80 | Traffic noise |
| - | 90 | Heavy vehicular noise |
| 2 x 10$^{-0}$ | 100 | Pneumatic drill/aircraft noise |
| - | 110 | Roc-band music |
| 2 x 10$^{1}$ | 120 | Threshold of pain |
| - | 130 | Rocket launch |

### 4.1.2 Sound Levels

Sound levels are frequency-weighted, and sound level meters are provided with a set of frequency-weighted networks, with A-, B-, C- scales (see Fig. 1 below). Sound levels are marked according to the weighted scheme scales, dB-(A), dB-(B), dB-(C). A-scale has a very prominent frequency-dependence for frequencies below 1000Hz. A-scale is the most useful one, as it approximates the response of the human ear to sound levels below 55 dB. The B-scale is useful for measuring steady exposure to continuous noise (drone). C-scale is practically linear, with little dependence on frequency in the greater part of the audible frequency range.

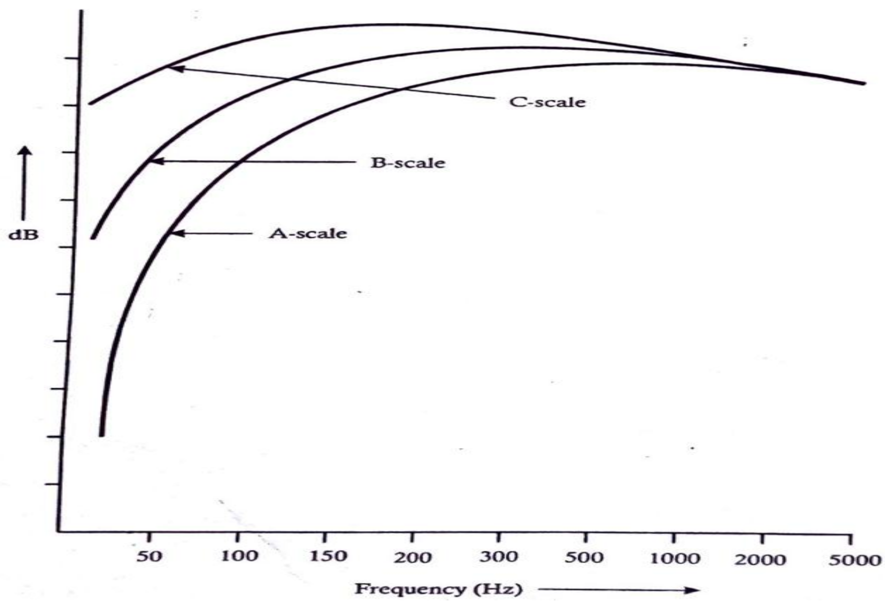


**Fig. 1: Frequency Response Characteristics of the Human Ear.**

### 4.1.3 Noise Pollution Measurement

Sound is due to pressure fluctuation. The pressure, P, is related to the density, ρ

P = $C^2$ρ

$V^2$P - $\frac{1}{C^2}\frac{\partial^2 P}{\partial t^2}$ = S($x$, t)

1. If there is no source, S($x$, t) = 0, and

$\frac{\partial^2 P}{\partial x^2}$ - $\frac{1}{C^2}\frac{\partial^2 P}{\partial t^2}$ = 0 (with no source term)

2. For a monopole,

S($x$, t) = - $\frac{\partial Q}{\partial t}$

3. For a dipole source

P = $\frac{WQ_0}{4\pi r}$ (K. d $cos\emptyset$) sin(K. r - $\omega$t)

W = $\frac{P^{-2}}{\rho C}$ . $4\pi^2$ (for spherical wave)

Where, Q = quantity of mass added to the fluid per unit volume per unit time;

$\emptyset$ = angle the field point makes with the line joining the two monopoles;

K = wave number = $\omega$/C;

W = power output;

$\omega$= anguar velocity;

$\sqrt{P-2}$= R.M.S. value

The particle velocity, U, and specific impedance, Z, are

U = $\rho_0$ $\frac{\partial U}{\partial t}$ = -VP

Z = PC

Sound level meter is a device for measuring the intensity of noise. This includes music and other sounds. It consists of a microphone for picking up the sound and converting it into an electric signal, an amplifier, a filter bank and detector/ readout and other electric systems so that the desired characteristics can be measured (see Fig. 2 below).

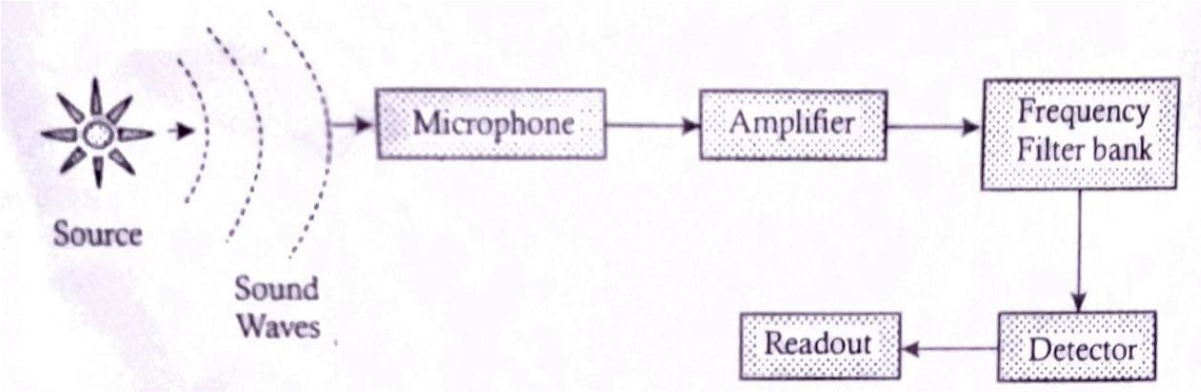


**Fig. 2: Block Diagram of a Sound Level Meter.**

Sound level is a measure of loudness, but actual loudness is a subjective factor and depends on the characteristics of the ear of the listener. Human ear does not have linear response to all sonic frequencies. It is less efficient at lower sonic frequencies. Therefore, in an attempt to overcome this problem, a weighted network is used, to correlate human response to noise. It is logarithmic to measurement for sound power level. ($P_{ref}$ = 2 x $10^{-5}$ $N.m^{-2}$).

### 4.2 Noise Control Strategies

It is unfortunate that once noise gets established in air, there has been almost no way in which it can be controlled by using a power-driven device. However, it could be controlled by passive means that do not consume energy. Noise control can be done mainly by planning and fore thought, control of noise in mines can be achieved by reducing sound at source, interrupting the path of noise and protecting the receiver. General methods of noise pollution control (Bragdon, 1971; Narayanan, 2009) are:

a) Removal of the source
b) Reduction of the decibel level
c) Minimizing the vibratory parts of the gadgets and machines by better design, fastening and padding with noise insulators.

Noise control strategies are given in Table 7.

**Table 7: Noise Control Strategies (adapted from Tiwari et al., 2000).**

Control at source

**Control at source**

(i) Reduction of amplitude of exciting forces in following ways:
1. Reduction of impact/impulse force
2. Balancing of moving mass
3. Using dynamic compression
4. Reducing frictional force
5. Vibration isolation
6. Modified m/c design
7. Timely maintenance and lubrication of m/c

**Control of transmission path**
1. Sitting
2. Building layouts
3. Path deflections
4. Closures
5. Absorption and impedance mismatch

(ii) Reduction of the response of various components to exciting forces
1. Alteration of natural frequency of resonance element
2. Increasing the energy dissipation

**Control of receiver**
1. Use of earplug and earmuffs
2. Education and Publication
3. Exposure control
4. Remote control of m/c

(iii) Change in operating procedure
1. Path deflection
2. Enclosures
3. Absorption
4. Siting
5. Building layout
6. Controlled blasting

## 4.3 Case History (Mining, Development and Environment: A Case Study of Bijolia Mining Area in Rajasthan, India.)

Data reveals that noise levels are comparatively higher in the active zones like drilling, blasting and mine service stations, which are intermittent in nature and form point sources only. Truck transport, tractor-troll transport and heavy machinery like shovels and compressors also generate noise levels beyond tolerable limits. The noise levels measured by using digital decibel meter were found to be in the range of 96 to 125 dB (Chauhan, 2010). These are much above the limits of 75 dB prescribed by WHO for day time industrial area. The exposure for longer periods to these higher levels of noise is likely to affect the ear diaphragms of the workers.

Control measures would be to install noise control treatment on existing equipment or to design inherently quiet equipment. Personal hearing protection devices like "ear plugs" and "ear muffs" are most effective and easy to use. Thick green belts along road sides and in townships, work as acoustic screens and can help in reduction of the noise intensities.

## 5.0 CONCLUSION AND RECOMMENDATION

With increased mechanization in opencast mines/quarries and underground mines, dust and noise have become more or less an integral part of mining environment. Prolonged exposures of miners to high noise doses cause physiological disorders and hence, it should be contended or curbed. Dust pollution in terms of particulate matters is increasing tremendously mainly due to rise of open cast/quarrying projects, transportation, coal stockyard overburden dumps as well as mineral mine fires and other domestic activities. The particulate matters going to atmosphere are generally of size 1 to 100 μm, particle size from 1 to 10 μm remain suspended for long time depending on its weight, but particulate greater than 10 μm due to gravity settles on near vegetation surface, plant leaves, soils, water bodies etc. act as pollution sink. Noise pollution could be continuous, intermittent, impulsive or low frequency. Low frequency noise is the hardest type of noise to reduce at source, so it easily spread for miles around. Mine dust can result in a serious nuisance and loss of amenity for populations living in the vicinity of a mine. Exposure to dust may lead to several distinct types of diseases in the body. The effect of dust pollution on plant life is no less harmful. Noise has been found to interfere with our activities at three levels: radiological level, biological level and behavioral level affecting the sociological behavior of the objects. Dust Prevention and effective Dust Control Systems should be implemented to protect workers' health, surrounding communities, and the environment. Dust control can also be achieved by use of bag filters, precipitation, scrubbers, cyclones and conversion. Noise control can be done mainly by planning and fore thought, control of noise in mines can be achieved by reducing sound at source, interrupting the path of noise and protecting the receiver.

It is hereby recommended that Government Agencies responsible for mining activities should revise its environmental management policy to ensure that the environmental effects of mining activities are reduced to the barest minimum. Adequate compensation should also be paid to host communities whose livelihood is affected by the mining and quarrying operations.

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