Level of Sound in a Power Plant Generated by Natural Gas: A Case Study of Its Mapping

ระดับเสียงในโรงไฟฟ้าพลังก๊าซธรรมชาติ กรณีศึกษา : รูปแบบของเสียง

Md Mukarrom Hossian[1], Mohd Nur E Alam Siddique[*1], M. Golam Mostafa[1], Uzma Khalil[2], Fouzia Perveen Malik[3], Fokir Rafiqul Alam[4] and Zainal Abedin[5]

[1]Dept of Analysis and Development, Global Environment Consultant ltd., Dhaka

[2]Jinnah College for Women, University of Peshawar, Pakistan

[3]National University of Sciences and Technology, Pakistan

[4]Dept of Chemistry, National University of Bangladesh

[5]Dept of Environment, Independent University, Bangladesh

Abstract

The Noise Pollution and Abatement Act of 1972 is a statute of the United States initiating a federal program of regulating noise pollution with the intent of protecting human health and minimizing annoyance of noise to the general public. According to view of Environment Conservation Rules, 1997, the DOE Bangladesh the perfect sound condition for Bangladesh is 75 dB for the day time and 70 dB for the night in industrial areas. Regent Energy Power limited (REPL) 106 MW power plant and 38 natural gas generated machines and 68 exhaust fans. The level of sound was produced by generators and exhaust fans of REPL. The aim of the study will be mapping of sound around the REPL. According to sound mapping the sound level was somewhat greater than standard level (75 dB) of day time. OSHA has been shown 3 dB decreased by one meter distance from its origin, but 0.44 dB decreased by one meter distance from its origin in around REPL.

Keywords: Noise level, Noise mapping, Decibel, OHSA, Noise meter

*Corresponding Author, e-mail: nasiddique75@gmail.com

บทคัดย่อ

พระราชบัญญัติมลภาวะทางเสียงและการลดมลภาวะทางเสียง ค.ศ. 1972 นับเป็นกฎหมายของสหรัฐอเมริกาที่เริ่มมีการควบคุมมลภาวะทางเสียง โดยมีวัตถุประสงค์เพื่อดูแลสุขภาพของประชาชนและลดการรบกวนทางเสียงต่อสาธารณะ จากหลักเกณฑ์การอนุรักษ์สิ่งแวดล้อมปี 1997 ของ DOE ประเทศบังคลาเทศ ระดับเสียงที่เหมาะสมที่สุดในพื้นที่อุตสาหกรรมของบังคลาเทศคือ 75 เดซิเบล ในเวลากลางวัน และ 70 เดซิเบลในเวลากลางคืน บริษัทรีเจ้นท์ เอ็นเนอร์ยี่ เพาเวอร์ จำกัด (REPL) มีโรงไฟฟ้าขนาด 106 เมกะวัตต์ ประกอบด้วยเครื่องกำเนิดไฟฟ้าด้วยพลังงานงานก๊าซธรรมชาติ 38 เครื่องสร้าง และพัดลมดูดระบายอากาศ 68 เครื่อง ซึ่งเป็นที่มาของเสียงดังที่เกิดขึ้นจากการผลิตไฟฟ้าจากบริษัท REPL นี้ งานวิจัยนี้มีจุดมุ่งหมายเพื่อศึกษารูปแบบของเสียงรอบๆ บริษัท REPL ผลการศึกษาพบว่า ระดับเสียงค่อนข้างสูงกว่าระดับมาตรฐาน (75 เดซิเบล) ในเวลากลางวัน OSHA แสดงให้เห็นว่าทุกๆ ระยะหนึ่งเมตรจากจุดกำเนิดเสียง ระดับเสียงจะลดลง 3 เดซิเบล แต่ในพื้นที่รอบๆ บริษัท REPL ทุกๆ ระยะหนึ่งเมตรจากจุดกำเนิดเสียง ระดับเสียงจะลดลงเพียง 0.44 เดซิเบล

คำสำคัญ : ระดับเสียง รูปแบบของเสียง เดซิเบล OHSA มาตรวัดเสียง

Introduction

Sound is what the human ear hears; noise is simply unwanted sound. Sound is produced by vibrating objects and reaches the listener's ear as pressure waves in the air or other media. Sound is technically a variation in pressure in the region adjacent to the ear. When the amount of sound becomes uncomfortable or annoying, it means that the variations in air pressure near the ear have reached too high amplitude.

The human ear has such a wide dynamic range that the decibel (dB) scale was devised to express sound levels. The dB scale is logarithmic because the ratio between the softest sound the ear can detect and the loudest sound it can experience without damage is roughly a million to one or 1:106. By using a base-10logarithmic scale, the whole range of human hearing can be described by a more convenient number that ranges from 0 dB (threshold of normal hearing) to 140 dB (the threshold of pain).This frequency-weighting results in the dB(A) scale, which was adopted by OSHA in 1972 as the official regulated sound level descriptor. Engine noise - This is mainly caused by mechanical and combustion forces and typically ranges from 100 dB (A) to 121 dB(A), measured at one meter, depending on the size of the engine. Cooling fan noise - This results from the sound of air being moved at high speed across the engine and through the radiator. Its level ranges from 100 dB(A) to 105 (A) dB at one meter. Engine exhaust - Without an exhaust silencer, this ranges from 120 dB(A) to 130 dB(A). The total noise level from a generator set is the sum of all the individual sources, regardless of frequency. However, because the dB(A) scale is logarithmic, the individual dB(A) readings cannot be added or subtracted in the usual arithmetic way. For example, if one noise source produces 90 dB(A) and a second noise source also produces 90 dB(A), the total amount of noise produced is 93 dB(A) - not 180 dB(A). An increase of 3 dB(A) represents a doubling of the sound power; yet, this increase is barely perceptible to the human ear. (Figure 1)

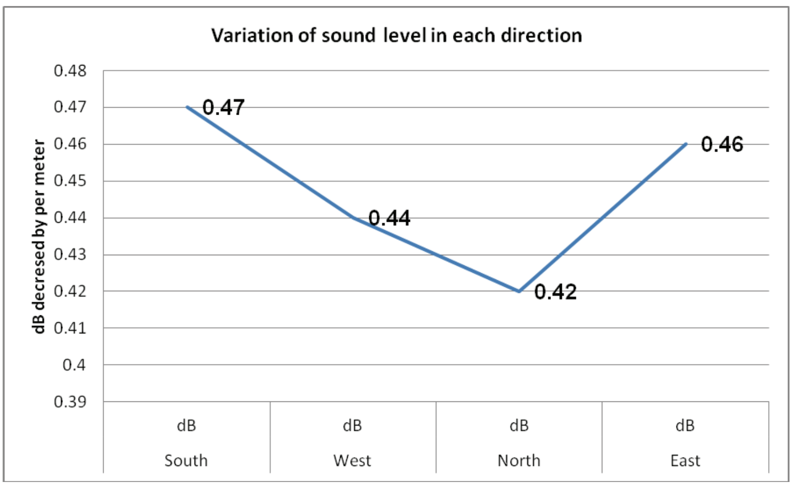

Figure 1 Variation of sound level in each direction

'Noise mapping' (Figure 2) shall mean the presentation of data on an existing or predicted noise situation in terms of a noise indicator, indicating breaches of any relevant limit value in force, the number of people affected in a certain area, or the number of dwellings exposed to certain values of a noise indicator in a certain area; The objective of this guidance note is to provide practical information, advice and guidance to designated Noise Mapping Bodies on the development of strategic noise maps under the Environmental Noise Regulations.

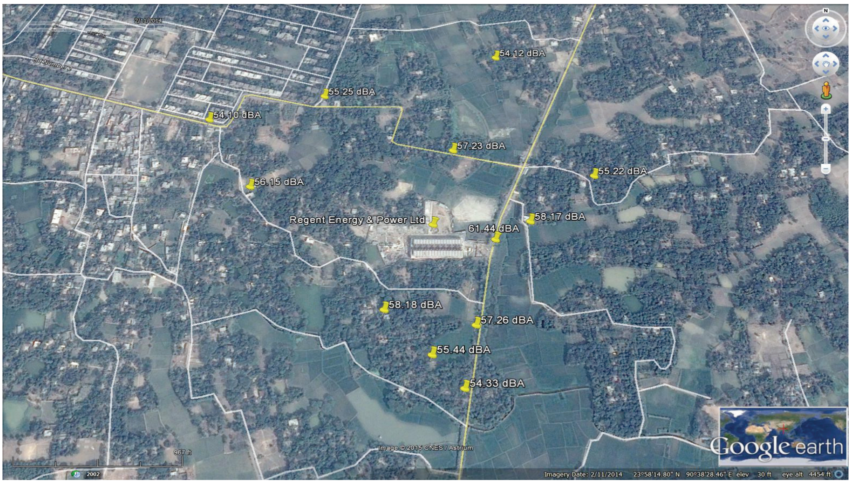

Figure 2 Noise Mapping Plan (Running condition) at different locations around Regent Energy and Power Limited

Now a day's noise pollution is one of the biggest problems that the world is facing. The noise originates from human activities, especially the urbanization and the development of transport and industry. But noise pollution did not create much public concern due to ignorance. It is, along with other types of pollution has become a hazard to quality of life.

Kiernan (1997) finds that even relatively low levels of noise affect human health adversely. It may cause hypertension, disrupt sleep and/or hinder cognitive development in children. The effects of excessive noise could be cause a permanent loss of memory or a psychiatric disorder (Babis et.al,1993).

Noise may not seem as harmful as the contamination of air or water, but it is a pollution problem that affects human health and can contribute to a general deterioration of environmental quality. (D Silva, 2007). In a word, noise is just un-pleasant sound. The quality of unpleasantness of sound waves (Figure 4) have been found to depend upon one or more of the following factors such as industrial generator sets, boilers, plant operations, trolley movement, transport vehicles, pumps, motors etc. With the progress in industrial growth, the level of noise has been increasing continuously. (Makenzie and David, 1998)

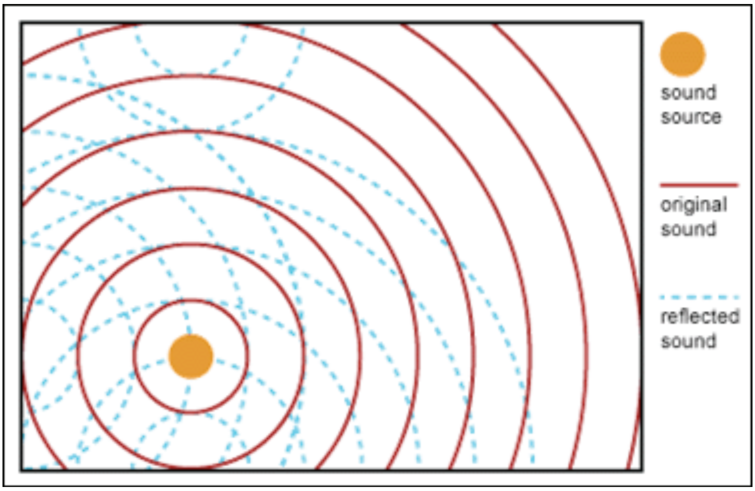

Figure 4 Original and reflected sound waves

Specific and detailed guidelines to implement the requirements of the Environmental Protection Act have been prepared in 1996 by Resource Control Company of Bangladesh, AIC Watson Consultants ltd. of India and Planning and Development Services ltd. of Bangladesh in document titled “Rules and Regulations EPA/1995”.

The Rules and Regulations were slightly revised and recently became enforceable under Bangladesh law by publication in the official Gazette on August 27, 1997. This ESSA has been prepared to comply with these regulations. If there are future changes to the standards and procedures published in the Gazette, these will be taken into account by project management at the appropriate time.

The guidelines for acceptable noise level, especially outside plant boundary have been considered as levels recommended by internationally acclaimed standards. “World Bank Pollution Preservation and Abatement Handbook” prescribed maximum noise level for power station which is: “Noise abatement measures should achieve either the following levels or a minimum increase in background levels of 3 dBa. Measurements are to be taken at noise receptors located outside the project property.” The maximum noise allowable limit is presented in Table 1 and 2 in the unit of dBa.

Table 1 Bangladesh Standards for Noise

Location Category	Standards determined at dBa unit	
	Day	**Night**
Silent Zone	50	40
Residential Area	55	45
Mixed Area (basically residential and together used for commercial and Industrial purposes)	60	50
Commercial area	70	60
Industrial area	75	70

Source: ECR -2006 (SRO-212 Law/2006) Schedule 4, a Compilation of Environmental Laws, DoE

"Environment Guidelines for selected industrial and power development projects" published by the Asian Development Bank suggests that: "In the range of 55 dBa to 75 dBa, impacts are of the "annoyance" type resulting in interference with speech communication, general well being and sleep. Response to such problems varies with the receptor, for example, schools, offices and similar receptors where ease of speech is of primary concern, will not have the same response to an increase from 55 dBA to 60 dBA as a busy commercial district. Above 75 dBA, the possibility of severe health effects occurs such as loss of hearing." Protected noise levels that are presented in these guidelines are presented in following Table 2

Table 2 Maximum Noise Allowable limit

Receptor Type	Daytime (07.00 - 22.00h)	Nighttime (22.00 - 07.00h)
Residential; Institutional; Educational	55	45
Industrial; Commercial	70	70

Source: Thermal Power–Guidelines for NPW plants, World Bank, 1998

The World Health Organization (1991) promotes actions against noise pollution. Environmental noise management is a part of environmental impact studies and of guidelines for urban development in various countries. According to WHO the maximum level of noise should be 81 dB.

Principle of noise pressure

The vibrations cause variations in air pressure around the atmospheric pressure - sound propagates as a pressure wave. Decibel (dB) scale is a log-based scale developed to quantify sound. It is compresses range to 0-140 dB and scale starts at zero when sound pressure equals the threshold of human hearing

$$\text{decibel} = 10\log_{10}\left(\frac{\text{acoustic energy}}{\text{reference energy}}\right)$$

But, Acoustic energy cannot be readily measured; acoustic energy is proportional to the square of the sound pressure

$$\text{dB} = 20\log_{10}\left(\frac{P}{P_0}\right)$$

The noise level (L) measured at a particular location in a factory with a noisy machine.

$$L = 10\log_{10}\left(10^{\frac{I}{10}} - 10^{\frac{I_0}{10}}\right)$$

Here, I is the level of sound when machine in operating and I0 is the level of sound when machine in turn off.

However, for the multiple machines operating in one location, then level LT

$$L_T = 10\log_{10}\left(\sum_{i=1}^{n} 10^{\frac{L_i}{10}}\right)$$

The maximum level of sound is 90 dB according to Occupational Safety & Health Administration (OSHA).

If a point source in a free field produces a sound pressure level of 90 dB at a distance of 1 meter, the sound pressure level is 84 dB at 2 meters, 78 dB at 4 meters, and so forth (Figure 3). This principle holds true regardless of the units used to measure distance. In spaces defined by walls, however, sound fields are more complex. When sound-reflecting objects such as walls or machinery are introduced into the sound field, the wave picture changes completely. Sound reverberates, reflecting back into the room rather than continuing to spread away from the source. Most industrial operations and many construction tasks occur under these conditions.

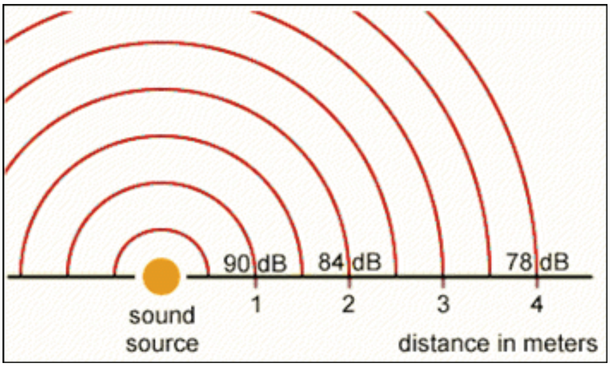

Figure 3 Sound mapping system with respect to distance

The net result is a change in the intensity of the sound. The sound pressure does not decrease as rapidly as it would in a free field. In other words, it decreases by less than 6 dB each time the distance from the sound source doubles.

Far from the noise source--unless the boundaries are very absorbing--the reflected sound dominates. This region is called the reverberant field. If the sound pressure levels in a reverberant field are uniform throughout the room, and the sound waves travel in all directions with equal probability, the sound is said to be diffuse.

In actual practice, however, perfectly free fields and reverberant fields rarely exist--most sound fields are something in between.

In current industrial practice especially power plant, two-dimensional noise mapping is plotted for the workplace and used as information for preparing initial noise monitoring reports. Authorities use the noise map to identify high-noise area for conducting personal noise exposure measurements. However, the development of strategic noise mapping needs to be concerned with workplaces because current industrial practice is inaccurate and unreliable.

Objectives

The present study introduced the use of the random walk approach for the prediction of strategic noise mapping and personal noise exposure in the workplace.

Development of a new stochastic simulation framework and procedures to predict strategic noise mapping were discussed.

Materials and Methods

Measurement of noise—Noise is a combination of intensity and frequency and can be measured in decibels. Decibel is a unit of sound, named after Alexander Graham Bell.

The level of sound is usually expressed in terms of the Sound Pressure Level (SPL) in decibels, which is defined as:

$$SPL = 20 \log_{10} P/ P_o \ \text{dB}$$

Where P is the pressure variation measured in N/m^2 and P_0 is the standard reference pressure taken as $2x10^{-5} N/m^2$

Noise quality has been measured instantly on the site by Noise level meter. At each location 10 to 12 times reading were taken over a short period of time. At the time of measurement, whenever there was an interfering effect like mike noise, human voice from house and bazaar, vehicular sound, sound of machine and tool from workshop etc. was also recorded.

Side selection:

Regent Energy and Power Ltd. (REPL) has set up a 108 MW natural gas fired Power Plant at Narsingdi, Bangladesh. Power has been produced by the 38 generators and 68 exhaust fans. The noise has been produced by the generators and exhaust fans. There is vacant high land lying on the North side as well as some scattered homesteads on the North-West side of the sampling. The South side is mostly tree covered area with few kacha (house made by mud) houses. Some low vacant lands are lying on the West side of the project area. The property of Bangladesh Railway lies on the East side of the proposed project along with the road to Ghorashal bypass. The level of noise was taken in each one meter after from the origin. The distance of experiment was considered 45 meter in each direction.

Results

When all generators and exhaust fans were moving, the following noise has produced which is shown in the tables (3-5). The value of noise was 88.6 dB in the north direction after 7 meter distance, 77.0 dB in the west direction after 7 m distance, 81.6 dB after 11 m distance and 83.0 dB after 6 m distance.

Table 3 Noise level in different direction with respect to source of origin

<table>
<tr><th>Distance (m)</th><th>South dB</th><th>West dB</th><th>North dB</th><th>East dB</th><th>Average dB /meter (South)</th><th>Average dB /meter (West)</th><th>Average dB /meter (North)</th><th>Average dB /meter (East)</th></tr>
<tr><td>1</td><td>82.2</td><td>75.7</td><td>71.3</td><td>78.0</td><td rowspan="15">88.6-84.5= 4.1 dB for 8 meter distance
sound level decreased by 0.51 dB per meter</td><td rowspan="15">77.0-73.0= 4. dB for 8 meter distance
sound level decreased by 0.50 dB per meter</td><td rowspan="15">81.6-79.8= 1.8 dB for 4 meter distance
sound level decreased by 0.45 dB per meter</td><td rowspan="15">83.0-78.6= 4. dB for 9 meter distance
sound level decreased by 0.48 dB per meter</td></tr>
<tr><td>2</td><td>83.1</td><td>76.5</td><td>71.4</td><td>79.0</td></tr>
<tr><td>3</td><td>83.7</td><td>76.7</td><td>72.8</td><td>79.3</td></tr>
<tr><td>4</td><td>84.0</td><td>77.0</td><td>74.2</td><td>80.5</td></tr>
<tr><td>5</td><td>86.7</td><td>76.5</td><td>76.3</td><td>81.6</td></tr>
<tr><td>6</td><td>87.2</td><td>76.7</td><td>77.3</td><td>83.0</td></tr>
<tr><td>7</td><td>88.6</td><td>77.0</td><td>78.6</td><td>82.2</td></tr>
<tr><td>8</td><td>82.5</td><td>76.4</td><td>79.2</td><td>81.5</td></tr>
<tr><td>9</td><td>84.2</td><td>76.4</td><td>79.4</td><td>81.7</td></tr>
<tr><td>10</td><td>84.8</td><td>76.3</td><td>79.8</td><td>81.4</td></tr>
<tr><td>11</td><td>85.0</td><td>75.6</td><td>81.6</td><td>80.6</td></tr>
<tr><td>12</td><td>85.5</td><td>74.0</td><td>79.9</td><td>80.6</td></tr>
<tr><td>13</td><td>84.5</td><td>73.5</td><td>80.0</td><td>79.9</td></tr>
<tr><td>14</td><td>84.2</td><td>73.4</td><td>80.0</td><td>79.3</td></tr>
<tr><td>15</td><td>84.1</td><td>73.5</td><td>80.8</td><td>78.6</td></tr>
</table>

Table 4 Noise level in different direction with respect to source of origin

Distance (m)	South dB	West dB	North dB	East dB	Average dB /meter (South)	Average dB /meter (West)	Average dB /meter (North)	Average dB /meter (East)
16	83.9	73.5	80.7	78.7	83.9-76.8= 7.4 dB for 11 meter distance sound level decreased by 0.49 dB per meter	73.5-69.0= 4.5 dB for 11 meter distance sound level decreased by 0.41 dB per meter	80.7-75.1= 5.6 dB for 14 meter distance sound level decreased by 0.40 dB per meter	78.7-72.0= 6.7 dB for 14 meter distance sound level decreased by 0.48 dB per meter
17	83.2	72.4	79.1	78.4				
18	83.0	72.0	78.8	78.2				
19	82.6	71.8	78.8	77.5				
20	82.0	70.8	78.5	77.6				
21	81.6	71.0	78.8	77.4				
22	81.6	71.8	78.9	78.0				
23	81.4	70.9	78.2	78.0				
24	80.0	69.8	78.4	78.2				
25	79.8	69.7	78.0	77.4				
26	78.7	69.7	76.9	78.0				
27	78.5	69.0	76.9	76.2				
28	77.8	69.5	76.8	74.0				
29	76.8	69.4	75.8	73.1				
30	77.5	69.1	75.1	72.0				

Table 5 Noise level in different direction with respect to source of origin

Distance (m)	South dB	West dB	North dB	East dB	Average dB /meter (South)	Average e dB /meter (West)	Average dB /meter (North)	Average e dB /meter (East)
31	77.5	69.1	75.6	71.6	77.5-71.8= 5.7 dB for 14 meter distance sound level decreased by 0.41 dB per meter	69.1-64.6= 5.5 dB for 14 meter distance sound level decreased by 0.40 dB per meter	75.6-70.1= 5.5 dB for 14 meter distance sound level decreased by 0.40 dB per meter	71.6-65.8= 5.8 dB for 14 meter distance sound level decreased by 0.41 dB per meter
32	77.1	69.7	75.4	71.5				
33	76.5	69.2	75.3	71.5				
34	74.9	68.9	75.1	70.5				
35	74.6	68.4	74.6	71.3				
36	74.6	68.9	74.6	70.6				
37	74.3	68.2	74.3	70.2				
38	73.6	67	74.3	70.3				
39	73.6	67	73.0	70.3				
40	73.4	68	73.0	69.8				
41	73.7	65.4	72.5	69.6				
42	73.7	65.3	72.6	68.8				
43	72.8	64.9	72.7	67.9				
44	72.8	64.5	71.6	66.8				
45	71.8	63.6	70.1	65.8				

In this observation, the sound level decreased within 15 meter distance from origin of sound by 0.51 dB in the South direction per one meter distance, by 0.47 dB in the West direction per one meter distance, by 0.45 dB in the West direction per one meter distance and by 0.48 dB in the West direction per one meter distance. (Table 6)

Table 6 Average noise level decreased per one meter in different direction

Sound level	South dB	West dB	North dB	East dB
Sound level decreased by per meter for first 15 meters	0.51	0.50	0.45	0.48
Sound level decreased by per meter for first 30 meters	0.49	0.41	0.40	0.48
Sound level decreased by per meter for first 45 meters	0.41	0.40	0.40	0.41
Average (dB)	**0.47**	**0.44**	**0.42**	**0.46**

On average, the sound level decreased within 45 meter distance from origin of sound by 0.47 dB in the South direction per one meter distance, by 0.44 dB in the South direction per one meter distance, by 0.42 dB in the South direction per one meter distance and by 0.46 dB in the South direction per one meter distance. In this circumstance, 0.44 dB sound level decreased by on average

Discussion

The level of sound was higher in the south direction and comparatively low was in the north direction. The sounds have a chance to reflect north direction because of some trees was remained in the South side of REPL and north side was opened of the power plant. The level of sound decreased 3 dB according the Occupational Safety and Health Administration (OSHA), but sound decreased 3 dB experimentally round the REPL. There are several causes for deviation of sound; the waves of sound were super-imposed as a result to form a beat and the level of sound might be reflected away to the nearest wall. A sound level meter with an analogue display (a deflecting needle or a bar-graph). If the sound level fluctuates too rapidly, the needle or bar graph changes so erratically that it is impossible to get a meaningful reading. Percussion has been taken up during the measurement of sound level. The deviation of sound level from OSHA is responsible by background noise around the REPL.

Conclusion

The level of sound was measured by electrical noise meter which has been calibrated by the SGS Bangladesh Limited. The level of sound was measured at day time and meter scale has been used during the measurement. Regent Energy and Power Ltd. (REPL) is 108 MW power plants and it situated in village with low noise area i.e in the silence zone. The sound level exponentially decreased with respect to length (m); about 0.44 dBA sound level decreased with one meter distance apart. Sound level with respect GIS around local areas was very low compared to the level in the point source of Regent Energy and Power Ltd. (REPL).

Acknowledgements

Author is greatly acknowledge to the Global Environment Consultant limited for financial support to carry out the research work

References

The World Health Organization (WHO). (1991) Report of the Informal Working Group on Prevention of Deafness and Hearing Impairment Programme Planning, June, (Geneva: WHO/PDH/91.1).

Nijs, T. C., Niet, R. D. and Commentuijn, L. (2004). Constructing land use maps of the Netherlands in 2030. *Journal of Environmental Management, 72(1),* 35-42.

Sing N. and Davar S. C. (2004). Noise Pollution- Source,Effect and Control. *J. Hum. Ecol, 16(3),* 181-187.

Uddin, M. J., Rahman, M. A. and Roy, R. (2009) NoiseMapping and their Interpretations of Sahbagh area, Dhaka, Bangladesh. *J. of Env. Res. 7,* 43-51.

Ali, J., Ansari, A. M. H. and Miah, A. B. (2000-2001). Environmental Management System (EMS) Manual of Zia Fertilizer Company Limited, A BCIC-World Bank Joint Project.

Sultana, M. S., Jahana, N., Islamb, M. S. and Masumc, S. M. (2011). Assessment of Noise Pollution in the Ashuganj Fertilizer Industrial Area, Ashuganj, Bangladesh. *J. Sci. Ind. Res. 46*(2), 183-190.