Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.3, No.5, 2013 www.iiste.org

Worker's Response (Attitudes) Towards Exposure to Steady-State Broad-Band Industrial Noise in Jos

Chagok, N.M.D. [1*], Gyang, B.N. [2], Domtau, D.L. [3], and Mado, S.D. [4]

1., 2.,3., and 4 Department of Physics, University of Jos, Jos-Nigeria.

* E-mail of the corresponding author: nchagok@yahoo.com

Abstract

Noise sound pressure levels in some companies/industries in Jos were measured and the attitudes of the workers to the noise were assessed in the same companies/industries. The objective physical measurements showed that the noise was steady-state, broad-band and continuous. The equivalent continuous noise levels in most of the companies were more than the 85dBA Time-Weighted Average. The Pearson correlation coefficient for noise rating and equivalent noise level $\gamma 1=0.735$ and the Pearson correlation coefficient for noise annoyance and noise level $\gamma 2=0.944$, both show strong positive correlations between objective and subjective assessment of noise. This implies that the higher the noise level, the higher the noise rating and the higher the annoyance.

Keywords: Noise, noise rating, annoyance, correlation coefficient, Jos.

1. Introduction

Noise is known to be an environmental pollutant that adversely affects community and individual well-being. Much data are available showing that excessive noise causes not only hearing damage, accelerated deafness and decreased worker efficiency, but other severe physiological and psychological damage (Alberti, 1998; Berger et al, 1978; Coles et al, 1968; Cunniff, 1977; Ebeniro and Abumere, 1999). However, there is a dearth of research publications into environmental noise pollution carried out in Nigeria (Ebeniro and Abumere, 1999; Onuu and Menkiti, 1993; 1996; 1997; Menkiti, 1994; Onuu, 1999; Obisung et al, 2007) despite the increase in mechanisation occasioned by increase in Nigeria's industrialisation which expectedly, is accompanied by a rise in the incidence of noise and its attendant effects. People who work in most manufacturing industries are very much exposed to high level noise. Some of these people are exposed to an average of 85dB or more and, often there is a lack of concern for these workers.

Most efforts to regulate environmental noise for the protection of public health and welfare have relied on social surveys to quantify the effects noise has on the people. With increasing problem of environmental noise, emphasis shifted from a prediction of overt response (complaint) recommended in Rosenblith and Stevens (1953) to a prediction of annoyance (George et al, 1982). Implicit in the shift of emphasis was the need that people should be protected from unhealthy levels of noise whether or not they complained.

Schultz (1978) suggested that when people are highly annoyed by noise, the exposure and the expressed subjective reaction is high both for individuals and for groups. In other words, when the noise exposure is felt to be extreme, people have little difficulty in sorting out their feeling about the noise from their other non-acoustical attitudes. However, arbitrariness in counting the percent highly annoyed drew severe criticism and heated debate between Schultz and Kryter (Schultz, 1978; Kryter, 1982a; b; Schultz, 1982).

The equivalent continuous noise level of a time-varying noise L_{eq} is given by Cunniff (1977) as follows:

$$L_{eq} = 10log_{10}\left(t_1 x10^{\frac{L_1}{10}} + t_2 x10^{\frac{L_2}{10}} + \cdots \dots \dots + t_n x10^{\frac{L_n}{10}}\right)/T \quad (1)$$

where t_i is the time in hours the workers work in a section whose sound level reading is L_i . T is the total time, i.e. $\sum t_i$

The sound Exposure Level (L_E) is proportional to the total A-weighted sound energy received by the ear over the exposure time. This concept (Equal Energy Hypothesis EEH) combines in a single parameter the sound pressure level and the duration of exposure to the noise. A simple statement of the EEG is that the trauma associated with a particular noise exposure is a monotonic function of the total amount of acoustic energy received by the ear

To obtain an expression for the sound exposure level (L_E), the sound exposure, E, defined by Stevin (1982) as the time integral of the squared sound pressure $P^2(t)$ over a stated time T given in equation (2) was used.

$$E = \int_0^T P^2(t)dt$$

(2)

This is essentially an estimate of the sound energy associated with the noise over the time T. The sound exposure level is the expression in decibels of the ratio of the weighted sound exposure to the reference sound exposure. The reference sound exposure (E_0) is equal to the product of the squared reference sound pressure (P_0) of 20μP_a and the reference duration (t_0) of one second.

That is

$$E_0 = P_0^2 t_0 = P_0^2 \quad (3)$$

The A-weighted sound exposure level L_{AE} is therefore

$$L_{AE} = 10log\left(\int_0^T \frac{P^2(t)dt}{P_0^2}\right)$$
$$=10\log\left[\left(\frac{P}{P_0}\right)^2 T\right]$$
$$= 10log\left(\frac{P}{P_0}\right)^2 + 10logT$$
$$= L_A + 10logT \quad (4)$$

L_A is the A-weighted equivalent sound pressure level as given in equation (1)

The daily dose (D) should not equal or exceed 100%, as calculated according to the expression

$$D = \left[\frac{t_1}{T_1} + \frac{t_2}{T_2} + \cdots + \frac{t_n}{T_n}\right] \quad (5)$$

where t_n is the total time of exposure at a specific noise level and T_n is the exposure duration for which noise at this level becomes hazardous. The daily dose, D, can be converted into an 8-hr Time Weighted-Average, TWA, according to

$$TWA = 10log\left(\frac{D}{100}\right) + 70 \quad (6)$$

2 Materials and Methods

2.1 Physical measurements

A-weighted Sound Pressure Levels (SPL) measurements and ⅓-octave band spectra of the noise levels at machine operator positions at the sites of the companies/industries included in this research were done by the use of *Brüel & Kjaer* Impulse Precision Sound Level Meter Type 2209 in conjunction with the ⅓-Octave Band Filter set, Type 1616. The Pistonphone Type 4220 which generates 124dB ±0.2dB at a frequency of 250Hz was used to calibrate the sound level meter. These companies/industries, all located within Jos-Bukuru metropolis were identified to use machinery that generate high levels of noise and had granted permission for the research to be carried out in their premises. Some companies/industries declined participation.

In taking a sound level measurement at a location on the company floor, the microphone was placed at a horizontal distance of 1m from the noise sources (corresponding to the average worker position) and at a height of 1.5m (corresponding to the average head position or ear level) of workers. For all measurements, the sound level meter was held steadily as far away from the body as possible and away from any hard reflecting surface or material. With the meter function selector switch on "slow" and the weighting network selector switch on "A", weighting, for readings on the dBA scale, the sound level was read and recorded. Finally, a ⅓-octave

band filter was coupled to the sound level meter and with the meter deflection damping characteristics on "slow" and frequency weighting selector switch on "linear", the ⅓-octave band sound pressure levels were obtained. Measurements were made between the usual business hours of 8:00 am and 5:00 pm, when the companies/industries were in full operation. Care was taken so that the measurements were made with the minimum interference with normal working patterns as possible and that none of the measurements was influenced by external noise, such as aircraft or road traffic noise. These measurements were repeated on subsequent visits to confirm that the noise environment had remained unchanged.

3. Assessment of Workers Attitudes Towards Noise

To assess the subjective impact of noise on the workers, a questionnaire was used. While a few respondents completed the questionnaire on their own, in most cases, the researchers asked the respondents questions and entered their responses into the questionnaires. This helped to avoid incomplete responses and non-return of questionnaire, loss of questionnaire, misunderstanding of the questions and other shortcomings on the part of the respondents.

4. Results and Discussion

4.1 *Sound Pressure Levels*

The noise data on the acoustic environment of the workers obtained by use of the Impulse Precision Sound Level Meter Type 2209 used in conjunction with the $\frac{1}{3}$ -Octave Filter Set Type 1616 are tabulated in appendix B_1. The noises in the sections of the mills were very constant and continuous, and essentially devoid of any impulse components. These values represent noise levels for given mills locations (sections) since the noise levels for single locations were essentially invariant.

For a given mill, employees were not confined to only one work station and therefore the time that a typical employee spent at each location within an area was then estimated from data supplied (during interviews) by the foremen and supervisors of the mills. Thus each work station was assigned an equivalent level and an exposure time. This meant that variations in sound level caused by movement among locations within an area were treated in the same manner as time-varying noise levels at any particular location. During a single 9-hour shift, an employee worked 8 hours, spending the remaining 1 hour time of break in the day in areas where the noise levels were also measured. This was accounted for in the calculations.

Table 1 shows the Equivalent Continuous Noise Levels (L_A) of the mills obtained by using equation (1), Noise Exposure Level (L_{AE}) obtained by using equation (4), Noise Dose (D) obtained by using equation (5) and Time Weighted Average (TWA) of the mills obtained by using equation (6).

5. Social Survey

Noise rating of workplaces is represented by the bar chart of the percentage responses to the noise rating of the workplaces as shown in Figure 1. The workplaces were rated to be noisy except D2 which was rated to be moderately noisy. The overall workplace noise rating was calculated by introducing scale values, x, in the form of numbers to represent the respondents' workplace noise rating. The numbers x = 4, 3, 2, 1 and 0 represent noisy, moderately noisy, quiet, don't know and refused to comment respectively and n is the number of responses. The overall workplace noise rating is noisy. Table 2 shows the overall rating of mill noise for the various mills.

Figure 2 shows the percentage of respondents for each mill and their expressed degrees to which they found the noise bothersome/annoyance.

The overall rating of annoyance was calculated by the introduction of scale values, x, in the form of numbers to represent the respondents' annoyance rating. The numbers x = 4, 3, 2, 1, 0 represent "extremely", "very much", "moderately", "slightly" and "not at all annoyed" respectively and n is the number of responses. Table 3 shows the overall rating of noise annoyance by respondents in the mills and it could be inferred that the overall mills noise annoyance rating depended largely on the level of the noise.

To obtain the correlation coefficient for the objective and subjective measurements of the mill noise rating, the A-weighted equivalent continuous levels of the mills from Table 1 and the average scale of noise rating as shown in Table 2 are reproduced in Table 4. The equivalent continuous A-weighted sound level

(objective responses) are the x-variates and the noise rating by respondents (subjective responses) represented by their corresponding scale values are the y-variates.

Using the Pearson equation $\gamma = \frac{\sum_1^n xy - \frac{(\sum_1^n x)(\sum_1^n y)}{n}}{\sqrt{\left[\sum_1^n x^2 - \frac{(\sum_1^n x)^2}{n}\right]\left[\sum_1^n y^2 - \frac{(\sum_1^n y)^2}{n}\right]}}$ for the correlation coefficient for mill noise

rating by respondents and equivalent continuous A-weighted sound levels, we obtain

$$\gamma_1 = \frac{5992.73 - \frac{(1549)(65.37)}{17}}{\sqrt{\left[142759 - \frac{(1549)^2}{17}\right]\left[252.88 - \frac{(65.37)^2}{17}\right]}}$$

$= 0.735$

This result shows that the subjective and objective measures were more than 73% correlated.

The correlation coefficient for the noise annoyance rating of the mill noise and the noise levels was obtained. This was done by using the A-weighted equivalent continuous levels of the mills from Table 1 and the average respondents' noise annoyance rating from Table 3 as shown in Table 5. The equivalent continuous A-weighted sound levels (objective responses) are the x-variates and the noise annoyance rating by respondents (subjective responses) represented by their corresponding scale values are the y-variates.

The correlation coefficient

$$\gamma_2 = \frac{\sum_1^n xy - \frac{(\sum_1^n x)(\sum_1^n y)}{n}}{\sqrt{\left[\sum_1^n x^2 - \frac{(\sum_1^n x)^2}{n}\right]\left[\sum_1^n y^2 - \frac{(\sum_1^n y)^2}{n}\right]}}$$

$$= \frac{2985.93 - \frac{(1549)(31.69)}{17}}{\sqrt{\left[142759 - \frac{2399401}{17}\right]\left[65.6433 - \frac{1004.2561}{17}\right]}}$$

$=0.944.$

This shows that there is a very strong positive correlation between annoyance and sound pressure level

6. Conclusion and Recommendation

An assessment of workers' attitudes towards noise in some companies/industries in Jos-Bukuru metropolis was carried out and results indicated that the noise rating and the annoyance due to the noise depended upon the noise level. The measured noise sound pressure levels in the companies/industries showed that most workers were being exposed to occupational noise levels that are above the maximum threshold recommended by international regulatory agencies. From this work, it is recommended that noise levels in workplaces should be monitored routinely and periodically and where necessary, workers exposed to high levels of noise should be provided with ear protection and be encouraged to use them. Also a regular and periodic awareness program on the potential dangers of exposure to high levels of noise should be mounted by companies.

References

Alberti, P.W. (1998). Hearing Conservation *In:* Peter W. Alberti and Robert J. Ruben (eds), Otologic Medicine and Surgery, Churchill Livingstone Inc. pp. 253-271

Berger, E.H., Royster, L.H. and Thomas, W.G. (1978). Presumed Noise-Induced Permanent Threshold Shift Resulting from Exposure to an A-Weighted Leq of 89dB. *Journal of the Acoustical Society of America.* 64(1): 192-197.

Coles, R.R.A., Garinther, G.R., Hodge, D.C, and Rice, C.G. (1968).Hazardous Exposure to Impulse Noise. *Journal of the Acoustical Society of America.* 43: 336-343.

Cunniff, P.F. (1977). Environmental Noise Pollution New York: John Wiley and Sons 210p.

Ebeniro J.O. and Abumere O.E. (1999) Environmental Noise Assessment of an Industrial Plant. *Nigerian Journal of Physics* 11: 97-106.

George, A.L.; Richard, R. and Schomer, P.D. (1982). An Analysis of Community Complaints to Noise. *Journal of the Acoustical Society of America* 73(4): 1229-1235.

Kryter, K.D. (1982a). Community Annoyance from Aircraft and Ground Vehicle Noise. *Journal of the Acoustical Society of America* 72 (4): 1222-1242.

Kryter, K.D. (1982b). Rebuttal by Karl D. Kryter to Comments by T.J. Schultz. *Journal of the Acoustical Society of America* 72 (4): 1253-1257.

Menkiti, A.I. (1994). Noise Studies in an Oil Drilling Environment. *Nig. Journal of Physics* 6: 16-26

Obisung, E. O., Onuu, M.U. and Menkiti A. I. (2007). Levels and Spectra of Aircraft Noise and People's Reaction in some Nigerian Cities. *Nigerian Journal of Physics* 19(2): 223 – 236.

Onuu M.U. (1999) Environmental Noise control: Review and Assessment of Theories and Models. *Nig. Journal of Physics* 11: 91-96.

Onuu, M.U. and Menkiti, A.I. (1993). Spectral Analysis of Road Traffic Noise in Parts of South-Eastern Nigeria. *Nig. Journal of Physics* 5: 1-9.

Onuu M.U. and Menkiti A.I. (1996). Analysis of Nigerian Community Response to Road Traffic Noise. *Journal of Science Engineering and Technology* 3: 536-547

Onuu M.U. and Menkiti A.I. (1997). Acoustic Power Spectra of (Mixed) Road Traffic Noise Sources in South-Eastern Nigeria. *Nig. Journal of Physics* 9: 15-19.

Rosenblith, W.A. and Stevens, K.N. (1953). Noise and Man in Handbook of Acoustic Noise Control Vol.2, U.S. Air Force Report WADCTR 52-204.

Schultz, T.J. (1978). Synthesis of Social Surveys on Noise Annoyance. *Journal of the Acoustical Society of America* 64(2): 377-405

Schultz, T.J. (1982). Comments on K.D. Kryter's Paper, Community Annoyance from Aircraft and Ground Vehicle Noise. *Journal of the Acoustical Society of America*. 72 (4): 1243-1252.

Stevin, G.O. (1982) Spectral Analysis of Impulse Noise for Hearing Conservation purposes. *Journal of the Acoustical Society of America* 72(6): 1845-1854

Table 1: Equivalent continuous noise levels of the mills.

MILL	L_A	L_{AE}	D%	TWA
A_1	92	137	605.62	90.82
A_2	87	132	198.03	87.97
A_3	90	135	372.15	90.71
B_1	85	130	121.34	85.84
B_2	89	134	314.78	89.98
C_1	89	134	298.54	89.75
C_2	86	131	153.46	86.86
D_1	75	120	11.97	75.78
D_2	67	112	1.96	67.93
E_1	102	147	6237.35	102.95
E_2	106	151	15381.55	106.87
E_3	104	149	9794.90	104.91
F_1	100	145	3775.72	100.77
F_2	98	143	2443.43	98.88
F_3	97	142	1901.08	97.79
G_1	94	139	961.61	94.83
G_2	88	133	247.72	88.94

Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.3, No.5, 2013

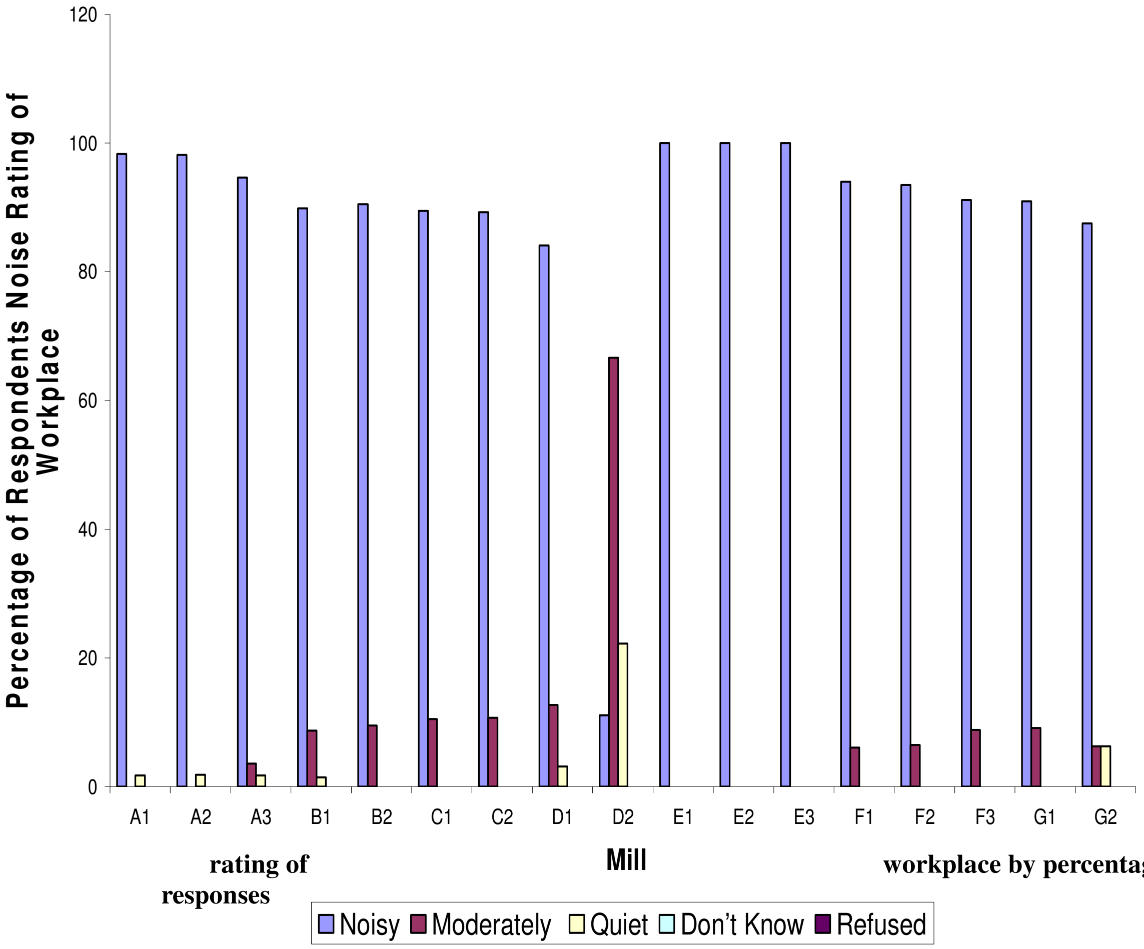

Figure 1: Noise rating of workplace by percentage of responses

Table 2: Overall Rating of Mill Noise

		Number of Responses in each Workplace Noise Rating							
		Workplace Noise Rating							
Company	Mill	Noisy (4)	Moderate (3)	Quiet (2)	Don't Know (1)	Refused (0)	Response per Zone	Weighted Rating. ∑NX	Ave. Value ∑(NX/N)
A	A_1	57	0	1	0	0	58	230	3.97
	A_2	53	0	1	0	0	54	214	3.96
	A_3	53	2	1	0	0	56	220	3.93
B	B_1	62	6	1	0	0	69	268	3.88
	B_2	76	8	0	0	0	84	328	3.90
C	C_1	51	6	0	0	0	57	222	3.89
	C_2	25	3	0	0	0	28	109	3.89
D	D_1	53	8	2	0	0	63	238	3.78
	D_2	2	12	4	0	0	18	48	2.67
E	E_1	67	0	0	0	0	67	268	4.00
	E_2	38	0	0	0	0	38	152	4.00
	E_3	48	0	0	0	0	48	192	4.00
F	F_1	31	2	0	0	0	33	130	3.94
	F_2	43	3	0	0	0	46	181	3.93
	F_3	31	3	0	0	0	34	133	3.91
G	G_1	20	2	0	0	0	22	86	3.91
	G_2	14	1	1	0	0	16	61	3.81

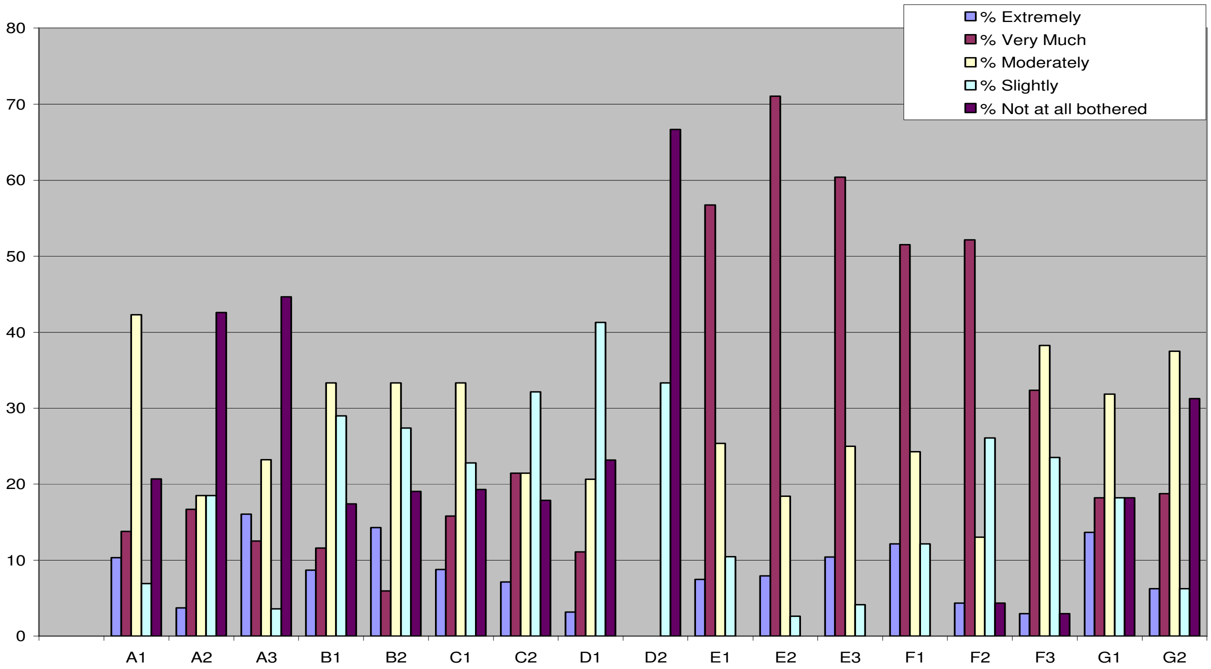

Figure 2: Percentage rating of annoyance.

Table 3: Overall Rating of Noise Annoyance

		Respondents' Noise Annoyance Rating								
Comp-any	Mill	Extre-mely (4)	Very Much (3)	Mode-rately (2)	Slightly (1)	Not at all bothered (0)	Total	Weighted Rating Σ(NX)	Average Response Rating Σ(NX/N)	L_A dBA
A	A_1	6	8	28	4	12	58	108	1.86	92
	A_2	2	9	10	10	23	54	65	1.20	87
	A_3	9	7	13	2	25	56	85	1.52	90
B	B_1	6	8	23	20	12	69	114	1.65	85
	B_2	12	5	28	23	16	84	142	1.69	89
C	C_1	5	9	19	13	11	57	98	1.72	89
	C_2	2	6	6	9	5	28	47	1.68	86
D	D_1	2	7	13	26	15	63	81	1.29	75
	D_2	0	0	0	6	12	18	6	0.33	67
E	E_1	5	38	17	7	0	67	175	2.61	102
	E_2	3	27	7	1	0	38	108	2.84	106
	E_3	5	29	12	2	0	48	133	2.77	104
F	F_1	4	17	8	4	0	33	87	2.64	100
	F_2	2	24	6	12	2	46	104	2.26	98
	F_3	1	11	13	8	1	34	71	2.09	97
G	G_1	3	4	7	4	4	22	42	1.91	94
	G_2	1	3	6	1	5	16	26	1.63	88

Table 4: Variates for calculating coefficient of correlation between noise rating by respondents and equivalent continuous A-weighted sound Levels

COMPANY	MILL	X_i	Y_i	X_i^2	Y_i^2	X_iY_i
A	A_1	92	3.97	8464	15.76	365.24
	A_2	87	3.96	7569	15.68	344.52
	A_3	90	3.93	8100	15.44	353.70
B	B_1	85	3.88	7225	15.05	329.80
	B_2	89	3.90	7921	15.21	347.10
C	C_1	89	3.89	7921	15.13	346.21
	C_2	86	3.89	7396	15.13	334.54
D	D_1	75	3.78	5625	14.29	283.50
	D_2	67	2.67	4489	7.13	178.89
E	E_1	102	4.00	10404	16.00	408.00
	E_2	106	4.00	11236	16.00	424.00
	E_3	104	4.00	10816	16.00	416.00
F	F_1	100	3.94	10000	15.52	394.00
	F_2	98	3.93	9604	15.44	385.14
	F_3	97	3.91	9409	15.29	379.27
G	G_1	94	3.91	8836	15.29	367.54
	G_2	88	3.81	7744	14.52	335.28
TOTAL		1549	65.37	142759	252.88	5992.73

Table 5: Variates for calculating coefficient of correlation between annoyance and noise level

COMPANY	MILL	X_i	Y_i	X_i^2	Y_i^2	X_iY_i
A	A_1	92	1.86	8464	3.4596	171.12
	A_2	87	1.20	7569	1.4400	104.40
	A_3	90	1.52	8100	2.3104	136.80
B	B_1	85	1.65	7225	2.7225	140.25
	B_2	89	1.69	7921	2.8561	150.41
C	C_1	89	1.72	7921	2.9584	153.08
	C_2	86	1.68	7396	2.8224	144.48
D	D_1	75	1.29	5625	1.6641	96.75
	D_2	67	0.33	4489	0.1089	22.11
E	E_1	102	2.61	10404	6.8121	266.22
	E_2	106	2.84	11236	8.0656	301.04
	E_3	104	2.77	10816	7.6729	288.08
F	F_1	100	2.64	10000	6.9696	264.00
	F_2	98	2.26	9604	5.1076	221.48
	F_3	97	2.09	9409	4.3681	202.73
G	G_1	94	1.91	8836	3.6481	179.54
	G_2	88	1.63	7744	2.6569	143.44
TOTAL		1549	31.69	142759	65.6433	2985.93