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STUDY ON THE NOISE PREDICTION IN MINING AND INDUSTRIAL PLANTS

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ABSTRACT :

Noise Levels (NL) in mining and industrial plants were investigated. Three mining and industrial projects, namely: Assiut Cement plant, Assiut Cement Quarry and El-Gedida mine were selected SL-130 and Bruel & Kjaer, Type 1625 sound level meters at the selected points away from the sources were used to measure the noise level. Numerical prediction models for noise level; ISO and VDI were applied. The differences between the measured values and the predicted ones using these models were compared in order to evaluate the accuracy of these models. The results of the field measurements at the three areas showed good agreement with the results of the noise prediction models. The results obtained indicated that; (a) the sound pressure levels were higher than the acceptable level at El-Gedida mine and lower than that at the other two areas, and (b) the measured noise levels at the management building and the workshop area in El-Gedida mine were higher than the acceptable level for the administration areas. Therefore, control measures are required in these projects to keep the environment safe.

INTRODUCTION:

Prediction of noise level near mining and industrial plants requires adequate information of the sound power level of the working machines. However, the problem of the prediction deals with the effects of interference and scattering of noise generated by various machinery working simultaneously. This problem is further complicated by the nature of operations within the industrial and earth moving machinery working in surface mines and quarries since they are generally working in groups.

Numerous studies have investigated the noise level through field experiments and numerical models in mining and industrial areas (e.g. Marsh, 1976; Grashof, 1976; Cerrato *et al.*, 1990; Pathak *et al.*, 1998; Abdel-khalik and Mohamed, 1999; pthak *et al.*, 2000 and others). Some of these studies are not suitable to predict the noise level as they did not take into consideration the attenuation factors such as ground effect, vegetations and barriers between source and receiver. More researches, Marsh (1982), Kragh *et al*. (1982), Rasmussen (1986) and Tonin (1999) have investigated theoretically the prediction of noise levels using different models. Sutton (1976), Larsson & Israelsson (1991), Buntin (1994), Tonin (1995), Pathak *et al*. (1996) and Kiely (1996) reported a few field trials for the noise prediction, which are useful to validate the accuracy of the noise prediction models.

The purpose of the present work is to predict noise levels using theoretical models. Analyze

the effect of noise level at the worker's locations, management buildings and the neighbouring areas. Examine the prediction models results against measured data. Use the prediction models to investigate the areas in the vicinity of the plants in accordance with noise pollution. And, identify the safe zones around the studied mines and industrial plants.

Description of the Field Experiments:

The field experiments were carried out at three working sites: Assiut Cement plant, Assiut Cement Quarry and El-Gedida mine at El-Baharia oasis. The main noise sources at the three projects were as follows: a) power shovel, drill, compressor, generator and bulldozer at El-Gedida mine, b) power shovel, crusher, hummers, loader, belt conveyer, compressor, trucks and drill at Assiut cement quarry and c) ball mills, furnaces, air coolers and belt conveyers at Assiut cement plant. The sound pressure levels of noise sources in El-Gedida mine and Assuit cement quarry were taken at different distances from the sources, whereas, the measurements in Assuit cement plant taken using equivalent monopole theory, as the sources are very closed to each other.

In order to understand the noise effects on the workers' locations, management buildings and the areas in the vicinity of the mining and industrial plants, measuring and predicting of noise level are carried out in El-Gedida mine, Assiut Cement Quarry and Assiut Cement plant. Ninety-three locations were selected in the three projects, which are shown in Figs (1, 2 & 3). The distances between the sources and the receivers at all locations were changed during the fieldwork. The noise level was measured at a height of 1.6 m from ground level, 1 m from walls and 2 m from crossing to avoid the earth reflection of the sound waves. The average of five values of noise level at each location was taken. While, the sound pressure level was measured at different distances from the noise sources.

Instrumentations:

The noise level on the network weighting was measured using the sound level meter model SL-130, where these weighting are A-network, B and C network. The A-network was used in the present work, which approximates the human response. While, Bruel & Kjaer, sound level meter Type 1625 was used to measure the amount of sound energy, in the form of sound pressure level, as a function of frequency components of various loudness distributed over the audible frequency range.

Numerical Models of Noise Prediction:

The aim of the numerical prediction models for noise level in areas of mining and industrial plants is to be able to predict noise levels at any position in the study area originating from a source at any location. Two numerical models were used in the present work. The first model was called VDI (Verein Deutscher Ingenieur) and presented by formula (1).

$$L_p = \sum_{allsources}^{\log} (L_w + K_1 - 10\log(4\pi R^2) + 3 - K_2 - K_3 - K_4 - K_5 - K_6 - K_7) \quad \text{..... (1)}$$

where:

L_w = source power level.

K_1 = source directivity index.

R = source to receiver distance.

K_2 = atmosphere attenuation.

K_3 = Attenuation due to meteorological conditions.

K_4 = Ground effect.

K_5 = Barriers effect.

K_6 = Attenuation due to woodland areas.

K_7 = Attenuation due to built-up areas.

For more details, refer to kragh *et al*. (1982) and Tonin (1985).

While, the second model was called ISO 9613 (International Organization for Standardization) and given by formula (2)

$$L_p = L_w + D_I + k_o - D_s - D_L - D_{BM} - D_D - D_e \quad \text{....... (2)}$$

where;

L_w = the sound power level of the source.
K_0 = the solid angle reflection distance.
D_L= air absorption factor.
D_D = attenuation measure due to built-up areas.
D_I = the directivity index.
D_s = attenuation due to geometric spreading.
D_{BM} = ground and meteorological attenuation.
D_e = attenuation measure due to barrier shielding.

For details, refer to kragh *et al*. (1982) and ISO (1996).

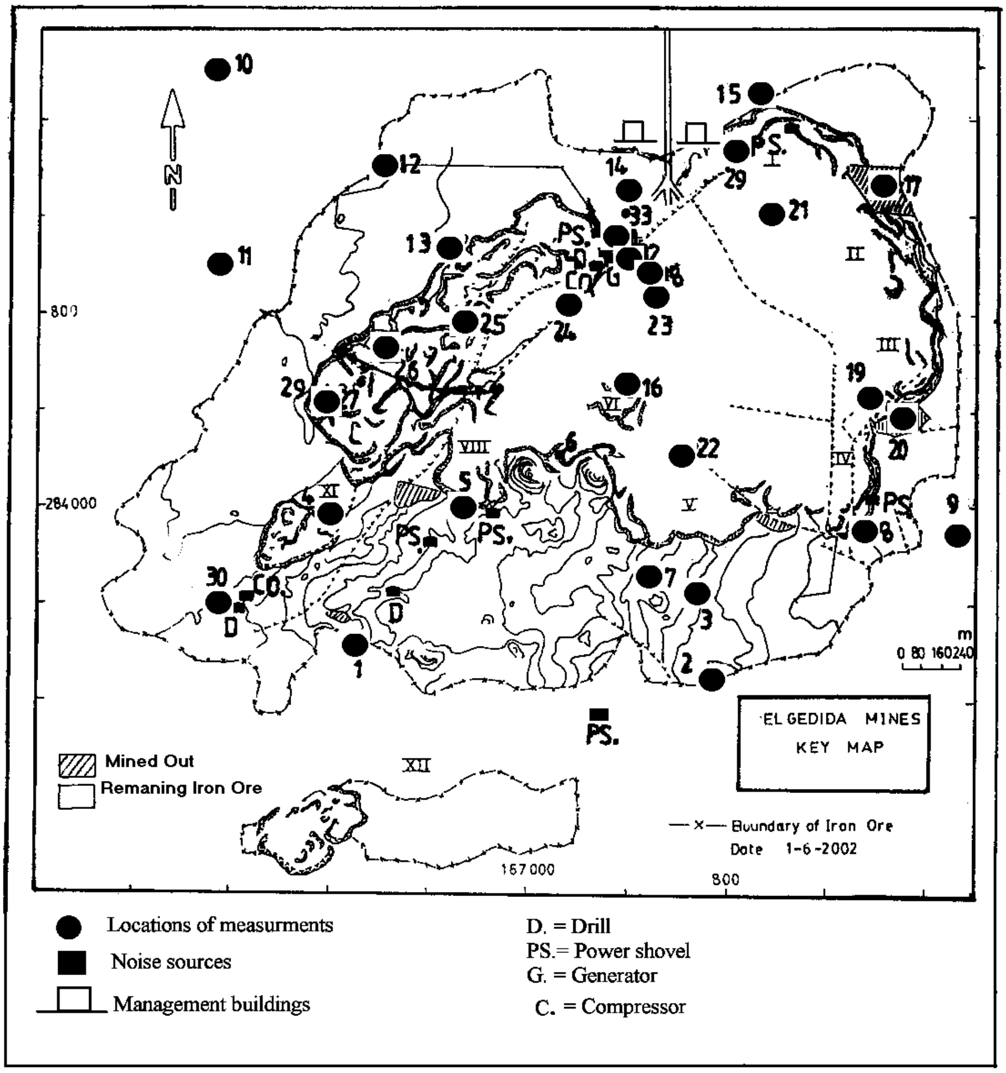

Fig. (1): Locations of noise measurements at El-Gedida mine.

RESULTS AND ANALYSES:

Results of the study are discussed below for the studied projects.

El-Gedida mine:

Results of sound pressure levels at El-Gedida mine are presented in Fig.4 and given in table (1). The maximum sound pressure level was found at the power shovel No. 215. This is due to the shovel No. 215 dealing with hard ore and work at different work activities, as face dressing, moving loaded and unloaded. The minimum sound pressure level was found at the low power drill of small horsepower, when compared with other sources. Also, it can be seen that, the sound pressure levels at El-Gedida mine were greater than that acceptable level (90 dBA). The measured noise level at the management building and the workshop area in El-Gedida mine was higher than the acceptable level for the administrations areas.

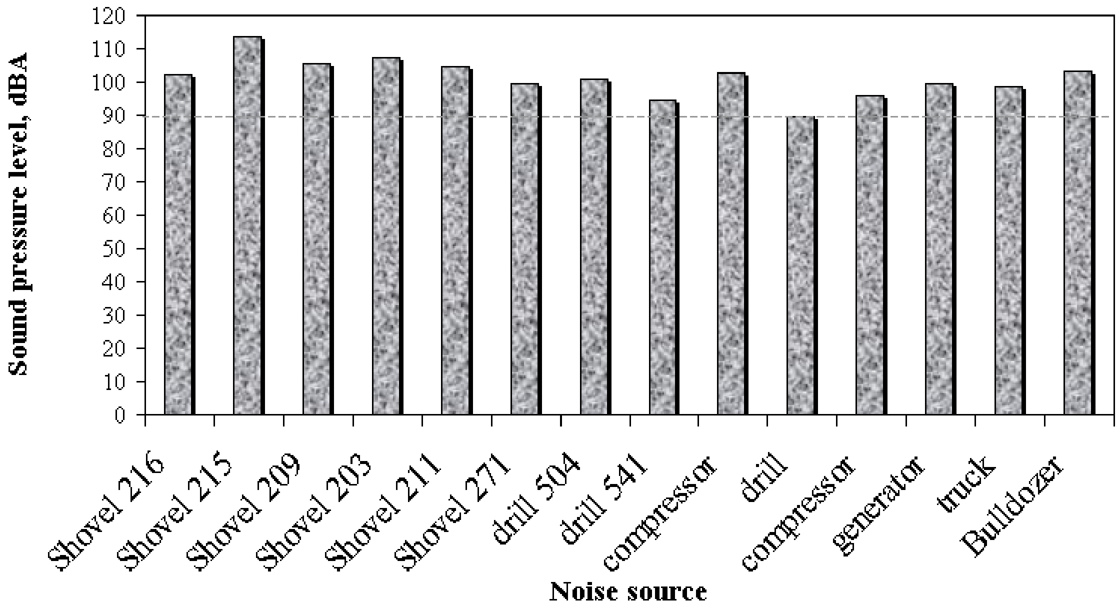

Fig. (4): Sound pressure levels measured at El-Gedida mine

Table (1): Distance of measurements from each sources in E-Gedida mine

Noise source	Sound pressure level (dBA)	Distance (m)
Power shovel No. 216	102.4	4
Power shovel No. 215	113.7	4
Power shovel No. 209	105.63	4
Power shovel No. 203	107.1	4
Power shovel No. 211	104.35	4
Power shovel No. 271	99.4	4
High power Drill No. 504	100.82	1
Low power Drill No. 541	94.63	1
Compressor	102.8	1
Low power Drill	89.63	1
Compressor	96.13	1
Generator	95.92	1
Truck (Caterpillar)	98.42	2
Bulldozer	103.3	2

Assiut Cement Quarry:

The sound pressure level measured at Assiut Cement Quarry is shown in Fig. (5), and given in table (2).

From Fig. (5), it is found that, the sound pressure level due to crushers was higher than that from other sources. This is due to the high horsepower and the friction between the crusher material and the ore. The sound pressure level from belt conveyers was found to be smaller than that from other sources, where it was located in an enclosed building. Measurements of noise levels in Assiut cement quarry prove that, the management building and the worker camps are suffering from high noise levels more than the acceptable levels.

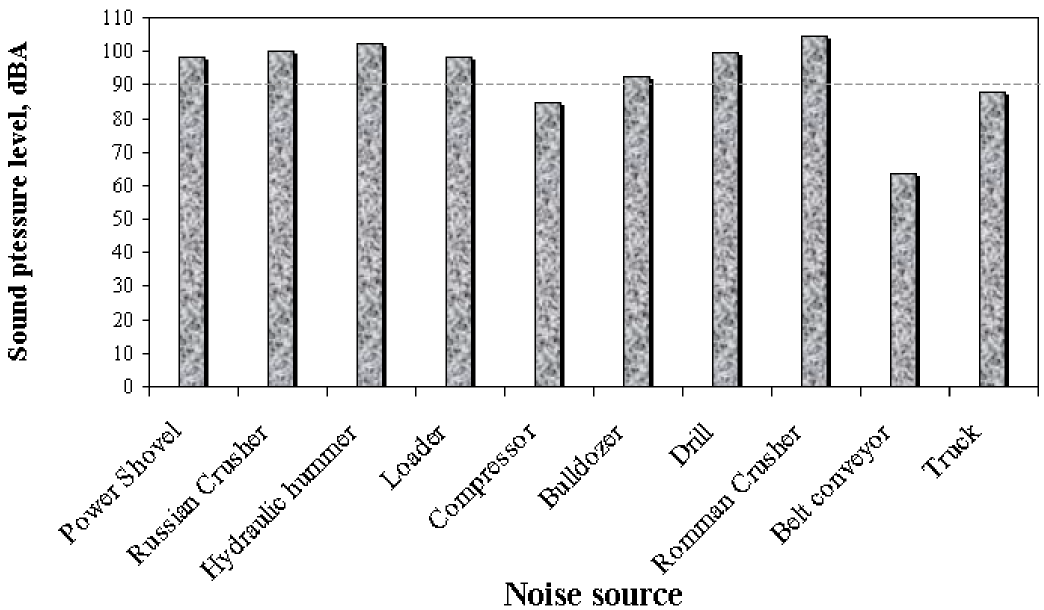

Fig. (5): Sound pressure levels measured at Assiut cement quarry

Table (2) : Sound pressure levels of noise sources at Assiut cement quarry

Noise sources	Distance (m)	Octave bands center frequencies (Hz)								dBA
		63	125	250	500	1000	2000	4000	8000	
Power Shovel, dB	8	90.82	83.57	81.31	78.47	79.38	75.72	74.97	66.95	83.85
Russian crusher, dB	3	88.26	89.68	86.07	88.43	87.28	84.67	78.83	71.97	91.58
Breaking hummer, dB	4	68.24	90.89	87.28	88.57	87.28	81.61	88.75	84.61	93.71
Loader, dB	8	83.64	85.00	82.30	83.11	77.68	74.67	71.14	67.28	83.95
Belt Conveyor, dB	4	64.49	67.32	63.52	59.89	50.50	52.20	50.59	41.62	61.40
Belt drive, dB	4	73.23	79.29	75.16	70.5	64.08	60.72	58.47	56.2	63.71
Compressor, dB	1	84.09	84.33	82.17	81.71	78.12	78.1	74.83	71.01	84.73
Truck, dB	1	63.71	65.27	70.99	79.46	82.1	82.63	81.65	64.73	87.94
Bulldozer, dB	1	90.28	92.15	85.33	89.9	87.96	83.94	81.87	72.19	92.25
Drill, dB	1	76.70	77.98	84.94	88.58	91.52	94.96	93.67	88.92	99.69
Roman Crusher, dB	5	88.90	89.67	87.72	85.76	90.64	88.20	82.65	76.69	94.06

Assiut Cement Plant:

The sound pressure level from different sources at Assiut Cement plant was so difficult to be determined because they are very close to each other. The measured noise levels at Roman centre; industrial security and at the management building in Assiut cement plant were the same. The three management buildings are protected from the noise levels using double glass doors and closed windows. Therefore there is no effect of noise levels inside these buildings. However, persons outside these buildings will suffer from the noise problem.

Noise Prediction Validation:

To examine the validity of the noise prediction models, a comparison between measured and predicted noise levels was carried out for the studied working sites.

1-EL-Gedida mine :

Comparison between the predicted and measured values of noise levels at the selected locations in El-Gedida mine is shown in Fig. (6) and given in table (3). The agreement between the predicted and measured values of noise levels was observed well at most locations with difference ranging from 1.11 dBA to 7.81 dBA. The relatively large difference if found in locations 3 and 33 because they are located near traffic roads and they are affected by the running vehicles during measurements.

Table (3): Measured and predicted noise level at El-Gedida mine

Point	Measured NL (dBA)	Predicted NL (dBA)	Difference (dBA)	Deviation (%)
1	57.25	55.5	1.75	3.05677
2	48.64	45.58	3.06	6.29112
3	61.72	53.91	7.81	12.6539
4	59.41	63.06	3.65	6.1437
5	64.57	60.35	4.22	6.53554
6	46.73	49.76	3.03	6.4841
7	51.62	47.33	4.29	8.31073
8	61.46	60.35	1.11	1.80605
9	50.53	47.21	3.32	6.57035
10	43.81	39.98	3.83	8.7423
11	48.68	46.03	2.65	5.44371
12	49.54	43.82	5.72	11.5462
13	44.26	46.03	1.77	3.9991
14	58.35	53.69	4.66	7.98629
15	60.46	57.14	3.32	5.49123
16	48.28	45.78	2.50	5.17813
17	58.83	62.44	3.61	6.1363
18	60.47	56.81	3.66	6.05259
19	52.38	46.77	5.61	10.7102
20	46.68	49.52	2.84	6.084
21	58.57	53.76	4.81	8.2124
22	47.26	45.93	1.33	2.81422
23	51.29	48.99	2.30	4.4843
24	45.87	47.47	1.60	3.4881
25	46.78	43.91	2.87	6.1351
26	52.63	49.69	2.94	5.58617
27	57.24	51.56	5.68	9.92313
28	51.67	53.45	1.78	3.4449
29	61.68	58.2	3.48	5.64202
30	89.46	87.58	1.88	2.1015
31	65.38	68.96	3.58	5.4757
32	72.54	69.04	3.50	4.82492
33	68.64	61.42	7.22	10.5186

2-Assiut Cement Plant:

Fig. (7) illustrates the comparison of results at Assiut Cement plant. At most locations, the results were observed in a good agreement, except location No. 13 because it is affected by traffic as given in table (4).

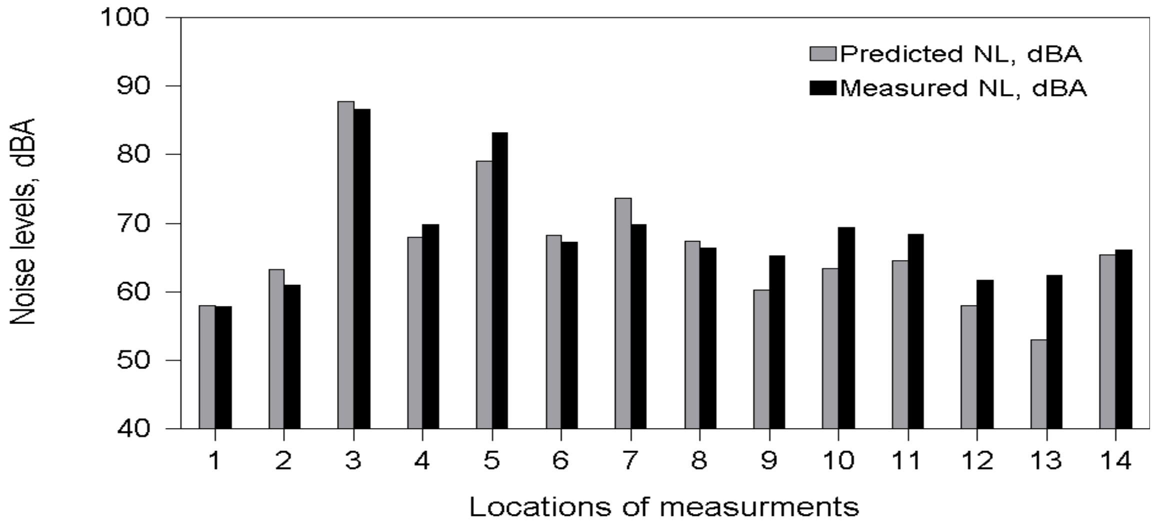

Fig. (7) : Measured and predicted noise levels at Assiut cement plant

Table (4): Measured and predicted noise level at Assiut cement plant (dBA)

Point	Measured NL (dBA)	Predicted NL (dBA)	Deviation (%)	Difference (dBA)
1	57.84	57.92	0.14	0.08
2	61.03	63.29	3.57	2.26
3	86.53	87.66	1.29	1.13
4	69.8	67.98	2.68	1.82
5	83.24	79.03	5.33	4.21
6	67.22	68.17	1.39	0.95
7	69.84	73.57	5.07	3.73
8	66.34	67.39	1.56	1.05
9	65.2	60.24	8.23	4.96
10	69.33	63.39	9.37	5.94
11	68.33	64.56	5.84	3.77
12	61.69	57.92	6.51	3.77
13	62.36	53.05	17.55	9.31
14	66.06	65.44	0.95	0.62

3-Assiut Cement Quarry:

Comparison between the measured and predicted noise levels at Assiut Cement Quarry is shown in fig. 8 and given in table (5). The agreement between the predicted and measured noise levels was found at all locations.

The above results proved that noise models can be used to predict noise level at different locations in industrial areas such as mining and industrial plants. Moreover, these models can predict the noise level in new locations inside industrial areas. Also, they can be used to determine the quietest areas in the plants.

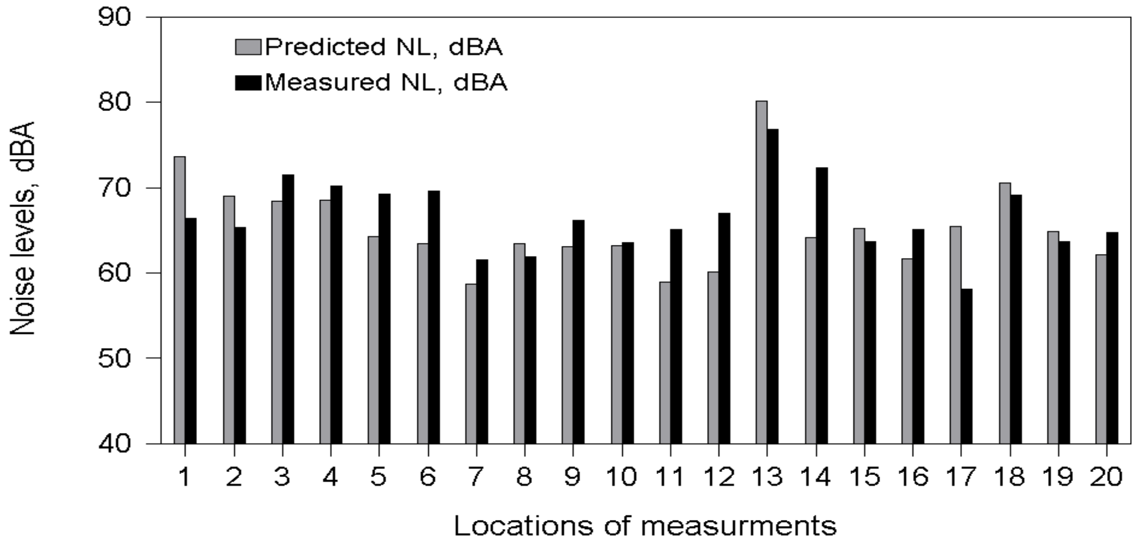

Fig. (8): Measured and predicted noise levels at Assiut cement quarry

Table (5): Deviation of measured noise level from the predicted value at Assiut cement quarry

Point	Measured NL (dBA)	Predicted NL (dBA)	Deviation (%)	Difference (dBA)
1	66.44	73.62	5.08	7.18
2	65.34	68.98	2.57	3.64
3	71.56	68.45	2.19	3.11
4	70.18	68.58	1.13	1.60
5	69.26	64.22	3.56	5.04
6	69.57	63.49	4.29	6.08
7	61.57	58.72	2.02	2.85
8	61.88	63.46	1.12	1.58
9	66.22	63.13	2.18	3.09
10	63.54	63.23	0.22	0.31
11	65.08	58.93	4.35	6.15
12	66.97	60.13	4.84	6.84
13	76.84	80.14	2.33	3.30
14	72.39	64.14	5.83	8.25
15	63.62	65.27	1.17	1.65
16	65.1	61.62	2.46	3.48
17	58.07	65.41	5.19	7.34
18	69.17	70.6	1.01	1.43
19	63.71	64.84	0.79	1.13
20	64.71	62.08	1.86	2.63

CONCLUSIONS:

From the above investigation on the noise level in mining and industrial plants may be carried out using field measurements and numerical models. The results obtained may be summarized as follows: (1) the maximum sound pressure level was found at the power shovel at a distance of 4 m, (2) the minimum sound pressure level was found at the power drill at a distance of 1 m, (3) the sound pressure levels were higher than the acceptable level at El-Gedida mine, (4) the measured sound pressure level from crushers was observed higher than that from other sources in El-Gedida mine, (5) the measured noise level at the management building and the workshop area in El-Gedida mine is higher than the acceptable level for the

sensitive areas, (6) the agreement between the measured and predicted values was found at many locations at the studied projects, (7) prediction models can be used to identify the safe zones with respect to the noise level in mining and industrial plants and (8) noise control can be achieved by isolations, absorptions, insulation and hearing protection, which should be applied in the studied projects.

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دراسة حول توقع الضوضاء من المشروعات التعدينية والصناعية

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في هذا البحث تم دراسة مستويات الضوضاء في المشروعات التعدينية والصناعية وتم اختيار ثلاثة مشروعات صناعية لتنفيذ هذه الدراسة، وهي مناجم الواحات البحرية ومحجر أسمنت أسيوط ومصنع أسمنت أسيوط، أيضا تم قياس مستويات الضوضاء باستخدام جهاز SL-130 وجهاز لقياس مستويات الضوضاء نوع 1625. كما تم استخدام نماذج رياضية لتوقع مستويات الضوضاء ومقارنتها بتلك المقاسة في بعض النقاط التي تم القياس فيها للتأكد من توافق القيم المقاسة مع تلك التي يجري توقعها طبقا للنماذج الرياضية.

وقد أكدت الدراسة أن مستويات الضوضاء في بعض الأماكن تجاوزت القيمة المسموح بها، مما جعل من الضروري تطبيق الإجراءات الهندسية المناسبة لضمان بيئة آمنة للعاملين في هذه المشروعات.