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EVALUATION OF EQUIVALENT NOISE LEVELS IN TOURIST RESORTDONJA LASTVA

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Summary. Compared to other environmental factors, control of noise pollution is not considered as one of the priorities in order to protect the environment. In developed countries, people clearly recognize the problem and point to noise as the main factor that affects the entire population. And here, the noise is recognized as one of the factors which threaten daily life, but also as a possible obstacle for further economic progress and development. In particular, noise is recognized as pollution factor in the resorts along the Montenegrin coast, with special emphasis on the summer season period. To confirm the presence of excessive noise in the tourist resort, we made the recording of noise levels in the Donja Lastva (Tivat municipality) in order to determine possible excess, and try to develop a mathematical model that best describe the relationship of equivalent noise levels and statistical noise levels. The aforementioned statistical levels are used in describing and identifying of noise sources, making it possible to describe the background noise (L90), impulse noise (L1,L10) and the noise represented in 50% of the time interval in which the observation was performed (L50).
Experimental results indicate the presence of increased environmental noise in the tourist resort Donja Lastva. Sensitivity of indigenous people related to increased noise is recorded during summer period. Significant overruns are especially pronounced in the peak of tourist season, and range up to 21dB. Applying mathematical method of linear regression, we developed model for predicting equivalent noise based on statistical noise levels, in this particular case.

1 INTRODUCTION

Environmental noise is not considered as one of the priorities to be addressed in order to protect the environment. The reason listed insufficient knowledge of the effects of noise on human life, health and the environment, especially when noise exposure is

long term. This approach is particularly pronounced in developing countries where the institutions responsible for dealing with problems of noise are considered as "luxurious appearance" which follows the everyday life. In developed countries, people clearly recognize the problem and point to noise as the main factor that affects the entire population. Unfortunately here is not the case, so the problem of noise in the coastal municipalities especially pronounced for time and the peak tourist season. To prove this claim in practice, we performed measurement of environmental noise level in the tourist resort Donja Lastva. Recordings were done during the tourist season. As the noise sources were identified: road traffic noise that goes along the Adriatic highway and local roads adjacent to the coast, the noise of air traffic that goes through the airport Tivat, the noise that comes from playing music from the restaurants, the vessels, the noise generated by air conditioning units and noise caused by the presence of crowed people.

Changing the noise in the time period can be represented only in the diagram, where the comparison with the allowable values is very complicated. For this reason, the expression of introduced time variable noise was presented by one single value. The most commonly used value for this is called an equivalent level Leq [dB]. The equivalent level is constant (average) noise level in a specific time interval that has the same sound energy as the observed timevariable noise. Figure 1 show how the dynamic (changeable) sounds in the environment can be.

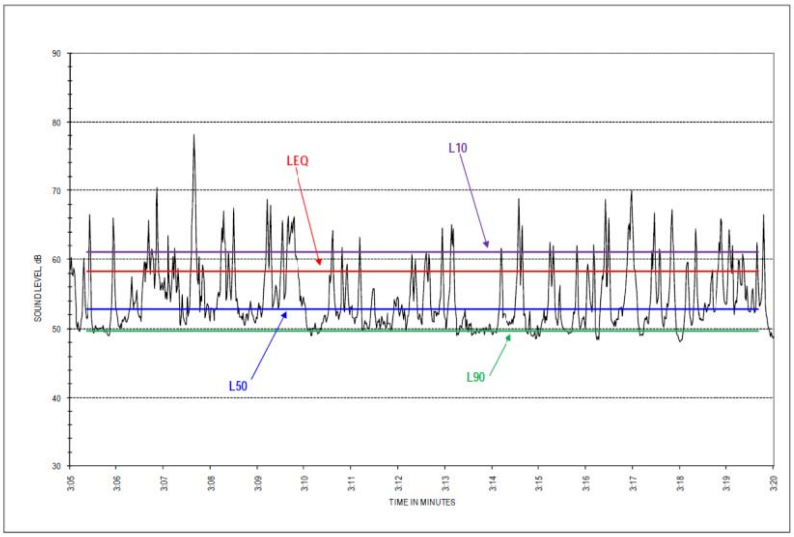

Figure 1: Noise changed in time diagram

As we can see from the figure 1, it is difficult to choose a place that defines the "noise" in the reporting period. To overcome this dilemma, we are using the statistical approach. Statistical levels are calculated based on the distribution of different levels of noise in relation to time. L1, L10, L50 and L90 are commonly use. Value of these levels is expressed, according to the percentage of time that the sound level was equal to, or greater, than some value. By using of statistical methods (regression analysis) we can get a mathematical

expression that will give good results for a particular case. Based on the results of measurements performed in the tourist resort Donja Lastva, we will determine the presence of excessive environmental noise.

2 METHODOLOGY

Tourist village Donja Lastva extends directly along the sea coast. To perform the experiment we selected the four positions that characterize the different sources of noise (Figure 2).

Figure 2: Satelite view of tourist resort with marked measurement positions

The first selected position (position 1) is located close to the local road and in front of the church "St. Roko". It is place of gathering a large number of swimmers and boats dock. From the noise source we detect the noise generated by vehicles, motorcycles, boats, ships and swimmers. The second measurement position (position 2) is also close to the local road, in front of cafe bar "Mar-Mar". This position was selected to determine the impact of noise generated by the guests, a music program that airs in the café and traffic that taking place along local roads. The third position (position 3) is directly in front of a residential building which is located along the street. There is central air conditioning unit (heat pump) implemented on the facade of the building. The choice of this position is to determine the noise generated by vehicles and air conditioning system. The fourth measurement position (position 4) is close to the road, in front of the former cafe "Donja Lastva" and a small beach. Characteristic for this position is the presence of a large number of people in the summer and the presence of "urban canyons" (two-storey buildings that separates the street which ensures the propagation of sound without significant impairment of energy that otherwise typically decreases when the distance increase in relation to the noise source). At this position we will

collect data on noise created by humans, the effect of increasing traffic and noise levels due to the "urban canyons".

Noise is measured by precision modular analyzer Brüel& Kjaer, model 2250L, that meets the prescribed standard IEC60804. In accordance with the ISO 1996 standard, the measuring instrument is set to be on the minimum distance of 1.5m from any reflective surface and the height of 1.2m from the ground. Selecting of measurement interval is observed by Article 6 in rulebook of measurement methods and instruments to be met by the organization to measure the noise[1]. Under this Ordinance changeable noise levels are measured in three intervals during the day (06h-22h) and two intervals during the night (22h-06h). Minimum duration of the measurement interval is 15 minutes. The first measurement interval was from 07:00 h to 07:15 h. The second measurement interval was from 11:00 h to 11:15 h. The third measurement interval was from 18:00 h to 18:15 h. The fourth measurement interval was from 23:00 h to 23:15 h. The fifth measurement interval was from 01:00 h to 01:15 h.

Values of environment noise level are normatively regulated[2], so noise levels in residential areas must not exceed the permissible value for a particular residential zone. In this case, residential area is classified in zone V, where the equivalent noise level limit shall not exceed a value of 60 dB for daytime and evening period, while during night time, equivalent noise level must not exceed 50dB. Characteristics of climatic conditions during the measurement process are clear and quiet weather (air speed $\leq$ 5 m/s), temperature varied in the range 13-32^{0}C, air pressure was in the range 880-1020mbar, and humidity of 59-93 %.

Based on the results of measurements, we will perform the regression analysis, in which as independent variables choose the statistical levels L10, L50 and L90, while the dependent variable will be Leq. We will complete a regression analysis using the software package version DataFit9-2008th. Based on experimental results, we defined a population of 60 members which is relevant sampling population. Regression analysis model is:

$$Y= aX_1 + bX_2 + cX_3+d \quad (1)$$

X_1,X_2,X_3 – independent variables L10,L50,L90
Y - dependent variable L_{eq}
a,b,c,d – regression coeficients

3 RESULTS

3.1 Analysis of results of measurements performed in summer season

Measurements of noise levels during the summer season were made in the period from 15-18.7.2011. It was performed for all four measurement positions. Within the period of 31.7-1.08.2011 measurement were at Position 1 and Position 4 in all terms, with order to check the noise level in the peak of tourist season on places where large number of swimmers is. The results of measurements for all positions are tabulate presented (Table 1).

TERMIN	Pos. 1 $L_{Aeq[dB]}$	Pos. 2 $L_{Aeq[dB]}$	Psz. 3 $L_{Aeq[dB]}$	Pos. 4 $L_{Aeq[dB]}$	Allowed $L_{Aeq[dB]}$
TERM 1	58	50	51	51	60
TERM 2	81	64	63	78	60
TERM 3	71	65	65	73	60
TERM 4	64	54	57	61	50
TERM 5	66	52	52	55	50

Table 1 : Measurement results for all four positions

Table 1 showed that in daily terms (Term 1, Term 2, Term 3) recorded values exceeding the permissible values at all four elected positions. Overdrafts are somewhere in between 3dB to 21dB. In order to determine the causes of these overruns were analyzed in detail diagrams of the equivalent noise level changes during the measurement period. As an example, consider the value of a position for Term 3, designated as the place where it gathers a large number of swimmers and boats dock. The diagram (Figure 2) is noticeable presence of five events that describe the noise of about 80dB, resulting from the passage of vehicles or motorcycles. The noise level is mainly the time ranged from 60dB-75dB as a result of the presence of a large number of people and music that comes from the coffee bar nearby. From Table 1, for night periods (Term 3 and Term 4), we see clear deviations in the range from 2dB to 16dB. A detailed analysis showed that the main causes of noise exceeding are motorcycles, which presence is expressed in the summer. Also, noise that coming from the restaurants and the noise made by tourists during the summer season, gathering people in groups and parties that lasted till early morning hours.

3.2 Linear regression results

The results of performed noise measurements are presented in table (Table 2).

LAeq [dB]	LAF10 [dB]	LAF50 [dB]	LAF90 [dB]
55.4	53.5	44.2	39.4
42.3	44.2	41.9	39.5
50.9	53.1	46.4	41.1
45.5	47.9	45.3	41.7
56.6	59.4	48.9	43.3
47.1	48.6	46.8	44.5
55.7	58.6	45.6	38.9
44.6	46.2	44.4	42.3

55.2	59.3	45.5	37.1
60.5	60.9	59.2	58.8
57.4	58.5	57.1	41.9
47.7	49.4	45	43.1
51.6	54.2	49.9	40.9
50.6	51.8	50.4	49.6
58.7	59.2	58.7	45.3
39.9	40.9	39.9	39
48.2	43.8	40	36.2
35.5	36.9	35.1	34.1
54.4	52.5	41.2	38.3
42.5	43.6	42.4	41.3
55.8	55.2	44.2	40.2
44	46.7	42.6	40.7
59.5	55.3	45.4	41.8
51.1	54.8	45	43.2
51.8	50.2	37.8	34.6
40.8	43.6	39.1	37.5
72.1	47.5	40.2	37.8
52.1	48.3	39.8	38.2
63.3	58.4	48.5	41.9
52.7	55.5	51	48.3
51.3	46.2	37.5	35.2
37.3	38.7	36.9	36
75.8	80.8	69.1	60.8
64.6	69.2	55	51.3
69.7	73.2	68	57.4
71.1	73.1	71.3	66.5
50.8	52.8	48.3	45.8
47.5	48.1	47.6	46.5
50.1	51.6	47.4	43.1
51.7	52.7	50.7	49.6
68.7	72.9	65	52.7
54.5	56.2	53.6	52.4
51.4	54.6	47.5	41.6
49.7	52.2	46.6	43
73.1	76.5	72.1	62.8
71	71.7	71.1	70.7
56.6	58.5	47.3	43.7
47.2	47.8	46.8	45.8
65.3	69.6	62.4	51.8

62.3	69.5	56.4	46.5
71.7	75.2	70.2	61.4
66.6	68.3	66.4	64.7
54.6	55.4	49.3	45.5
50	51.8	49.6	48.5
50.1	49.6	44.5	41.7
46.2	46.7	46.1	45.5
54	56.2	51.4	48.4
49.7	52.4	50.1	49
49.2	50.4	43.8	41.1
43.2	43.8	43.1	42.5
77.6	81.9	73.6	66.2
74.3	76.2	73.3	70.4
57.9	61.2	50.3	44.7
57.7	58.8	57.3	56.9

Table 2 : Values of the measured noise levels Leq, L10, L50, L90

Results of regression analysis on the model (1) were obtained by the software (Table 3):

Equation ID: a*x1+b*x2+c*x3+d
Model Definition:
Y = a*x1+b*x2+c*x3+d
Number of observations = 60
Number of missing observations = 0
Solver type: Linear
Sum of Residuals = -1.99662508748588E-12
Average Residual = -3.11972669919669E-14
Residual Sum of Squares (Absolute) = 877.574156005723
Residual Sum of Squares (Relative) = 877.574156005723
Standard Error of the Estimate = 3.82442622277234
Coefficient of Multiple Determination (R^2) = 0.8594340748
Proportion of Variance Explained = 85.94340748%
Adjusted coefficient of multiple determination (Ra^2) = 0.8524057785

Table 3 : Regression analysis results obtained by DataFit9 software

From the results, we assess parameters of independent variables and determine the coefficient of linear regression. The parameters of the independent variable a, b, c and d are presented in table (Table 4).

Variable	Value	Standard Error	t-ratio	Prob(t)
a	1.006634131	0.132500461	7.597212	0
b	-0.241475819	0.234317664	-1.03054	0.306
c	0.10904979	0.171277917	0.63668	0.52675
d	5.73079174	2.8073064	2.04138	0.04562

Table 4: Values of independent variable parameters

"t-ratio" is the ratio of the estimated parameters and standard deviations of the same. When is the value of "t-ratio" increased, then we have a significant impact on the dependent variable by the independent variables. Table 4 shows that the value of "t-ratio" for the parameter (a) has the maximum (7.597212281) value, and says about the biggest influence of coefficients X1 which present statistical level of L10. So, the biggest influence on equivalent noise level L_{eq} has the statistical noise level L10, that present impulse noise.

"Prob (t)" presents probability that a parameter value to the independent variable is zero. This parameter is used to test the null hypothesis. In the case that value of the parameter independent coefficient is equal to zero, than independent variable is not relevant for the assessment. If the parameter value is increased, there is higher probability that the null hypothesis is more accurate. The table shows that we have a relatively high value of "Prob (t)" for the parameters (b) and (c), indicating that the probability that a parameter X2 will be zero 30.689% and X3 be zero 52.675%. The obtained results support the fact that the greatest impact on the perceived equivalent noise level has impulse noise L10, followed by the L50 and L90 levels. The result supports the assertion that the level of equivalent noise impacts are the most impulsive events (L10), although the present time at least.

Based on the analysis of variance table (Table 5) we check the assumption that all the parameters of the independent variables are equal to zero (null hypothesis) against the assumption that at least one parameter of the independent variable is different from zero. The value of "Prob (F)" indicates the percentage probability that the null hypothesis is true. Result of this test gives information on whether the relationship between a dependent variable and the regression model is valid or not, or whether the model is adequate or not.

Variance Analysis			
Sum of Squares	Mean Square	F Ratio	Prob(F)
5365.57584399	1788.5252813	122.2819931	0
Error	877.574156005723	14.6262359334287	
Total 6243.15			

Table 5 : Variance analysis

From Table 5 it is clear that Prob (F) = 0, which were completely eliminate the hypothesis that all the parameter independent coefficients are equal to zero, and confirms that the

independent variable can be determined by presented model. The obtained regression coefficient is $R^2 = 0.8594340748$ (Table 3). When the value of the regression coefficient closer to 1, then we considered presented model as appropriate.

The final appearance of the model is given by the following expression:

$$L_{eq} = 1.0066341316\, L_{10} - 0.241414758\, L_{50} + 0.10904979962 L_{90} + 5.73079174 \quad (2)$$

4 CONCLUSION

- Experimental results indicate the presence of increased environment noise level in the tourist resort Donja Lastva. Significant overruns are especially pronounced in the peak of tourist season. Exceeding the noise level that is up to 21dB indicates the presence of a problem that definitely is a disturbing factor. What and how much negative impact on the life of local population, tourists and the environment have identified noise sources (cars, motorcycles, air conditioners, music from the restaurants, meeting more people), is an issue that should be dealt by the competent authorities and the entire community.

- Usage of method multifactor regression analysis creates mathematical expression that allows the representation of the equivalent noise level by using the statistical levels with adequate accuracy.

5 REFERENCES

[1] *Rules on the methods and instruments of measurement noise and the conditions to be met by the organization to measure noise*, Federal Republic Yugoslavia Official Gazette, nr.37/03.

[2] *Regulations on limited values of environmental noise,* Republic of Montenegro Official Gazette, nr.75/06 from 8.12.2006.

[3] David B. Torrey and Jeffrey R. Mc Culley," Limiting Motorcycle Exhaust Noise", *Temple Journal of Sci. Tech. & Envt. Law*, vol. XXV, 49-57 (2005).

[4] P. Frisman, *Motorcycle Noise Standards*, ORL, Research report, 2003.

[5] R. Vladušić, *The impact of aircraft noise on the environment,* Faculty of Mathematical Science, Split, 2005.

[6] *Law on envirnonment protection,* Republic of Montenegro Official Gazette, nr.45/06 from 17.07.2006.

[7] A. Kostadinović, M. Vuković, *Environmental Management,* College of Professional Studies for the management of traffic, Niš, (2009).

[8] M. Praščević, and D.Cvetković, *Enviromental noise,* Faculty on protection at work, Niš, (2005).

[9] J.R. Hassall, K.Zaveri and M.Phil, *Acustic Noise measurements*, Bruel&Kjaer, (1979).

[10] A.Vaš, *Modeling of multiple linear regression*, Master paper, Mathematical Faculty, Belgrade (2010).

[11] M. Delany, D.G. Harland, R.A. Hood and W.E. Scholes , "The prediction of noise levels L_{10} due to road trafic", *Journal of sound and vibration*, vol.48(3), 305-325.

[12] K.W. Yeow, N. Popplewell and J.F. MacKay , "Method of predicting L_{eq} created by urban trafic", *Journal of sound and vibration*, vol.53(1), 103-109.