The Evaluation of Some Temporal Sampling Strategies in Community Noise Measurement

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1.0 Introduction

The measurement of community noise, determining outdoor sound pressure level over the course of some time, is probably the most common type of noise measurement. Consultants, environmental officers, police officers, and people who run airports do these measurements. Sometimes, the people who make, or analyze, the measurements understand the complexities of the measurement. But few do. If people are asked to measure the same exact noise at the same exact location, the chances of them getting the same results are slim. The reasons are many: the microphone frequency response may be different, the type, or accuracy, of their sound level meters may be different, the frequency weighting may be different, and how they measure, or what or how sample, may be different. We emphasize this latter category in this paper.

As we all know, the variability of community noise is large. Two people taking measurements for two different time periods will probably not get the same answer. Of course the longer you measure, the better chance the average of two measurements will match. (We have a theory that if we measure the noise for 10,000 years and measure the Leq all reading will coalesce.) Of course the longer averages remove information about detail of measurement. (Perhaps that is why the US EPA used a metric known as a "yearly Ldn." It removed any semblance of reasons for people to complain, any reasonable budget to measure, and any chance loud, brief, disturbing noise to be a problem.)

So how to measure time varying sounds? What metric does one choose? Fortunately, some have no choice. Often the code or regulation might say, "measure the noise for one hour, etc., and take the Maximum Fast reading. If at this setting it is above, say, 55 dBA, the noise producer is dog meat. But unfortunately the problem is worded more vaguely, "Like, I mean, what is the decibel level in these here neighborhoods?"

To quantify an almost random, time-varying signal one could take a statistical approach based on samples of instantaneous (or on latched[1]) maximum (or minimum) fast (or slow) or on samples of an average over the interval period. Hence, given a measurement duration, and a measuring procedure (how to orient the microphone, etc.), the sample method will give values that can statistically be used to characterize the environment[2].

[1] Latched is the maximum (or minimum) value found anywhere within the interval.

[2] Keep in mind that, whatever the precision of these measurements in characterizing the sound measured, it bears no relation to the sound just before, or just after measurement period unless other factors are included.

2.0 Discussion

In this study we used the newest real time analyzer from Norsonic. For the same time period, 5 minutes in duration, we sampled the same measured signal over several different intervals to see how they compared. As you will see, and as one would expect, the sample time is critical to the description of the sound. That is, the results will depend on what is sampled and when are samples taken, everything else being equal. The usefulness of any of these results is really more of a political issue than a physical issue, but clearly, the sample time, at least for these common measurements, determines quite a lot about the site characterization.

The measurement was taken over the Oslo - Drammen freeway in Norway, on a footbridge, approximately 8m above the four-lane freeway. The background noise was very low as the measurement point is in the countryside, with no buildings or any other noise source around. A five-minute sample was taken. It could have been longer and we suspect if it were, the data and the conclusions would be quite different. The exactly same sound was sampled for 1s, 2s, ..., up to 5 min and the Leq (over each interval) and Lmax Fast (highest point of each interval during the sample time) was recorded. The number of samples for the period are progressively greater. So there is one 5m sample, five 1-min samples, ten 30s samples, and up to 300 1 s samples.

3.0 Results

We do not present profound results that can be applied to the solution of all community noise measurement problems. Rather discuss the ramifications of the use of different sampling protocols for these specific data.

3.1 Sampling Maximum Levels

If one measures the maximum level occurring in a 5 minute period, and the maximum sound level occurring during many sub intervals, there will always be one sub interval who's maximum equals the overall 5 minute interval. That is, if the maximum recorded A-wtd fast Lp was, say, 80 dB over a five minute period, than sampling every minute and recording the maximum level in each interval will provide at least one interval with a level of 80 dB. This is a much different measurement than one where at the end of every minute sample, the Fast level is recorded. Here it is quite possible to miss the maximum level of the event.

Table 1 presents the sampled Leq and Maxi for three sample intervals. Keeping in mind that the five minute Lmax and Leq were, 83.9 and 76.4 dB, respectively, one can see that recording

Lmax levels at prescribed but not contiguous intervals can lead to strange results.

Table 2 shows the standard deviation (SD) of all the maxima for different time intervals. While we would expect the SD to reduce as the number of samples decreases, the 60 s (five sample) SD was higher than the 30 s (10 sample) value.

If one were to do statistical analysis on the Lmax, as the number of samples increased (interval number decreased) we would expect to see a greater variation. This wasn't what we found. The 1-s sample provided the lowest, but not also the highest fables of the statistical descriptors. See Table 3.

3.2 Sampling Average Levels

The "energy average" or Leq weighs higher levels more than lower levels if one measures the Leq over an interval. For the 30-s intervals in Table 1, had one used Leq at those times for sampling, the results would have varied considerable.

The variation in the values of Leq is higher than the corresponding values of Lmax, perhaps because the Leq is weighted toward the higher levels. Table 2 shows that, as the intervals decrease, the variability of Leq is greater than Lmax for the same data.

Finally, in the statistical descriptors shown in Table 3, the Leq is very consistent in describing highest levels (L1) and least consistent in describing lower levels.

4.0 Conclusions

These data, like most community noise data are unique and probably irreproducible. Nevertheless this study shows that the sample interval and the sample metric is very significant in the interpretation and evaluation of results. It was most useful to be able to measure all different time intervals in the same instrument on the same signal. It helped provide a description and an understanding of the noise environment.

Table 1 A-wtd. Lp recorded at distinct time intervals

Time	30s Leq	10s Leq	1s Leq	30s Max	10s Max	1s Max
0:30	77	76.6	78.8	81.1	79.9	79.4
1:00	78.1	78.7	77.3	82.8	82.1	79.4
1:30	76.3	78.2	76.3	81.7	81.7	77.6
2:00	76.4	74.9	73.2	82	79.6	73.8
2:30	73.7	71.6	70.6	80.2	76	71.4
3:00	72.9	72.3	77.7	80	79.1	79.1
3:30	77.5	74.9	71.7	83.9	82.1	73.1
4:00	77	76.3	74	81.9	79.2	74.8
4:30	75.7	76.9	74.5	83.4	83.4	75.4
5:00	77.2	77.5	75	82.2	80.5	76.4

Table 2 Standard deviation of different samples

Sample Interval	Leq	Lmax
01 s	3.29	3.45
02 s	3.11	3.34
05 s	2.49	2.37
10 s	2.13	1.80
20 s	1.89	1.78
30 s	1.67	1.26
60 s	1.71	1.44

Table 3 Statistical descriptors for different sample times

	60s	30s	20s	10s	5s	2s	1s
Lmax							
L99 approx.	*74.5*	*80.0*	*77.0*	*76.0*	*74.0*	*69.0*	*68.0*
L50 approx.	*77.5*	*82.5*	*82.5*	*81.5*	*80.5*	*79.0*	*78.5*
L10 approx.	*79.5*	*84.5*	*84.5*	*83.5*	*83.5*	*82.0*	*81.5*
L01 approx.	*79.0*	*85.0*	*85.0*	*84.0*	*84.5*	*84.0*	*83.5*
Leq							
L99 approx.	74.0	73.0	73.0	72.5	70.5	67.5	67.5
L50 approx.	77.5	77.5	76.5	77.0	76.5	77.0	76.5
L10 approx.	78.5	79.0	79.0	79.5	79.5	80.0	80.0
L01 approx.	79.0	80.0	80.0	80.5	81.5	81.5	81.5