Measurement of Mosques Inner and Outer Sound Levels

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Abstract

Background: Having high or low sound level inside and/or outside mosques is a frequent complaint from many people in Saudi Arabia. Currently, there is no standard optimizing the noted sound levels. *Objective*: The objective of this study was to measure the sound levels inside and outside 12 randomly selected mosques in Riyadh, Saudi Arabia. A secondary objective was to examine the reliability of using mobile phones as sound meters. *Methods*: Because mosques have different sizes, two "relative" locations were selected to measure sound from. For the inner sound, the location of the prayer leader "Imam" was chosen. Because the first neighbour is potentially most affected by the outer speakers, the outer sound was measured right next to that particular location. These two measures were collected from each mosque. For the secondary objective, sound levels obtained by two mobile phones were compared against a reference sound meter in an isolated room. *Results and Discussion*: Mean inner and outer sound levels (in dB) were 73.6 and 77.8, respectively. Mean difference between sound levels obtained by the two phones and the reference device was $\pm$ 1.1% suggesting a reasonable reliability level. The study highlights a need for developing acceptable levels for mosques sound.

Keywords
Mosque sound levels, noise, sound meter, and noise measurement.

1. Introduction
Muslims pray in mosques several times a day. For each prayer, there are sounds for both announcing the prayer time (Athan) and prayer performance. In Riyadh alone, there are more than 45,000 mosques (Al-Saleh, 2010). Exceeding acceptable sound levels for residential areas can be harmful for people's heath, wellbeing, and comfort. Additionally, the intended purpose of prayers sound may not be optimally delivered when the sound is inappropriately high.

Determining whether a sound level is annoying is challenging. This is because there are several factors can affect the noted annoyance. Generally, these factors be classified as acoustic and nonacoustic ones (McCormick & Sanders, 1982). Examples of the former include sound level, frequency, fluctuation in both sound level and frequency, and duration of exposure to the sound. Regarding the latter, examples include time of day, past experience, predictability of the sound, and attitude toward the source of sound.

Given the multiple factors that influence how humans can be affected by sound, there are several measures were developed to quantify noise. Because the human ear is not equally sensitive to all frequency levels, an A- weighting scale was developed (unit is dBA) (Casali, 2012). This scale is closest to approximating the human ear. Another measure was developed to consider that fact that noise intensity often changes over a certain period of time (McCormick & Sanders, 1982). This measure is equivalent sound level (Leq).

There are three major types of noise depending on the noise duration: continuous, intermittent, and impulsive (ISO standard 1999, 2013). Guidelines were developed to control the continuous residential noise (also called community, domestic, and environmental noise) (World Health Organization, 1999). Major

sources of this type of noise include air traffic, road, and the neighbourhood. Per the noted World Health Organization guidelines for community noise, an outdoor continuous sound level should not exceed 55 dB LAeq (duration = 16 hours) to protect most people from being seriously annoyed during the daytime. In the United States, the Occupational Safety and Health Organization sets a noise level of 85 dBA time-weighted average as an action limit for an 8-hour workday.

Currently, there are no guidelines to optimize mosque sound levels. Applying the guidelines discussed earlier may not be appropriate given that exposure to mosque sounds is not continuous. As a step toward developing guidelines special for mosque sounds, this observational study was conducted with a main goal of determining the sound levels inside and outside mosques in Riyadh. A secondary goal was to examine the reliability of mobile phones as sound meters to potentially facilitate wide spread evaluations across mosques.

2. Methods

12 mosques were randomly selected in different neighborhoods in Riyadh, Saudi Arabia. For each mosque, the mean inner and outer sound levels were measured for 15 seconds over three instances: Athan (means the 1st call for prayer), Eqamah (means the 2nd call for prayer), and prayer. Because mosques have different sizes, "relative" locations were defined for both the inner and outer measurements. For the former, the location of the prayer leader "Imam" was defined. More specifically, sound was measured right behind the Imam in the first row. For the latter, the location of the nearest neighbour was chosen. This is because that particular neighbour is potentially most affected by noise.

The sound was measured by two mobile phones (iPhone X and iPhone 7 plus) using the Decibel X application. The accuracy of both used phones were tested against a sound meter level (Dose sound meter type 4444, England) in a laboratory environment. Data was collected for 15 seconds for each measurement.

To test the reliability of the used phones, testing was done to compare data obtained from the noted sound meter and the two used mobile phones. Inside an isolated room in a laboratory, one portion of one Athan sound was played 10 times. The used portion duration was 15 seconds. Distance between the sound source and the three measurement devices was controlled at 150 cm. The three devices produced a mean sound level (dB) for the 15 seconds for each of the 10 replicates. The difference between the reference device (sound meter) and each of the two phones was calculated.

3. Results and Discussion

3.1 Phones Reliability Testing

Across the 10 replicates, the iPhone X and iPhone 7 plus phones differed from the reference sound meter ±1.2 and 1.0%, respectively. Table 1 show the reliability testing data. This percentage suggests that such phones can be used with reasonable level of reliability for sound measurement. It was desired to use an easy measurement approach to facilitate wide spread measurement technique when a recommended sound level is developed or enforced.

Table 1: Reliability testing for the two used phones against a reference sound meter. Results in dB.

Measurement Device	10 replicates of the same 15 seconds sound									
Reference sound meter	78	75	77	74.2	75.1	72.4	76.2	71.8	76.4	78.6
iPhone 7 plus	77	74.3	79.2	75.6	74.4	71.8	76.3	71	77.3	79.2
iPhone X	76.7	74.8	78.3	75.3	74.6	72.2	76.9	72.4	75.8	79.6

3.2 Mosques Sound Levels

Across the 12 mosques, Table 2 indicates the mean inner and outer sound levels (dB) for each of the three measured instances (Athan, Eqamah, and Prayer) as well as two overall means.

Table 2: Mean (SD) inner and outer sound levels (dB) across the 12 mosques

Location	Athan	Eqamah	Prayer	overall
Inner	73.9 (1.8)	74.2 (2.2)	72.7 (1.1)	73.6 (1.8)
Outer	77.9 (1.9)	75.3 (2.1)	80.3 (2.1)	77.8 (2.9)

Al-Saleh (2010) examined mosque sound levels in 20 randomly selected mosques in Riyadh, Saudi Arabia. The study found a mean of 77.74 and 68.95 dB for the inner and outer sound levels, respectively, and highlighted that sound levels varied between examined mosques. The study also surveyed 52 worshipers who prayed in 20 different mosques and found that 32.7 and 36.5% of them rated their inner and outer mosque sound levels as "high", respectively. The study also indicated that worshiper's opinion was not affected by the respondents age. Abdelazeez et al. (1991) examined changing the interior surfaces materials of a mosque to solve acoustical problems and found promising results.

As discussed earlier, the effect of sound depends on several factors (e.g., exposure intensity and duration) (Casali, 2012). Abdou (2003) discussed that mosques acoustical quality can change depending on the occupancy level. This finding further highlights the multifactorial nature of noise in mosques. This study highlights a need to develop standards (or recommendations) to optimize sound level inside and outside mosques.

4. References

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Biographies

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